Professional paper

Threats to local drinking water in the municipality of Ljubljana

Polona **LESJAK**[1*], Barbara **ČENČUR CURK**[2]

ABSTRACT

This article presents the key findings of an analysis of the local water supply in the Municipality of Ljubljana and all changes which affect on local area water quality. The detailed review covers several local water supplies located in the western part of Ljubljana. Inventory of existing land use in the recharge area of individual water supply and a survey of individual reservoir managers were performed in the field. An analysis of the data collected from a laboratory analysis of water samples from local water supplies was performed.

Based on an analysis of the technical conditions of the reservoirs along with the proposed measures for improvement, the statistical processing of the results of the microbiological and physical-chemical analysis of the groundwater samples was carried out. Sampling was monitored from 2005 – 2010. The Water Framework Directive approach DPSIR (*Driving forces, Pressures, State, Responses*), was also used in the study which allows more detailed analysis of local captures and definition of threats. Results of DPSIR approach are not presented in this paper.

The purpose of the research work is to identify threats to existing local reservoirs in the Municipality of Ljubljana regarding the sanitary-technical conditions and the health aspects (water quality impacts on human health) and to define the hydro geological aspects (quantitative and qualitative status of the particular groundwater) and finally to outline measures to improve the situation. The research results show physical and chemical, microbiological and other environmental factors, which influence the quality of each individual reservoir. According to the research data the reservoirs Dolgo Brdo, Vnajnarje Korito and Besnica are the most problematic regarding drinking water quality.

Key words: public and private water supply, local water resource, water capture, drinking water quality

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INTRODUCTION

Provision of safe drinking water is one of the global challenges of the 21st century [1]. Yet, for several decades, about a billion people in developing countries don't have a safe and sustainable water supply. It has been estimated that a minimum of 7.5 litres of water per person per day is required in the home for drinking, preparing food and personal hygiene, the most basic requirements for water; at last 50 litres 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 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 source water using good management strategies can help communities to reduce the threat of drinking water contamination [3]. Source water 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].

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) a stringent water protection area with the strictest protection regime; (II) a narrow water protection area with a strict protection regime; and (III) a general water protection area with a temperate protection regime [6, 7, 8].

In the Municipality of Ljubljana 40 local reservoirs are provided. Most local water supply systems are located in the eastern part of Ljubljana (Figure 1). Five are managed by Javno podjetje Vodovod – kanalizacija d.o.o., (hereinafter: J.P.VO-KA), 27 are operated by Municipality of Ljubljana, and eight reservoirs are abandoned or are already connected to the water supply of other communities.

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

The amount of water consumed per person in Ljubljana in the areas under consideration varies widely and ranges from 150 L to 250 L per person per day [9]. Since drinking water is considered as a 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. The internal control is carried out in compliance with the HACCP system [10, 11], which allows the risks to be assessed and the entire supply system to be controlled. From the perspective of local communities there is a need for the protection of local water sources, which are now neglected because of larger public water systems.

The working hypothesis stated that the local reservoirs in the eastern part of Ljubljana, which are managed by the Municipality of Ljubljana

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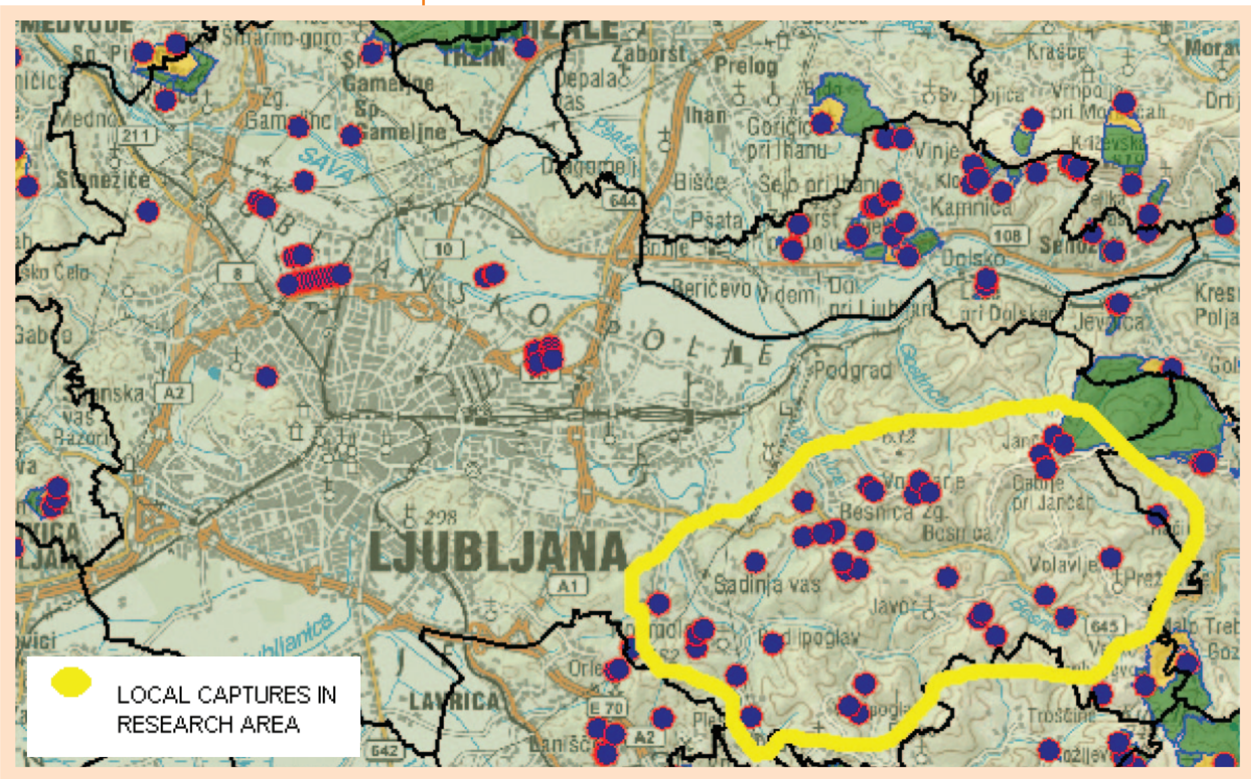


Figure 1.
Map of local water captures for the area of the Municipality of Ljubljana.
(Source: ARSO (http://gis.arso.gov.si/atlasokolja/profile.aspx?id=Atlas_Okolja_AXL@Arso)

(Public Health Institute), are more endangered in terms of achieving quality and volume in comparison with other reservoirs in Ljubljana, which are monitored by the public-sewerage company (J. P. VO-KA). These reservoirs are more endangered due to their access and location. However, the local legislation does not allow inspection control over these reservoirs.

METHODS

Internal control over compliance of drinking water in local water systems is carried out in accordance with the Rules on Drinking Water [12]. It has to follow established procedures based on the HACCP plan [10, 11] which contains the sampling sites, the type of trials and a minimum frequency of the sampling. In the period 2005-2010 there were in average 352 microbiological samples and 144.2 samples for chemical testing. Samples were collected and analysed by the laboratory of the Institute of Public Health.

Data from existing microbiological, physical and chemical analyses of water samples (which were performed by health institutes of Ljubljana, Maribor, Celje and J.P.VO-KA) were statistically analysed [13]. Based on the monitoring program of drinking water [14, 15, 16, 17, 18, 19] in the period 2005-2010 an average of samples were taken once a year for regular and occasionally testing.

Collected existing studies and the background of individual reservoirs were used in preparation of the analysis [20-50]. For each water capture, description of the location, hydro-geological characteristics of catchment area, aquifer type and other parameters were determined.

Data on existing land use were obtained from European CORINE land cover map[1]. Planned land use was gained from spatial master plan of Municipality of Ljubljana. The investigation defined the existing state of the captures including the recharge area from a sanitary – technical point of view. The existing land use and the list of potential pollutants in individual catchments were also established.

The investigation defined the existing state of the captures including the recharge area from a sanitary – technical point of view.

A field survey (opinion poll) included operators who are responsible for maintenance of each individual capture. With field survey several parameters were obtained, such as contaminants across the water protection zones, state reservoirs (age, maintenance, supplies, construction), risk factors, cost control, analysis of land use, etc.

In collaboration with the administrators 35 captures were successfully examined, for 10 captures there were no useful information because they had been connected to the other municipalities. Five local water supplies are operated by the J.P VO-KA, 40 of them are operated by Municipality of Ljubljana [10]. 90 % of captures were successfully examined, 10 % of the reservoirs were not covered in the survey because responsible person refused to participate in the analysis.

The data processing and evaluation were 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 statistical analysis of the results of the microbiological and physic-chemical analysis of the groundwater samples are shown in the results chapter. Minimum, maximum and average values and trends were determined for each parameter.

All the samples that exceeded the values were discussed. A calculation of all minimal, maximal and average values and expected trends have been made for each local water supply. The numeric data of the most exposed reservoirs has been presented also 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 presented in the Excel Pivot Tables.

The survey covered 81.8 % of all reservoirs, which are managed by the Municipality of Ljubljana. The reservoirs, which are managed by the public sewerage company J.P. VO-KA have not been problematic in terms of water quality [51].

RESULTS

The study of drinking water sample analysis has shown that for some parameters threshold values are often exceeded. These parameters are faecal bacteria's (Escherichia coli, Enterococci), Clostridium perfringens

[1] CORINE (land cover CLC2000) 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.

(including spores), Coliform bacteria counts at 22°C, the number of colonies at 37°C and Manganese (Mn), Iron (Fe) and Desethylatrazine. The focus of this paper is based solely on the analysis and results of these parameters. One factor endangering water supply is heavy rain, which represents (during the flooding in September 2010) another reason for increased pollution.

Physical parameters of drinking water

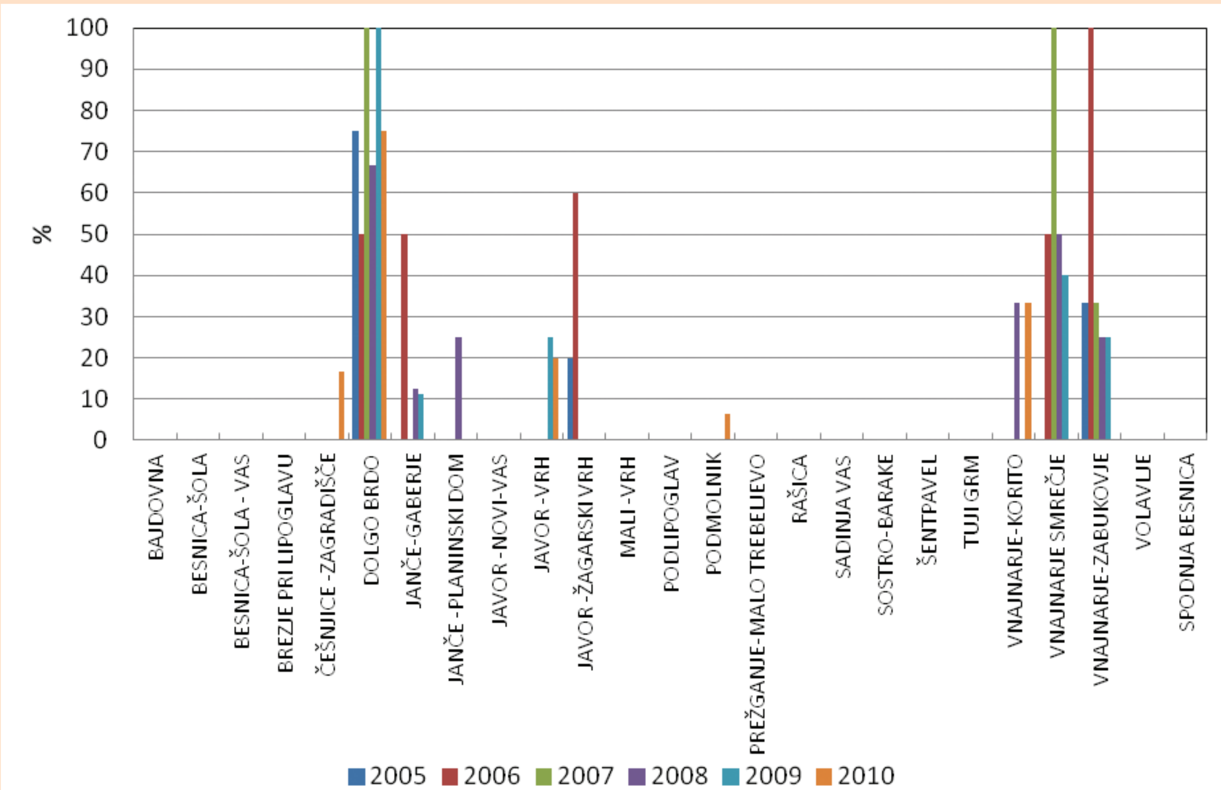
Basic regular physical analyses of drinking water include measurements of following parameters: colour, visible dirt, odour, turbidity, pH and specific electric conductivity.

On the basis of the Rules of the drinking water [12] an annual monitoring program for drinking water has been prepared [14-19], which includes six times a year sampling frequency for regular physical testing, and once a year for 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 2005-2010 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 pH of 9.8 to 10.4.

Figure 2 shows the highest proportion of samples (%) with exceeded threshold values for pH for individual local captures (in the period 2005- 2010). There are three prominent captures: Dolgo Brdo, Vnajnarje Smrečje and Vnajnarje Zabukovje. The highest portion samples with poor quality were found in Dolgo Brdo (2007 and 2009). 2007 in Vnajnarje Smrečje and 2006 in Vnajnarje Zabukovje. The portion of in-

Figure 2.
Portion of samples (%) with exceeded threshold values for pH for individual local captures (in the period 2005–2010).



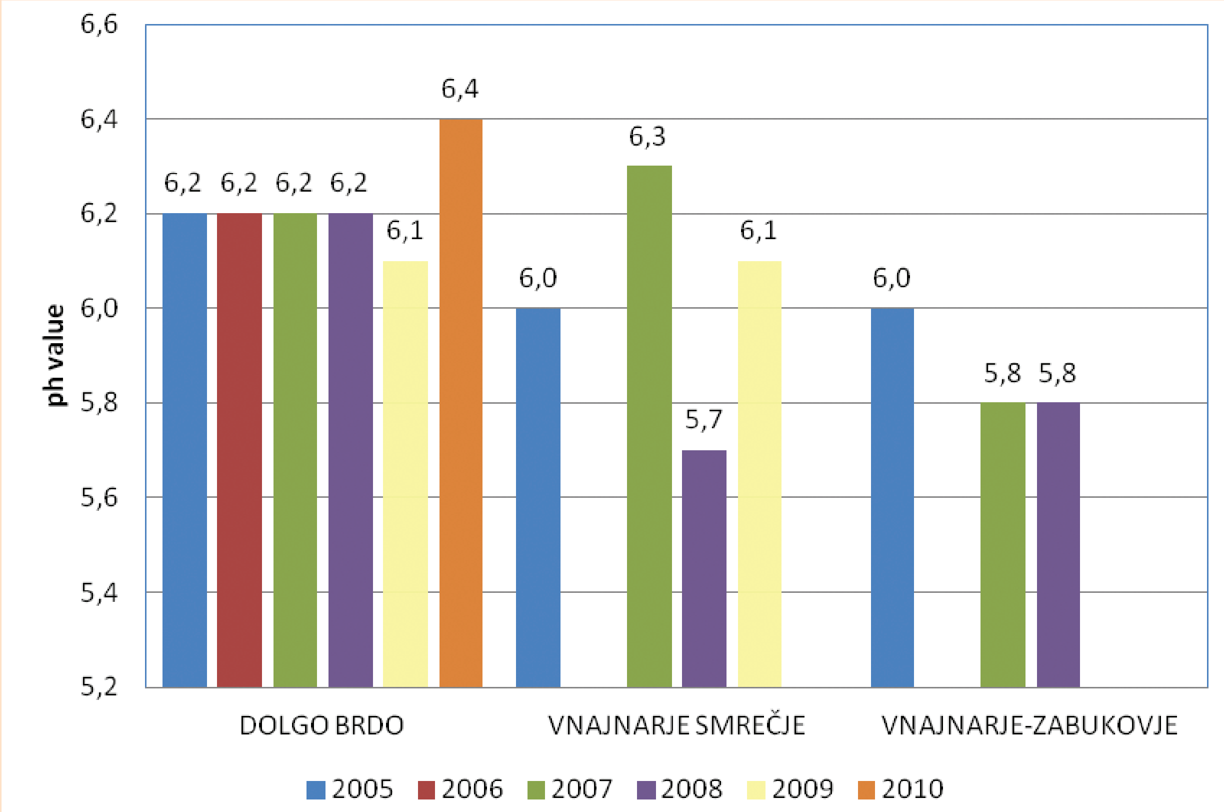


Figure 3.
pH values for individual local water captures (based on all samples with exceeded value included in the period 2005–2010).

ferior 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.

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 the 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 3 shows the yearly average pH of water samples with exceeding threshold values for five years (2005-2010). The highest portion is in the following captures: 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 supplies: Vnajnarje – Smrečje in 2007, Vnajnarje – Zabukovje in 2005, and Dolgo Brdo in 2010. More than 50 % proportion of inferior quality samples were found in the following water supplies: 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.

Results of the microbiological analyses

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.

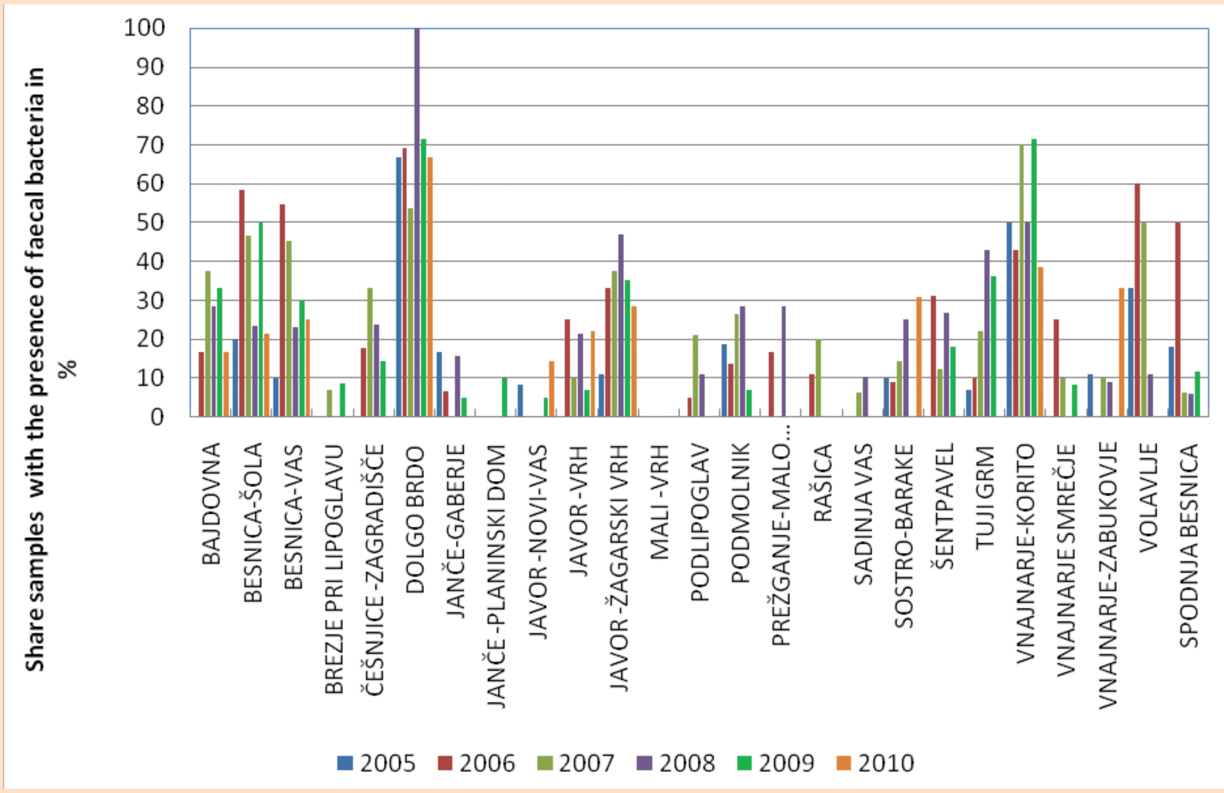
On the basis of internal control system HACCP [12, 13] in the period of 5 years (2005-2010) on average 352 samples per year were taken for microbiological testing by the laboratory of the Institute of Public Health of Ljubljana (ZZV Ljubljana). Annual reports contains only the total number of samples with exceeding parameters and the total number of the faecal bacteria origin.

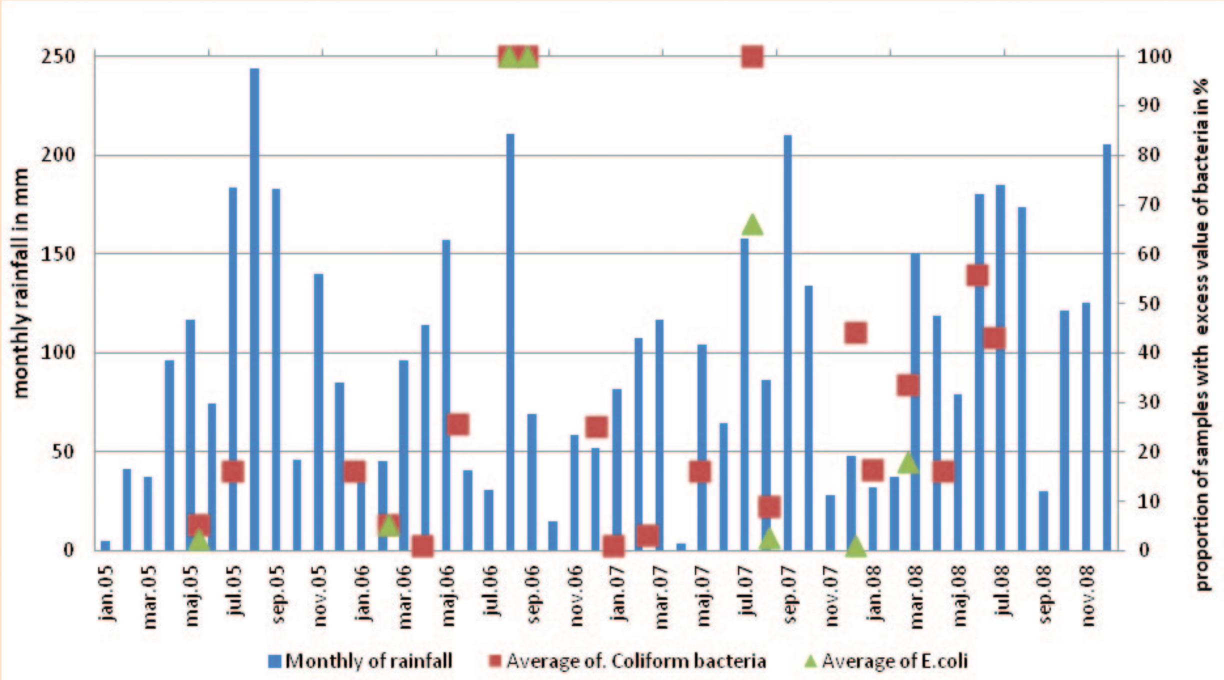
Figure 4 shows the portion (in %) of water samples with the presence of faecal bacteria for individual local water supplies in the period 2005-2010. Water supply Volavlje, Dolgo Brdo and Vnajnarje Korito have the worst water quality regarding presence of bacteria. In 2008 in Dolgo brdo all samples were containing 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.

The obtained results show the relationship between content of bacteria and amount of rainfall for the most critical captures Besnica vas, Dolgo Brdo and Vnajnarje Korito. In the **Figure 5** presented data were taken and calculated from monthly and annual reports of the Institute of Public health. The data indicate the period in which the samples contained minimal faecal bacteria. The Figure 6 contains monthly data on precipitation over the 10 year period covered in the reports of rainfall compiled in the nearest station Dobrunje [52].

Highest concentration of water samples with presence of faecal bacteria in the Besnica vas local captures were in August – September 2006

Figure 4.
The portion (in %) of water samples with the presence of faecal bacteria for local water supplies in the period 2005–2010.



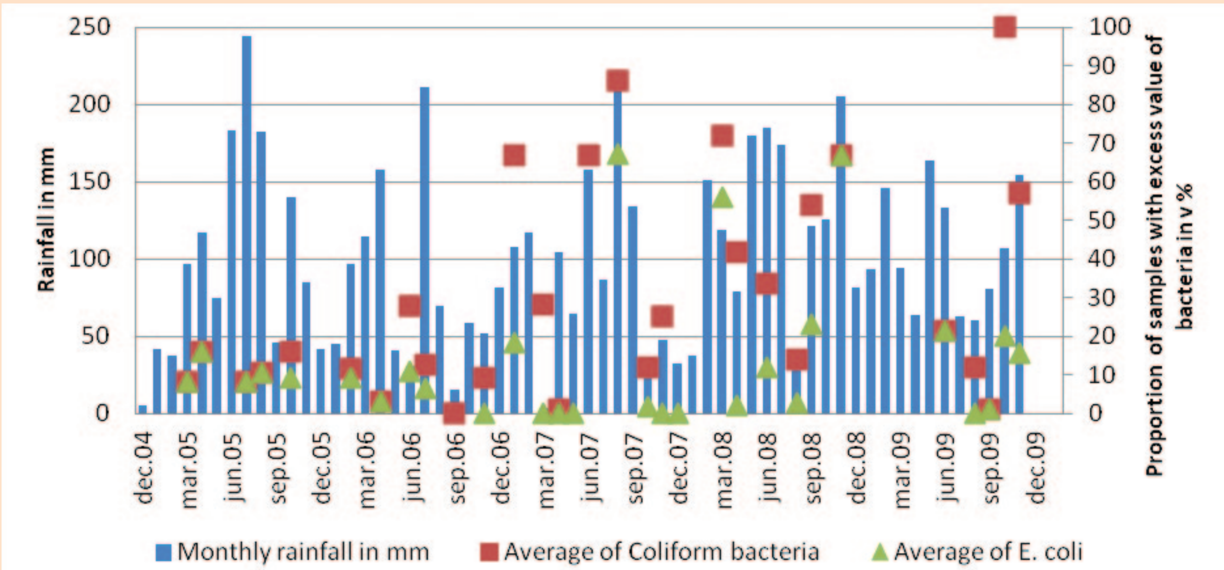


(100 %) and October 2007 (66 % and 100 %). Increase of faecal bacteria (in summer and autumn) is reflected in the period of drought or in the period of increased rainfall in autumn. The climate factor is the main reason for the increased level of pollution of the Besnica vas reservoir.

Figure 5.
Share of water samples (in %) with the presence of faecal bacteria and monthly amount of rainfall for the catchment of the Besnica vas capture.

Figure 6 shows the highest percentage of samples with faecal bacteria in Dolgo brdo (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 July to October 2007, rainfall can be a reason for the microbiological pollution. In 2010 there was no excess value of bacteria.

Figure 6.
Share of samples with excess value of bacteria in % and monthly amount of rainfall for the capture of the Dolgo Brdo.



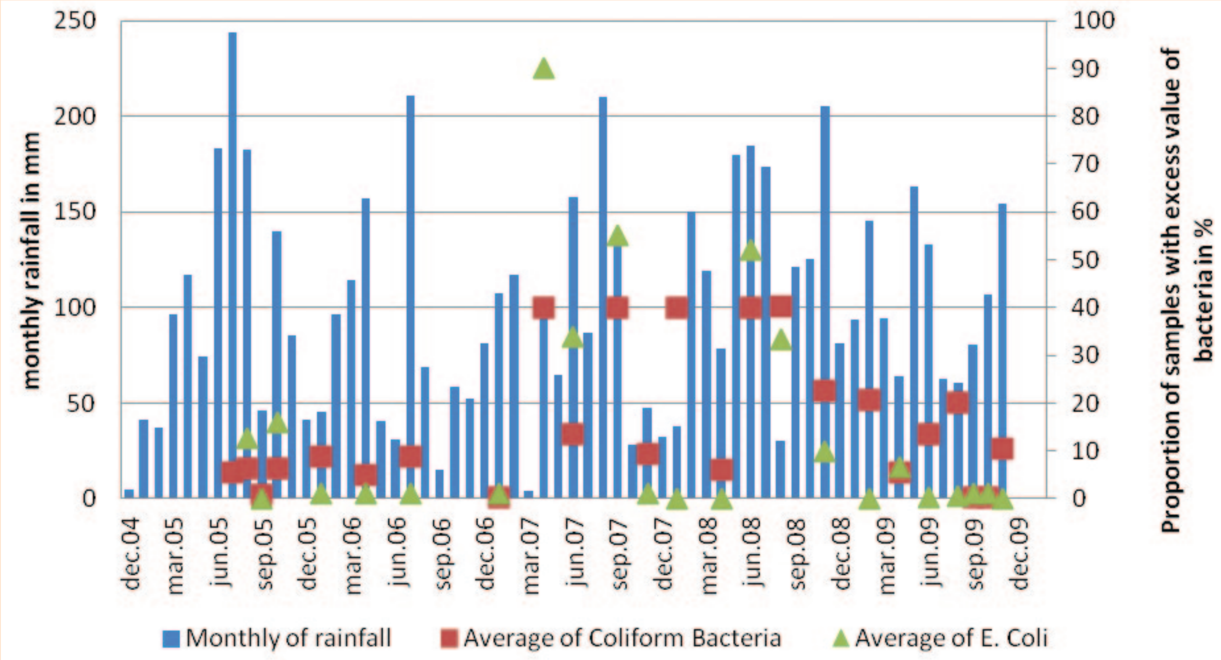


Figure 7.
Share of samples with excess value of bacteria in % and monthly amount of rainfall for the capture of the Vnajnarje Korito.

Figure 7 shows average bacteria content (E. coli and Coliform bacteria) in the capture of Vnajnarje Korito in comparison with monthly rainfall amount. The largest increase in Coliform bacteria for the Vnajnarje Korito is evident for the periods May – October 2007 as well as in February, June and September 2008. Increase in E. coli in this waterworks can be seen also in May 2007. The biggest amount of rainfall is observed in July 2005, August 2006 and December 2008. It is not possible to find the correlation between the ccurrence of the number of bacteria and the increased rainfall. On the basis of the examination of the terrain, the survey and overview of the reports it is established that there are other prevailing factors present (poor construction of the reservoir, fertilizing meadows).

Results of the chemical parameters analysis

Basic regular chemical analyses of drinking water include following parameters: TOC, ammonium, nitrite and occasional investigations nitrate. Detailed chemical analyses include the general physical parameters and the chemical parameters (smell, taste, colour, conductivity, pH, nitrate, etc...), metals and non-metals (aluminium, boron, quicksilver, 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.).

Statutory limit values of the parameters are: Manganese 50 µg/L, Iron 200 µg/L, Desethyl atrazine 0,10 µg/L. Other chemical parameters that are identified in drinking water are metals and non–metals (aluminium, boron, quicksilver, 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.).

Other parameters are recorded in the period of 5 years. Only the exceeded values of the following parameters are shown. The taste was unacceptable in Janče Gabrje, Janče planinski dom and Dolgo brdo in year 2008. Exceeded threshold values for Desethylatrazine; in Podmolnik (0,12 μg/L in 2005). Exceeded threshold values for Manganese; Vrtina pri Jančah (500 μg/L – 1.100 μg/L) and Janče planinski dom (375 μg/L – 1.525 μg/L).

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

Survey of the local captures

Local water systems are mostly located in the Sostro district in the eastern part of Ljubljana. In collaboration with the administrators 35 captures were successfully examined as interview survey; for 10 reservoirs there were no useful information, because they had been connected to the other municipalities or are present in databases. Five local water supplies are operated by the J.P VO-KA, 40 of them are operated by Municipality of Ljubljana. 90 % of captures were successfully examined, 10 % of the reservoirs were not covered in the survey because responsible persons for particular capture refused to participate in the survey.

After analysis of reports, which are made on the basis of archival material [13, 51] for the 2005–2010 period, it is evident that most reservoirs continually have not meet the minimum sanitary and technical conditions required by Rules of Drinking Water [12]. Some water sources have already been replaced by the new wells [20-50]. Public services of supplying drinking water in all settled areas of the Municipality of Ljubljana performed by J.P VO-KA (except in areas above an altitude of 1,500 m a.s.l., and settlement areas with fewer than 50 residents with an annual average water supply less than 10 m^3 per day). 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 description of the constructed distribution network including water connections. The survey took place over the period from spring to autumn 2010.

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 8 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.

Figure 8.
Threats to water sources (**Legend**: 1... lowest risk, 10... highest risk).

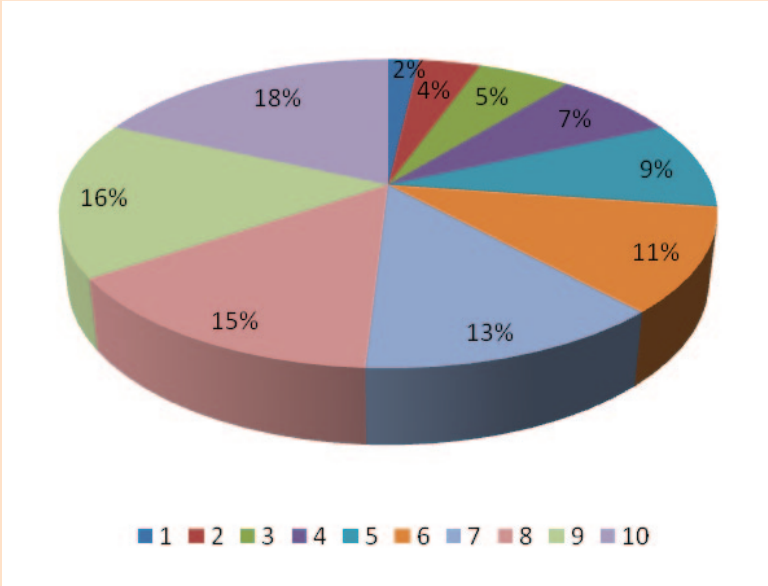


Figure 9 shows that in the most captures (85 %) presence of illegal activities in recharge area affecting the environment were not detected. An 11 % share is represented by catchments areas, where in the close vicinity there is an illegal building (or a built residential facility located in the immediate vicinity of the inner water protection zone).

During the interview, municipal waste (plastic, furniture parts and pieces of iron) was observed in the area of three captures and municipal waste (plastic, furniture parts, pieces of iron, etc.)

Figure 10 shows that 77 % of the surveyed capture managers said that also municipal waste (e.g. household appliances tyres, furniture, and plastic waste) were observed near their reservoirs.

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.

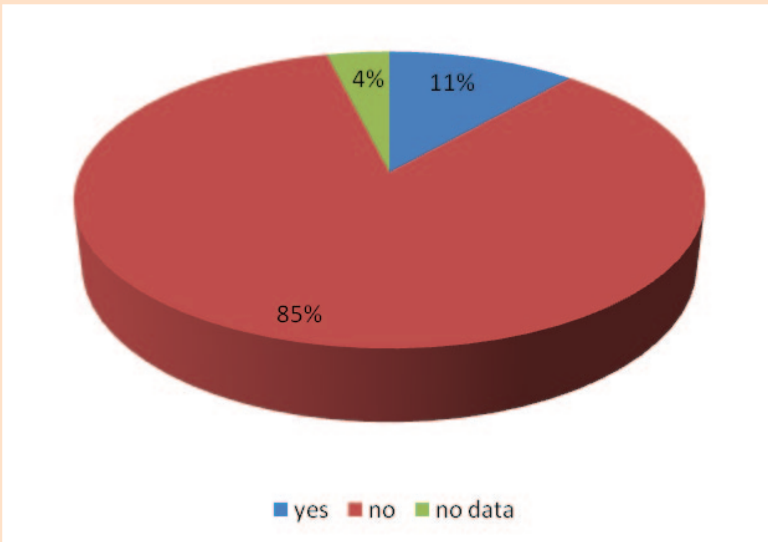


Figure 9.
Presence of illegal construction in the vicinity of the captures.

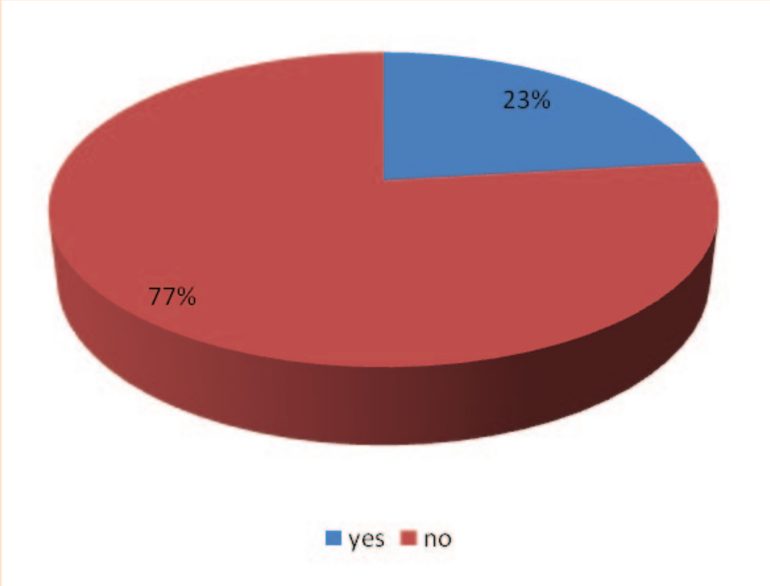


Figure 10.
The presence of municipal waste in the vicinity of capture.

Figure 11 shows how economically the local water reservoirs are controlled by trustees. 7 % of those in charge believe it is sensible and economical to continue to monitor and ensure the capture, while the higher proportion of administrators – trustees (33 %) say that the control is not effective due to obstruction of access, location, and weather conditions.

Figure 11 shows how reasonable is transition to the new capture or borehole. A larger proportion of administrators – trustees said that transition to the new capture or borehole is justified. From the situation in the field and the responses of members of local committees, 7 % believe that the connection was not meaningful. The reason for the transition is the current financial opportunity rather than capture problem.

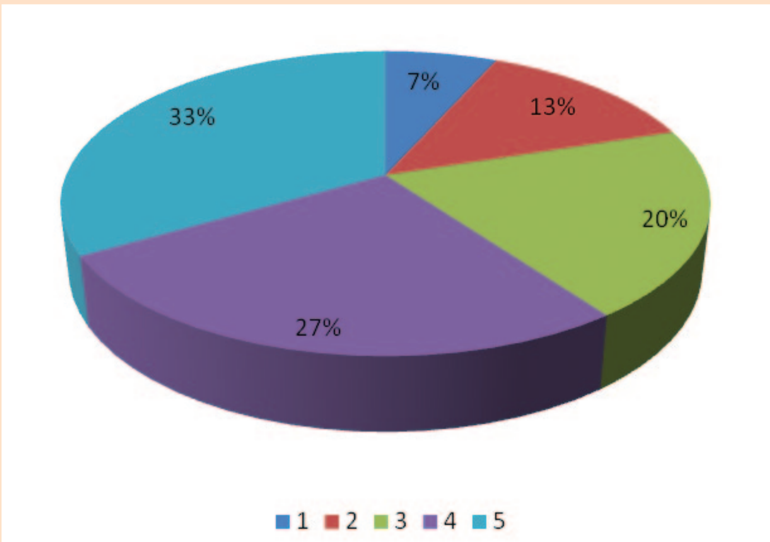


Figure 11.
Cost control of water reservoirs by the managers
(**Legend:** 1 is not economical 5 is high economical).

Figure 12.
Local capture of buildings divided by age.

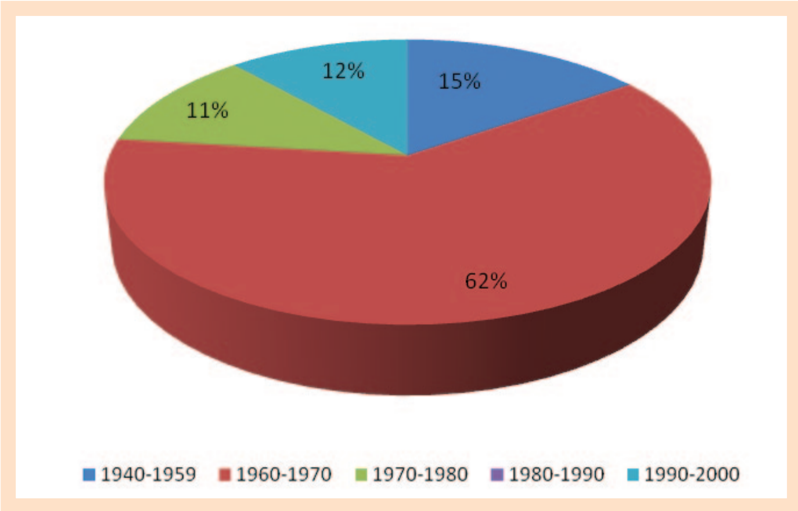


Figure 12 shows that according to the managers' responses, 70 % of reservoirs were built between 1960 and 1970, while the smallest proportion (13 %) were built between 1990 and 2000.

The persons in charge of water supply committees were asked to answer when the capture was restored. **Figure 13** shows the statements of person in charge: half of the reservoirs were restored in 1990 and 2000, 22 % in 2007 and 18 % in 2005.

According to the trustees, the majority of captures are made of concrete (84 %), more than 15 % of the reservoirs are being constructed from other materials (rocks, plastic, bricks), **Figure 14.**

Figure 15 shows the need to look towards nature for a greater share of the risk factors of contamination. Thus, global changes, which are also reflected in the climate (droughts, floods, sudden temperature drops and increases inconsistent with the season) are the dominant causes of water pollution in the catchments area.

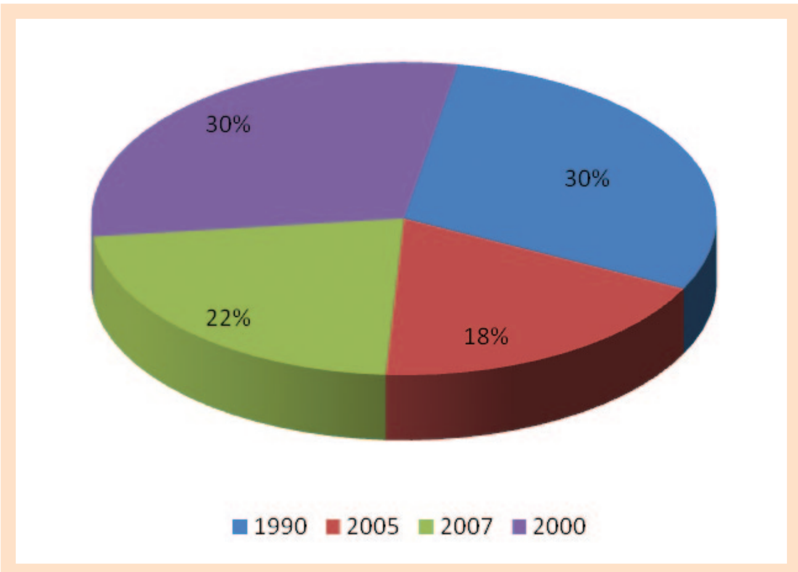


Figure 13.
Local captures by year renovated.

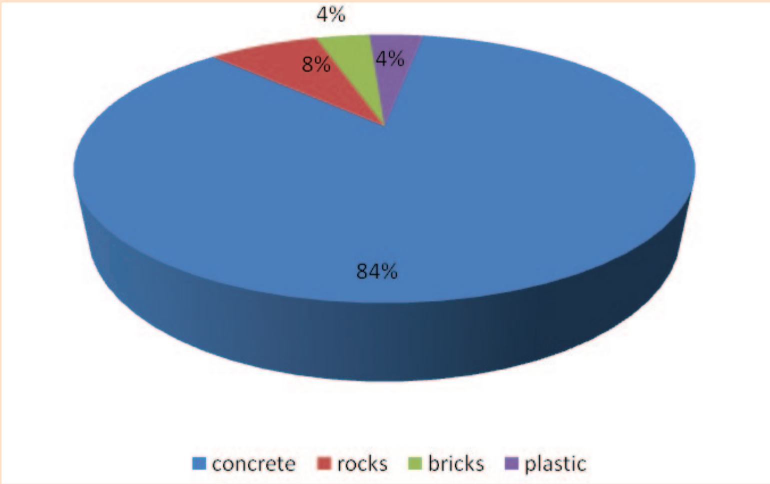


Figure 14.
Local capture by type of material.

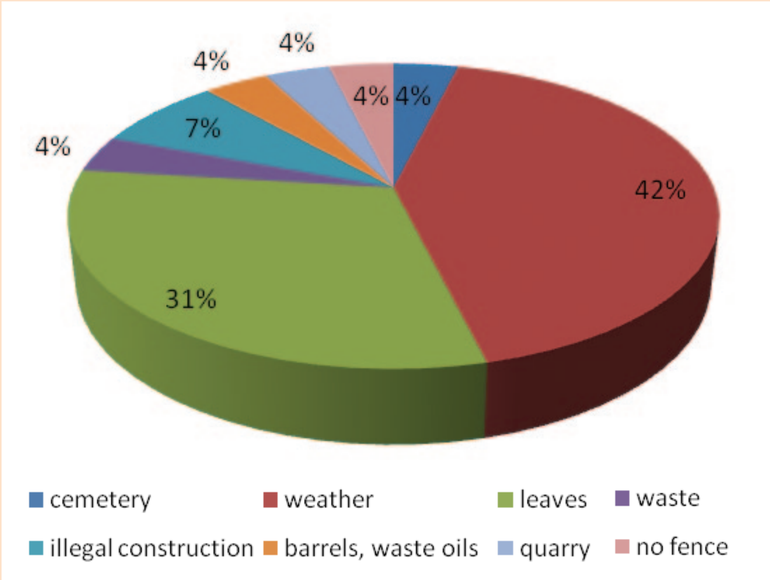


Figure 15.
Risk factors with regard to the subject of risk.

DISCUSSION

Based on the findings of the interview survey of local water supplies and their managers and drinking water quality monitoring, one can state that most of the local water supply is not healthy, mainly due to polluted groundwater in the catchments area.

Microbiological parameters

By considering the situation in the field and reports of past years, it can be found that water in most local water supplies (captures) many times exceed threshold for microbiological parameters. In 2005 there were 17 captures (or 62.9 % of all examined captures) which contained exceeded threshold. In 2006, there were 22 reservoirs (or 81.4 % of all examined reservoirs), in 2008 24 reservoirs or 88.8 % of all examined reservoirs, which contained exceeded threshold. In 2009 there were 17 reservoirs with exceeded thresholds or 62.9 % of all examined reservoirs.

The analysis undertaken can lead to the following hypothetical view that the local water supplies areas under Municipality of Ljubljana management are more vulnerable in terms of achieving qualitative and quantitative conditions such as bigger capture (water works) in the Municipality of Ljubljana and its surroundings. Local water supplies are more vulnerable, becouse of the lack of the certain water protection areas with legal restrictions on land use in these areas.

The catchments areas of local water supply are generally exposed to heavy pollution from agricultural land, inappropriate wastewater discharge from villages and hamlets, unregulated polluted storm water drainage from roads, illegal dumps and uncontrolled water discharges of hazardous substances into the soil and buildings which have appeared in the immediate vicinity of water protection zones.

Physical and chemical parameters

Local water supplies are more vulnerable, becouse of the lack of the certain water protection areas with legal restrictions on land use in these areas.

The physical and chemical parameters of drinking water sample tests also show that water is polluted in several captures.

In 2005, they found six samples with pH exceedances of the limit (of the 27 examined reservoirs). In 2006 they found 4 samples and seven samples they found in 2007, in 2008 they found 10 samples, and 5 samples they found in 2009. The taste was unacceptable in four cases in year 2008. Manganese was exceeded once in 2006 five times in year 2007 and six times in 2008. Desetylatrazine was exceeded once in 2005. On the given results of physico-chemical examinations of drinking water can be concluded that the drinking water in these 5 years in general is less polluted contrary to microbiological examinations.

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

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

The managers of local water supplies acting in water committees in local communities or individuals lack the necessary professional qualifications and perform this function on a voluntary basis.

In recent years the Municipality of Ljubljana has been systematically resolving the complex water supply problems of local water utilities through drilling new wells.

In a regular plan especially restoration and renovation works are carried out on local water distribution systems, which do not have safe drinking water. With renovation works physical and chemical water pollution in reservoirs is prevented in the long term. In some places, the quantity of water has increased.

In 2002 the municipality began to regulate the supply and renovation of local reservoirs in order to finally resolve the problem of drinking water supply.

In the area of the aquifer have been (based on hydrogeological studies) specific micro-location of deep boreholes. They can cover a sufficient quantity of quality drinking water for more local water supply systems where the water shortage or drought is of poor quality.

In the eastern part of the Municipality of Ljubljana, deep wells have been drilled at these locations, providing max capacity of 25 L/s of safe drinking water. The water from these wells will be, according to the building development programme for the restoration of local water utilities, in the near future replaced by water which is inappropriate from a sanitary-hygienic viewpoint.

Intensive agriculture, dysfunctional septic tanks and cesspits, unclean craft activities and ecological disasters (the floods in 2011) in the protection zones of water resources have caused chemical or microbial risks which, even with treatment and rehabilitation processes, cannot be removed or reduced to an acceptable level.

Field survey

Based on the surveys and interviews with the managers of some reservoirs the transition to new wells has not been justified since, by adhering to the rules of preventive environmental protection (uncontrolled pouring slurry zones, unprotected water source, water protection of local, illegal building activity in the immediate vicinity of the local capture), people can on the long term protect the catchments area.

In spring and autumn of 2010 terrain examinations of actual reservoirs in presence of the representative of Public Health Institute and interviews with reservoir caretakers were carried out.

In collaboration with the caretakers of the water distribution systems 90 % of the reservoirs have been examined, while 10 % were left unexamined due to non collaboration of caretakers. On the basis of terrain examinations, interviews and examination of reports for the period 2005–2010 it has been established that reservoirs do not meet the minimal sanitary and technical standards required by legislation. Besides obtaining data on the number of people supplied with water, the examination of each local reservoir was included the inventory of the state of facilities, the maintenance of these facilities and the description of the reservoir.

According to the state of terrain and documentation examination some old reservoirs are better replaced by new borehole [20 - 50] which is adequate to health and reliable in terms of quantity.

Further investigations needed to improve the situation

In cases of such threatened water resources, abandoning of supply and connecting to another, more appropriate water source has been proposed. To establish alternative water sources hydro-geological and sanitary-hygiene research within a broad area of research has also drilled deep wells containing significant amounts of quality drinking water. In the near future this water supply will replace what is now supplied by reservoirs threatened by inappropriate water quality or a shortfall in times of drought.

If some locations were not dominated with capital interests, public awareness-raising activities could be carefully planned to ensure the hy-

In the eastern part of the Municipality of Ljubljana, deep wells have been drilled at these locations, providing max capacity of 25 L/s of safe drinking water.

According to the state of terrain and documentation examination some old reservoirs are better replaced by new borehole which is adequate to health and reliable in terms of quantity.

If some locations were not dominated with capital interests, public awareness-raising activities could be carefully planned to ensure the hydro geological characteristics of individual areas can be easily maintained to sustain individual catchments for several years.

dro geological characteristics of individual areas can be easily maintained to sustain individual catchments for several years.

Of course, often some drinking water from water catchments does not meet the criteria specified in the Rules of Drinking Water [12] and it is therefore necessary to reasonably provide water resources for devices for drinking water by replacing existing water sources with new, wholesome and reliable quantities of water sources.

CONCLUSIONS

This analysis has provided clear evidence for the main factors contributing to the contamination of private water supplies.

The climate (droughts, floods, sudden temperature drop and increases which are not consistent with the seasons) are the dominant causes of water pollution in the capture area.

Protecting source water using good management strategies can help communities to reduce the threat of drinking water contamination

The transfer of powers from the local community (the control and sanctioning) will be represent additional protection of local coverage.

Small water supplies are often vulnerable to contamination. In many rural contexts, there is often a lack of integrated approaches regarding water source protection; sanitary protection of drinking- water sources is frequently inadequate.

Small water supplies are often vulnerable to contamination. In many rural contexts, there is often a lack of integrated approaches regarding water source protection; sanitary protection of drinking- water sources is frequently inadequate.

Small water supplies have relatively greater capital costs for technical installations, and per unit costs of materials and construction are also generally bigger.

There is often a lack of financial mechanisms to cover the local cost for monitoring, maintenance and operation.

Due to the larger geographical spread covered by small-scale water supplies and sometimes their remoteness and isolation, operators do not have easy access to information, expert assistance and technical support; there is also a low level of networking in scientific and professional communities.

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