Study of alternative solutions for waste water treatment in Richnava local municipality

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Table of contents

List of Tables

List of pictures

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1. Introduction – setting goals and ways to achieve them

Mayor of Richnava (Gelnica County) village M.Sc. Anna Harmanova announced on 18 May 2009 tender for a feasibility study mapping possible alternatives of waste water collection and treatment. Associate Professor Igor Bodík, PhD from Technical University in Bratislava, Faculty of Chemical and Food Technology, initiated a group of experts to prepare the feasibility study.

The expert group comprised of:

Eng. Milan Matuška – project leader

M.A. Elena Fatulová – nature conditions, legal and financial aspects

Associate Professor Igor Bodík, PhD. – proposal of waste water collection and treatment

M. Arch. Róbert Zvara – decentralized waste water sewage system for Roma settlement in the vicinity of Richnava village

After initial e-mail exchange of information between the expert group and local municipality representatives about the feasibility study, the expert team made a field trip to Richnava village in August 2009.

The visit resulted in the following:

1) Clarification of local municipality requirements regarding feasibility study goals and its content including the first draft of its content that was further clarified by e-mail communication.

2) The expert team made a visit to the Roma settlement nearby Richnava village that provided valuable information and basic data for proposal of waste water collection and treatment system for Richnava village with or without neighboring Roma settlement.

Contract for work in the study has been signed by Dr. Boris Minarik, Chair of GWP Slovakia on behalf of the expert group and by M.Sc. Anna Harmanova, Mayor of Richnava village.

Goals of the feasibility study were set up on the basis of information gained during the field trip, study of relevant archive documents and official correspondence with Ministry of the Environment. It was agreed that the study consists of:

- Short analysis of natural conditions
- Status of existing pollution sources
- Legislation related to local municipality possibilities and responsibilities in the field of waste water
- Identification of funding sources
- Preparation of alternative proposals for waste water collection and treatment including centralized and decentralized systems with traditional and alternative technologies using

natural waste water treatment as well as a financial analysis of investment and maintenance costs and a short comparison of their strengths and weaknesses.

Richnava local municipality discussed alternatives within its council and its citizens during a meeting in June 2010. Based on consultation results, the municipality will select a suitable alternative to be developed into a project for waste water disposal and treatment in Richnava village including the Roma settlement. However, public consultation needs to be carefully prepared with possible involvement of public participation experts because the topic is quite complex even for waste water experts. Citizens should be able to take active part in the discussion and decision making process related to selection of the most suitable alternative for waste water treatment. It will be crucial to invite **state water administration** to the public consultation, because it would be possible to realize selected alternative only with its approval.

Also, design project should be prepared by a certified expert or organization because it is one of pre-conditions in obtaining co-funding from European Union or any other financial sources for construction of waste water disposal and treatment system.

2 Analysis of the current situation

2.1 Characteristics of local municipality area in terms of solved problem

2.1.1 Short overview of natural conditions

2.1.1.1 Studies carried out in the territory of local municipality

Natural conditions in the territory of local municipality (geomorphology, hydrology, geology and hydrogeology) have been assessed on the basis of available information (Geofond), taken from final reports, hydro-geological and engineering-geological surveys, carried out in Richnava village in the past. The following is a review of studies that have been undertaken so far.

Forberger J., 1988: hydro-geological study to verify source of drinking water for Kluknava farm agriculture yard located in Richnava village. The study comprised of three exploration wells to a depth of 44-46 meters, located north of Richnava village near the Zlatnik Stream. Out of three hydro-geological wells, two wells were positive with the total yield of 0.61 liters per s^{-1}. Groundwater from two wells was clean from sanitary point of view; however, groundwater in one well was unsuitable for drinking purposes due to high concentrations of iron, ammonia and bacteriological pollution.

Puzder J., 1985: engineering-geological study for Kluknava farm consisting of six wells to a depth of 7 meters. Lithological conditions of surface layer consisting of clay loam with small gravel, sandy clay with medium gravel and clay gravel were found. From the depths of 4.2 to 4.8 meters a weathered shale was verified. Groundwater table was not hit.

Ostrolucký J., 2003: hydro-geological survey to ensure drinking water source for the Roma settlement in Richnava village. Results of the survey documented drinking water source south of Richnava village in the valley below Peter Mountain, comprising of three springs with a total yield of 0.61 1iters per s^{-1}. Quality of water makes it suitable for drinking purposes in terms of its chemical characteristics; however, it is microbiologically polluted.

Cabala D., 2005: Additional hydro-geological survey to determine protective zones of water source for the Roma settlement.

Cabala D., 2005: hydro-geological study of the local cemetery to verify hydro-geological conditions of the surface layer. The survey comprised of five wells, 3.5 meters deep. It verified quaternary sediments - clays and clay slope with mixture of gravel and base young Paleozoic sediments plate - fragmented sandy shale with sandstone loam with a clay mixture.

Cicmanová S., 2007: study to assess natural conditions in Richnava village in order to obtain background data for solving environmental problems of its inhabitants - collection and treatment of waste water in the village and finding drinking water source.

Above mentioned studies describe in detail natural conditions, therefore we present only relevant information taken from archive files in other parts of the study.

2.1.1.2 Geomorphology

Cadastral area of Richnava village is located in the eastern tip of Hornádska Fold. It lies at the junction of three geomorphologic units - Branisko Mountain, Hornádska Fold and the Slovak Ore Mountains. Northwestern part of the village belongs to southern Branisko Mountains, main central part of the cadastre lies at the edge of Kluknavská Fold and finally, southern part of the cadastre, located on the right side of the Hornád valley, belongs to Hnilec Hills.

With regards to morphology, the area has highland-lowland character. The village is located on the left side of the Hornád River in the gently sloping terrain with an inclination of 7-8 ° towards south of the River. Roma settlement is located on the right side of the Hornád River, in steep terrain close to the River.

2.1.1.3 Hydrology

The main recipient in the area is the Hornád River which collects mostly left side, rather short, tributaries from slopes of Branisko (ridge Slubice). The largest of these are Jaseňovec, Slatvinka and Zlatník Streams. These are however, small water courses with flows up to 8 1iters per s^{-1}. Flow of the Hornád River for Q_{355} is 1.723 m^3 per $^{s-1}$ (Cicmanová S., 2007).

2.1.1.4 Geology

Geological structure of the surrounding area includes crystalline formations, young Paleozoic-Mesozoic packaging sequence as well as Paleocene sedimentary formations.

Richnava village lies on Permian strata covered by Quaternary deposits. In the southern part of the village, this stratum is in direct contact with alluvial flat of the Hornád River. A Paleogene stratum (Inner-Carpathian Paleogene) is formed by sediments of different origin (river-delta, transgress-sea). They are also polymictic conglomerates on base of the strata, which pass into finer silt-sandstone sediments. This stratum is particularly widespread in the northeastern part of the territory, in wider area of the Zlatník Stream.

On the right side of the Hornád valley, on Hnilec Hills, there is Inner-Carpathian Paleogene formed by flysch formations consisting of top Eocene-Oligocene in which clay stones prevail over siltstone and sandstone.

Quaternary sediments fill substantial part of the Kluknavská Fold, formed by a sink of depression in Neogene. They are formed particularly by fluvial, deluvial (slope) sediments and proluvial deposits consisting of clay and sandy clays with varying mixture of gravel and sand. The Hornád River alluvial meadow along the stream has fluvial sediments containing flood loam and loamy-sandy gravel.

2.1.5.1 Hydrogeology

Geological structure in the area suggests that Pre-Quaternary as well as Quaternary formations do not create favorable conditions for the establishment of major ground water aquifers.

Pre-Quaternary formations (Permian), consisting of colorful slate Permian sandstones and local positions of conglomerates are not very permeable. Slates itself are considered as hydro insulator. Positions of sandstones are little watered with the average estimated transmissivity of $1 \cdot 10^{-5}$ $m^2 \cdot s^{-1}$. Positions of sandstone can contain waster sources which, however, do not provide significant yields. Low permeability sandstone strata demonstrate proven low yield of three hydro-geological wells in the range of 0.2 to 0.3 liters per $^{s-1}$.

Out of Quaternary sediments, the most significant are fluvial deposits of the Hornád River, represented by the sandy loam gravel. The average thickness of the aquifer reaches 4.6 meters and the filtration rate is estimated at $3.9.10^{-5}$ meters per s^{-1}. Groundwater from alluvial sediments is replenished by infiltration of the Hornád River surface water and rainfall.

Deluvial clay sediments that form the cover of Paleogene ground formations are generally considered to be less permeable than the fluvial sediments without major ground water aquifers.

In qualitative terms, it is expected that groundwater alluvial sediments are not suitable for drinking water purposes due to their replenishment by polluted water of the Hornád River. Available information on the quality of groundwater indicate that the groundwater in shallow aquifers of deluvial clay sediments, which are replenished by rainfall water are polluted locally mainly due to organic pollution originating from cesspools and agricultural activities. Springs on the right side of the Hornád River (over Roma settlement) as well as a spring in the village used for drinking purposes (municipal office and a kindergarten) have satisfactory quality of drinking water.

2.1.2 Demographic conditions

According to current information, there are about 2,400 inhabitants registered in the village, out of which 700 live in houses in Richnava village proper. Another 1,700 Roma people are located in illegal settlement with a homeless status. They live in shacks without house registration numbers outside the village in Ružokovec area, partly on forest land in the cadastral territory of Richnava municipality and partly in cadastral territory of Kluknava village.

Actually, the village does not have a public drinking water supply system. The supply of drinking water in the village comprises of six individual residential wells and public wells. Agricultural farm has built its own water supply source with a capacity of 50 m^3. Residents in the Roma settlement are using water from two public wells.

The village does not have waste water collection system. Waste water from households, local municipality office and school is treated individually, i.e. discharged into residential cesspools or septic tanks which are in most cases technically unsuitable. Out of a total of 275 houses/flats (2001 data), 128 houses/flats had cesspools or septic tanks. Waste water from the Roma settlement is poured on the ground in front of shacks into scraggly gutter.

2.2 Identification of surface and groundwater pollution sources

The main sources of pollution of groundwater and surface water in the study area are:

- Treatment of waste water from households - cesspits or septic tanks, pouring sewage water on the surface of the terrain.
- Farming - farm yard, midden, fertilizing farmland.
- Municipal and industrial waste landfills.

2.2.1 Waste water from households

Method of waste water treatment from households, i.e. collecting in defective (leaking) cesspools or pouring directly on the ground, can be seen as a major source of groundwater pollution in the area. These diffuse sources cause water pollution particularly by organic pollutants and nitrates as well as microbiological pollution due to faecal contamination resulting in poor quality of groundwater which makes it unsuitable for drinking water purposes. Pollution has an impact on groundwater and surface water of left side low watered tributaries of the Hornád River (especially Zlatník and Slatvinka). Considering impervious nature of watered environment and flow rates in the area (estimated Hornád River surface water infiltration into the valley floodplain) is not expected that this source of pollution has a significant negative impact on the quality of the Hornád River. Increased supply of organic pollution can be expected during rain period when rainwater may wash surface pollution into the stream.

2.2.2 Agricultural activity

There is an intense agricultural activity in the study area. Fertilization and use of plant protection chemicals are another potential diffuse sources of pollution, which may have a negative impact on groundwater (transfer of pollutants to ground water), but also surface waters (flushing of pollutants by water erosion). Main pollutants from agricultural activities are nutrients (nitrogenous substances and phosphorus) and organic matter. In case of plant protection chemicals application, occurrence of pesticides in groundwater can be expected. Concentrations of pollutants depend primarily on the intensity of fertilizer application and plant protection chemicals.

In addition to diffuse sources of pollution in the area, there are also point sources of pollution. These include agricultural farm with livestock (cattle or pigs) and midden pit located above the village. An increased content of pollutants from agricultural activities (organic matter and nutrients) can be expected in the vicinity of the point pollution sources.

According to Government Decree 617/2004 Richnava village is classified as a vulnerable area. This means that agricultural activity in this area has resulted in a significant increase in nitrate concentrations in groundwater (above 50 mg/l) which is of a diffuse nature. However, the local presence of nitrates in groundwater above this limit can not be eliminated. For that reason, there are no limits to agricultural activity (such as a limit for fertilizers) under the Ministry of Agriculture Decree 199/2008 establishing a Program of Agricultural Activities in Areas Declared Vulnerable.

2.2.3 Municipal and industrial waste landfills

There are many illegal waste dumps in the territory of the local municipality. The biggest illegal dump, basically a depression spontaneously filled with waste, is located in Roma settlement Ružokovec. Landfills are a source of point pollution out of which different pollutants can contaminate groundwater.

In the western part of the cadastral territory of Richnava village is located now obsolete industrial waste landfill of Krompachy town, Kovohute and SEZ Krompachy - Halňa. It is a remnant of the former industrial activity, resulting in particularly soil and the Hornád River pollution. The main contaminants are mercury, arsenic, copper and lead. Toxic metals were not found in shallow ground water horizons or in the water source. Solving this issue, however, does not fall under responsibility of Richnava local municipality.

2.2.4 Options for supply of inhabitants with drinking water

According to the conceptual design, embedded in the spatial plan of the village, supply of drinking water is planned by a capture of spring's system located under Peter Mountain and construction of municipal drinking water system.

Another alternative is to supply drinking water from individual wells, which are currently polluted mainly by organic pollution. Construction of waste water collection system to divert sewage out of the village and at the same time to improve the quality of groundwater in order to become suitable for human consumption would indeed support realization of drinking waster supply. Currently, it is not possible to assess to what extent this assumption is realistic as well as to determine future trends of groundwater quality due to incomplete information. In particular, actual state of pollution in the territory in relation to identified sources of pollution, details of local flow ratios and others are missing. Although it is realistic to expect that after cessation of pollutants discharges into groundwater, groundwater quality will gradually improve, it will be a long process. Now it is not possible to estimate the time horizon when decrease in concentrations of contaminants reaches limit values for drinking water. Also, it is not possible to estimate the impact of other sources of pollution (mainly from agricultural activities) which remain active and will affect groundwater quality locally.

Given the low permeability of watered layers on which are built shallow household wells, it can be assumed that the self-cleaning process will run very slowly and the resulting effect of improving groundwater quality may not be achieved throughout all area of the local municipality. Therefore, the conceptual plan to address the drinking water issue from individual household wells seems not very promising not only from qualitative but also quantitative point of view, especially if there is a positive demographic development in the village. In case of acceptance of the concept for supply the village with drinking water from individual wells, a separate project that responds to basic technical and financial aspects of such an approach has to be prepared first, followed by a decision on implementation of alternative drinking water supply, which will be acceptable for Richnava village.

The purpose of this study is not a detailed analysis and design of the drinking water supply for Richnava village. This issue is mentioned only marginally, especially with regards to alternative proposals for wastewater treatment solutions or impact of these alternative proposals on planned sources of drinking water within boundaries of the village.

3 Legal aspects of waste water treatment

3.1 Brief description of the relevant European, national and local legislation

3.1.1 European legislation

The basic legal framework in the field of wastewater collection and treatment in the European Union countries is the Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment (hereafter as the Directive). The Directive reflected Member States' obligations regarding the collection, treatment and discharge of urban waste water and deadlines to achieve them.

The obligations of this Directive are derived from:

- Size of agglomerations, while the agglomeration is considered "an area where the population or economic activities are sufficiently concentrated that it must pay them to collect municipal waste water, municipal wastewater treatment plant, or a final discharge".
- Susceptibility to eutrophication, according to which and a set of specified criteria, sensitive areas or less sensitive areas where stricter criteria for the treatment of urban wastewater apply, are identified. If a Member State decides to declare its entire territory as the sensitive area, sensitive areas have not to be identified.

Member States shall ensure the following according to the Directive:

- All agglomerations are provided with collecting systems for urban waste water and that urban waste water entering collecting systems are before discharge subject to secondary treatment (secondary treatment means treatment of urban waste water by a process generally involving biological treatment with a secondary settlement or other process in which the requirements established in Table 1 of Annex I are respected) as follows:
    - at the latest by 31 December 2000 for those with a population equivalent (P.E.) of more than 15,000
    - at the latest by 31 December 2005 for those with a P.E. of between 2,000 and 15,000
- For agglomerations less than 2,000 P.E. to ensure appropriate treatment of urban waste water entering collecting systems (appropriate treatment means treatment of urban waste water by any process and/or disposal system which after discharge allows the receiving waters to meet the relevant quality objectives and the relevant provisions of this and other Community Directives) at the latest by 31 December 2005.
- In sensitive areas to ensure that agglomerations of more than 10,000 p.e are provided with collection systems and urban waste water entering collecting systems before discharge be

subject to stringent treatment (removal of nitrogen and phosphorus) at the latest by 31 December 1998.

The Directive provides for discharged urban waste water limit values for BOD5, COD and suspended solids. For discharges to sensitive areas, limit values are provided for total phosphorus and total nitrogen, which are differentiated by the size of agglomerations. For all indicators of pollution, either concentration or percentage of reduction can be used. The limit values are shown in the table below.

Tab. 3.1 Limit values (Source: Directive 91/271/EEC)

Parameters	Concentration	Minimum percentage of reduction
Biochemical oxygen demand (BOD5)	25 mg/l O_2	70 - 90
Chemical oxygen demand (COD)	125 mg O_2	75
Total suspended solids	35 mg/l (optional)	90 (optional)
Total phosphorus	2 mg/l – 10,000 – 100,000 P.E. 1 mg/l – more than 100,000 P.E.	80
Total nitrogen	15 mg/l – 10,000 – 100,000 P.E. 10 mg/l – more than 100,000 P.E.	70 – 80

Urban waste water discharges are also covered by the Water Framework Directive (2000/60/EC), which requires achievement of good status of surface waters by 2015. This Directive refers to urban waste water discharges in cases where, despite meeting the requirements (limits) of the Directive 91/271/EEC concerning urban waste water treatment (baseline measures), good water status in the territory is not achieved and it is clear that the cause of this status is discharge of the urban waste water. In this case, the limits may be tightened or other appropriate complementary measures have to be applied.

3.1.2 National legislation

Slovakia, on accession into the European Union, was obliged to adopt requirements of European directives into national legislation. It is the right of the Member State to adopt more stringent requirements than those laid down in European law.

Requirements for urban wastewater collection and treatment are reflected in the following legislation:

- Act 364/2004 on water and changes of the Act of the National Council 372/1990 on offences as amended (Water Act).
- Act 442/2002 on public drinking water supply and sewerage amending Act 276/2001 on regulation in network industries, as amended.
- Government Decree 617/2004 establishing sensitive and vulnerable areas.
- Government Decree 296/2005 establishing surface water quality and quantity objectives and limit values for waste water and specific water pollution indicators.

Water Act and related regulations

Requirements arising from the Directive 91/271/EEC concerning urban waste water are transposed the provisions of the Water Act. Regarding the deadlines to comply with the

Directive in agglomerations that fall under the Directive (above 2,000 P.E. and under 2,000 P.E. with constructed waste water collection system), in the accession negotiations have been agreed for Slovakia transition periods in order to meet the requirements of the Directive, embedded in the Accession Treaty with the European Union. These deadlines are binding for Slovakia.

Under the Accession Treaty, the whole territory of Slovakia was declared a sensitive area. This means that a stricter requirement for urban waste water treatment (removal of nitrogen and phosphorus) is valid for all agglomerations over 10,000 P.E. throughout Slovakia. In accordance with the Accession Treaty, Government Decree 617/2004 establishing sensitive and vulnerable areas was issued.

The Accession Treaty, negotiated between the European Commission and the Slovak Republic, set up the following mandatory transition periods to comply with the Directive:

- **31 December 2004 for 83% of total biodegradable load**
- **31 December 2008 for 91% of total biodegradable load**
- **31 December 2010 for agglomerations over 10,000 P.E. (stringent treatment)**
- **31 December 2012 for 97% of total biodegradable load**
- **31 December 2015 for agglomerations between 2,000 - 10,000 P.E.**

There are no transitional periods for agglomerations under 2,000 P.E. in the Accession Treaty, which have adequate public waste water collection system without appropriate waste water treatment. Therefore, these agglomerations should comply with the Directive by 31 December 2005.

Requirements under Directive 91/271/EEC in accordance with the Accession Treaty are set out in §36 of the Water Act.

Under the provisions of §36 of the Water Act urban waste water generated in agglomerations has to be collected and properly treated only by a public collecting system. Only where the establishment of the collecting system requires excessive construction costs or it would not produce significant environmental benefits, it may be appropriate to use other suitable methods of urban waste water collection, which reaches the same level of water protection, as in case of waste water drainage by the public collecting system. This provision applies to all agglomerations irrespective of their size, i.e. also to small settlements under 2,000 P.E. which can be regarded as more stringent requirement as laid down in the Directive 91/271/EEC, which strictly requires the establishment of collection systems for urban waste water in agglomerations above 2,000 P.E.

According to provisions of §36 paragraph 3 of the Water Act, in agglomerations from 2,000 to 10,000 P.E. and in agglomerations under 2,000 P.E. with public collecting system without adequate treatment, urban waste water is discharged in accordance with paragraph 1 by 31 December 2015 and in agglomerations over 10,000 P.E. by 31 December 2010, as specified by the National Programme of the Slovak Republic for the implementation of Council Directive 91/271/EEC concerning urban waste water treatment as amended by the Commission Directive 98/15/EC and the European Parliament and Council Directive 1882/2003/EC (hereinafter referred to the National Programme). The National Program includes a list of over 356 agglomerations over 2,000 P.E., covered by the Directive 91/271/EEC. Until 1 November 2009 (before Water Act 384/2009 entered into force), it was necessary to ensure that urban waste water discharges are in line with the Plan for

Development of Public Drinking Water and Collecting Systems, which has a different definition of agglomerations, therefore, contains a different number and size of agglomerations as the National Programme.

According to §36 paragraph 4 of the Water Act, urban waste water before discharge into receiving waters must be subject to secondary treatment or an equivalent treatment that ensure pollution limits under normal weather conditions.

Limit values for indicators of pollution of urban waste water are listed in Annex 3 of the Government Decree 296/2005. Compared with the limit values laid down in the Directive 91/271/EEC, there are some differences in national legislation. Apart from limits values for 24 hour decanted samples ("p" value), the Government Decree provides limit values of a qualified point sample - 2 hour decanted sample ("m" value). The limit values for parameters such as BOD5, COD and suspended solids are differentiated by the size of agglomerations. The "p" values are lower than the values specified in the Directive while "m" values are higher or equal to the Directive limits. Generally it can be concluded that the limit values of pollution indicators in national legislation are more stringent than those set out in the relevant European Directive. In this case, national legislation is valid despite difference as a Member State may adopt more stringent limits.

Requirements for collection and treatment of urban waste water under the Directive 91/271/EEC under provisions of the Water Act, in accordance with the Accession Treaty and national programs, are also reflected in Slovakia's Water Plan, approved by Government Resolution 109/2010.

Act on Public Drinking Water Supply and Waster Water Collection Systems

The Act contains mostly technical requirements for the establishment and operation of public collecting systems and regulates rights and obligations of the owner and operator of public collecting system.

Provision §36 of the Water Act, establishing obligation of the Ministry of Environment to develop and approve Development Plan for Waste Water Collecting Systems for the Territory of the Slovak Republic (hereinafter the Development Plan), which includes the concept of collection and treatment of waste water, is important for the purpose of developing a framework proposal for waste water treatment in the stage of a study. In addition, Regional Environmental Authority has to prepare development plan for collecting systems in the territory of a region based on the Development Plan. Both planning documents are in line with Water Act background documents for the development of collecting systems.

Government Decree 119/2006 approved Plan for Development of Public Drinking Water Supply and Waster Water Collection Systems. Plans for development of collection systems for individual regions have not yet been published (Ministry of Environment had to approve them by 22 December 2009).

Regarding the list and the size of agglomerations covered by the Directive 91/271/EEC, there exist inconsistency between the Development Plan and the National Programme.

Obligations for local municipalities concerning public collecting systems are set out in § 36 Art. 7a. According to this paragraph local municipality provides conditions for collection or treatment of waste water by public collecting system from its citizens and others inhabitants in local municipality as well as conditions to empty content of cesspools in local municipality lacking public waste water collecting system.

Responsibilities of local municipalities in the area of waste water treatment are also defined by the Act 369/1990. According to §4 Art 3 chapter g) of this Act local municipality provides among other activities public services including waste water collection and waste water from cesspools.

3.1.3 Local legislation

Local legislation regarding urban waste water treatment has not been identified.

3.2 Definition of initial parameters for feasibility study on waste water treatment in Richnava village in terms of existing legislation

Definition of the initial parameters for waste water treatment is based on the following official planning documents of the Ministry of Environment:

- Development Plan for Public Drinking Water and Waste Water Collecting Systems, approved by the Government Decree 119/2006.
- National Programme of Slovakia for the implementation of Council Directive 91/271/EEC concerning urban waste water treatment as amended by Commission Directive 98/15/EC of the European Parliament and the Council and 1882/2003 EC (June 2008 and April 2007).
- Slovak Water Plan approved by the Government Decree 109/2010.

The basic parameter is the size of settlements. Size of Richnava agglomeration differs in the above mentioned documents. Under Waste Water Collecting Systems Development Plan, Richnava was part of Krompachy 'large agglomeration' with the size of 15,247 P.E. According to the National Programme from April 2007, Richnava agglomeration is listed separately with the size of 3,330 P.E. In Slovakia's Water Plan Richnava village was assigned into one agglomeration together with Kluknava totaling 3,330 P.E.

Given the above uncertainties, expert team sent a letter to the Ministry of Environment dated 21 December 2009 to clarify size of agglomeration. The response indicates that the relevant background document is the National Programme, according to which Richnava and Kluknava local municipalities form one agglomeration "Richnava", with the size of 3,330 P.E.

Another question concerned solution of specific feature of the agglomeration which is "illegal Roma settlement". Expert team asked two basic questions, namely:

- Is "illegal Roma settlement" population included into agglomeration Richnava?
- If so, then according to §36 Chapter 3 of the Water Act, waste water from this agglomeration shall be collected by public collecting system until 2015, however, it is not clear whether in this particular case "other appropriate methods of urban waste water collection" can be used.

Despite repeated requests, Ministry of Environment has not provided a clear answer to any of the above mentioned questions. Regarding the first question, Ministry of Environment recommended to use document "Terms and Definitions of the Urban Waste Water Treatment Directive (91/271/EEC)" and the criteria used in determining agglomerations in Slovakia in order to determine real size of the agglomeration. According to this criterion, city districts or parts of a local municipality within 500 meters from build up areas belong to an agglomeration. Relevant correspondence with the Ministry of Environment is in appendix of the study.

According to principles of the document “Terms and Definitions”, total amount of waste water in agglomeration consist of waste water produced by permanent residents plus waste water produced by temporary population (see chapter 1.3 of the document). Moreover, "illegal Roma settlement" is located within 500 meters from the build up area.

An analysis of legal aspects in the field of urban waste water treatment and guidance of the Ministry of Environment show that the "illegal Roma settlement" is a part of the Richnava agglomeration and therefore it should be included in the proposal of village waste water collection system.

Further response from the Ministry of Environment indicates that **Richnava and Kluknava municipalities waste water treatment and collection can be addressed separately, if it shows more suitable from environmental, technical and economic point of view.**

All of the above mentioned aspects have been considered in the design of technical alternatives for waste water treatment depending on number of citizens registered in Richnava village.

4. Idea proposal for waste water collection and treatment

Waste water treatment and collection is a relatively complex technology solution designed to prevent negative impact of waste water on the quality of surface water or groundwater. Therefore it is necessary to transport waste water to the place of its treatment when it will be treated. This, at a first glance very clear and straightforward task, has a number of alternatives from which to choose the right one has been for decades a major challenge even for experienced specialists in many professional areas. Choosing the right design and its implementation is extremely difficult and complicated, which often applies to its operation. This means that in addition to technical, economic and other environmental aspects also others have to be taken into account, synchronized and optimalized which in many cases makes solving a problem extremely difficult.

The text bellow briefly specifies basic principles of technical alternatives for waste water treatment and collection.

4.1 Characteristics of alternative ways of waste water collection and treatment

The overall technical objective of the whole collecting system is to collect waste water from households and industry and transport them together with rain water away from human settlements. There exist two basic types of collecting systems according to collecting different types of waste water: single and shared.

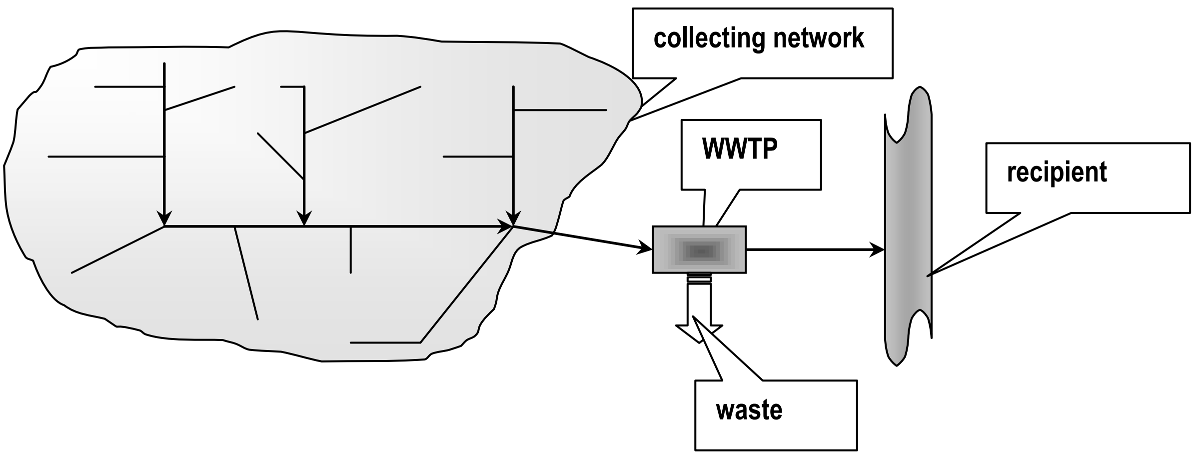
Single collecting network collects waste water from an area by a common sewage network. The various types of wastewater in the sewer network are blended together, which on the one hand, have a number of economic and technical advantages, but also significant technological disadvantages. Single collecting system is designed for the flow, which is equal to the sum of the flows of each type of waste water. Although the total flow of waste water in towns and villages is usually higher than the yearly balance of all types of waste water, the importance of rain water in a single collecting network is not negligible and plays an important role in design flows for waste water treatment plant. In economic terms, it is not necessary to treat entire volume of rain water, so the flow cross-sections of the single collecting network are designed for lower intensity rainfall and overflow chambers are constructed on interceptor in the vicinity of the recipient. Overflow chamber allows release part of waste water from the collecting network to the recipient, rainwater tanks, etc. after reaching a certain share of rain water. Main disadvantage of the single collecting network is that overflow chambers are in fact a direct link between the collecting network and the recipient. During torrential rains, additional and quite substantial amount of pollution reaches waster courses. Currently, there are several ways to reduce the impact of overflow on the recipient. Most promising in our conditions is inclusion of rainwater tanks or accumulation volumes in the network. However, even during rain water overflow, permitted indicators of pollution must not be exceeded.

Despite many advantages of the single collecting network, its construction for a small rural settlement such as Richnava is not economically viable. The volume of rainwater from the surrounding forest during intense rainfall would present a high hydraulic load to the collecting network as well as for waste water treatment plant, which is particularly unacceptable from an environmental point of view. Split collection of rainwater in rural areas is far easier to manage that in built up urban conditions where there is no possibility of a separate collection of rain water.

Split collecting network collects different types or groups of waste water separately. Split collecting network consists of several networks. Split collecting networks in towns and suburbs consist of two sewages often running under roads. One drains household and industrial waste water and other storm water. This, at least in theory, eliminates a direct impact of household and industrial wastewater on recipient. Collecting network draining rain water should contain a device to capture sediment and floating debris before reaching the recipient. The split collecting network is more expansive to build and operate than the single system. Its advantage compared with the single collecting system is that waste water treatment plant has is a more balanced load and collecting system in flat areas can be solved more efficiently. In practice, different combinations of single and split collecting systems are used, such as partially shared system with rainwater collecting network, partially shared system without rainwater collecting network, split system with pressure or vacuum network, etc. In terms of real use in Richnava conditions, construction of the split collecting network shows as optimal from the economic as well as construction point of view.

Generally, there are two basic collecting systems based on location and layout of sewage network and waste water treatment plant: centralized and decentralized.

Fig. 4.1 Components of the centralized sewage system (Author: Associate Professor Igor Bodík, PhD.)



Centralized sewerage system means collecting network draining waste water from households, small businesses, industrial plants and institutions, etc. and then transporting the water to central wastewater treatment plant, which is usually located on the outskirts of an area which is served by the collecting system (Fig. 4.1). Centralized solution is based on the collecting system which collects waste water into one waste water treatment plant with a single or split collecting network. This method, however, requires close supervision and monitoring by trained professionals.

The term **decentralized sewerage system** is also understood as collection and drainage of waste water, as well as its cleaning carried out in several waste water treatment plants closest its origin. In this case, waste water is collected and transported through system of pipes; however, sewers are incomparably shorter. Size, respectively capacity of waste water treatment plants is adapted to actually connected population in the vicinity of the waste water treatment plants, which significantly increases number of waste water treatment plants and reduces their capacity. Currently, the decentralized solution mainly uses facilities without flow - septic tanks, earth filters and home waste water treatment plant. Purified water does not necessarily be discharged into the recipient; and therefore, it is possible to consider its reuse (recycling) in aquatic environment (irrigation, use for other purposes than drinking water, infiltration, etc) after meeting appropriate conditions (especially protection of the environment and particularly groundwater) which are generally more stringent than for discharges into surface waters.

The degree of waste water collection system's decentralization depends on different aspects; however, the most prominent are density of population and landscape relief in a given area. Also, is it possible to build a semi-decentralized system where a certain area – a group of houses – presents a small decentralized subsystem, or respectively; totally decentralized system where each house has its own collection system and waste water treatment (home) plant.

Centralized and decentralized waste water collection systems exist and have been known for decades, however, decentralized system is rarely proposed. There are several reasons but the most crucial is that maintenance of the whole system consisting of several waste water treatment plants, although smaller, is problematic. Another usual argument is that construction and operation of a large number of small systems can be more expensive than the centralized system. These causes almost zero incentive for operating such a system. On the other hand, decentralized system can be more efficient in case of sparsely populated areas where waste water collection networks might be too long and their construction too expensive.

It is clear that the centralized system is more suitable, particularly in terms of the recipient protection, and it is highly probable that state administration (issuing permits) of the Slovak Republic would prefer it. Nevertheless, there are many areas in Slovakia (small settlements, villages, satellite settlements, etc), where application of the decentralized system is and will be more suitable. It is not possible to simply declare, without a proper analysis, which system is appropriate under a certain conditions. For this it is necessary to know many factors influence the final selection. The most important factors are:

- Population density of a given area both in terms of build up areas (distance of individual houses is important here), as well as number of inhabitants.
- Terrain relief of an area (flat slope relief, allowing only gravity waste water collection and intake into waste water treatment plant or complicated topography when it is necessary to draw the waste water into waste water treatment plant inlet).
- Presence, type, quality and watery of a recipient.
- Distance of waste water producers from the nearest collecting system.
- Financial potential of the population or a local municipality.

Only on the basis of an expert review as well as other factors specific to the given area, it is possible to determine whether construction of the centralized or decentralized waste water collections system is more suitable.

Table 4.1 indicates summary of the basic advantages and disadvantages of centralized and decentralized waste water collection system. It is obvious that other specific local conditions, often known only to the local inhabitants (e.g., sites of former and actually covered waste dumps or landfills, areas with frequent high levels of groundwater or areas prone to floods during rain, etc) need to be taken into account. Therefore, it is necessary to consider weight of individual advantages and disadvantages, because one disadvantage may outweigh the benefits of two or three advantages, not only financial but also operational or others.

Tab. 4.1 Comparison of the centralized and decentralized system in terms of selected characteristics

Centralized system	Decentralized system
The cost of waste water collection system are several times the actual cost of the waste water treatment plant	No high costs for waste water collection system
The basic network of collection system is usually necessary to build in frame of one large investment project	Waste water collection system of the village can be built gradually, individual houses or group of homes are not mutually dependent
Specific costs of a central wastewater treatment plant and its operational costs are lower	Specific costs for waste water treatment plant are higher
The bigger the waste water treatment plant, the operation can be more reliable with better cleaning effect and at the same time, its technology is easier to manage and control	Small and residential wastewater treatment plants are often not properly operated and they lack control of technology - the project of such a system should include a proposal to eliminate these disadvantages
In the case of a single collection system rainwater negatively affects the purification process. In case of a divided system, rain water is collected separately and a special storm drainage system is build.	Local municipality easier accepts the idea of decentralized rainwater solutions - local infiltration or use of rainwater on the local level
Treated waste water is usually discharged into the watercourse (river, stream)	Often there is a problem with the discharge of treated waste water, particularly in terms of groundwater protection requirements

4.2 Alternatives of waste water collection and treatment for Richnava village and their assessment

4.2.1 Centralized system

Table 4.2 shows basic population data in different municipalities of the agglomeration. There are more inhabitants living in Richnava (2,408) than in Kluknava (1,624) totaling up to 4,032 inhabitants. A table produced by Ministry of the Environment however gives a different figure (3,931) for both villages than the sum of their population. Also, it is obvious that the number of inhabitants in Richnava consists of 800 permanent residents (registered in the village) plus about 1,600 Roma, although officially registered, living illegally in the vicinity of Richnava and Kluknava villages in the Roma settlement (hereinafter the settlement) in the South of the Richnava village across the Main Road No 547 - see Figure 4.2

Tab. 4.2 Basic demographic population data in Richnava and Kluknava villages (Source: Ministry of Environment, 2008)

ID Statistical Area Units	Municipality name	Number of permanent inhabitants by 31.12.2008	Agglomeratio n code	Agglomeratio n name	Agglomeratio n size
543501	Richnava	2,408 (1,608 settlement + 800 village)	A8010648	Richnava	3,931

543233	Kluknava	1,624			

Note: There is a discrepancy in official data regarding size of the agglomeration, which according to communication with Ministry of the Environment, should be 3,330 P.E. This figure is given in Chapter 3.2 of the study. The same figure (3 330 P.E.) is also presented in Slovakia's Water Plan (Annex 4.1) which is an official document approved by the Government. Taking into consideration actual situation and results of the field trip, authors of the study decided using 3,931 P.E., which is also in line with actual data of the Statistical Office.

Following two main centralized waste water collection and drainage systems can be considered for Richnava municipality:

- Common centralized system for municipalities of Richnava and Kluknava
- Individual waste water treatment plant only for Richnava village

4.2.1.1 Common centralized waste water collection and treatment system for municipalities of Richnava and Kluknava

In terms of natural gravity of the whole area, construction of a common waste water collection and treatment system is probably more likely from economic and operational point of view, clearly showed in Figure 4.2. Proximity of the two villages is the main argument for a common waste water collection and treatment system. The common system is then more cost efficient in terms of construction and operation. So far, experience from Slovakia has shown that it is better to construct and run together particularly waste water treatment plant than two separate smaller systems.

Fig. 4.2 Overview of the agglomeration Richnava – Kluknava (Source: Google)

Defining quality and quantity of waste water for the entire agglomeration for the year 2040

Table 4.3 gives figures on actual and projected number of inhabitants in individual municipalities within the agglomeration, as well as average quantity and quality of waste water for the year 2040.

Despite the fact that the standard pollution level per capita is 60g BOD_5/per person/day, we can consider lower values for rural areas because when village is smaller then specific levels of pollutions are also lower. It is expected that in small village's people keep domestic animals, i.e. part of household waste is consumed by the animals rather than ending up in waste water. Also part of the population is active outside the village (commute to work and schools) and part of the pollution is therefore produced outside the village. We considered specific pollution load for Richnava village in the amount of 50g BOD_5/per person/day, 40 g BOD_5/per person/day for the settlement outside Richnava and Kluknava and 55g BOD_5/per person/day for the Kluknava village. In terms of flow, we assumed daily water production in the amount of 110 l/per person/day for the Richnava and Kluknava and 75 l/per person/day for the settlement. Based on these specific values, we defined daily waste water flow and its quality, shown in the table bellow:

Tab. 4.3 Basic demographic population data in Richnava and Kluknava villages for the year 2040

Local municipality	**Number of inhabitants**		**BOD5 (kg/day) 2040**	**Flow (m^3/day) 2040**
	Year 2010	Year 2040		
Richnava village	800	850	42.5	93.5
Richnava settlement	1,600	2,000	80.0	150.0
Kluknava	1,650	1,700	93.5	187.0
TOTAL	**4,050**	**4,550**	**216.0**	**430.5**

Data in the table are based on projections of future population growth and take into account expected increase by 2040 (in the opinion of the study authors). The result is that the capacity of reconstructed and extended waste water treatment plant Richnava-Kluknava is planned for the pollution load of 191 kg BOD_5 per day, which represents the value of 3,600 P.E. This means that basic parameters of waste water treatment plant Richnava-Kluknava and further technological calculations should take into consideration forecasted pollution load.

Waste water flows

Waste water discharge	430.0 m^3/day	5.0 l/s
Ballast water (10%)	43.0 m^3/day	0.5 l/s
TOTAL waste water	**473.0 m^3/day**	**5.5 l/s**

Q_{24m}	430 m^3/d	17.9 m^3/h	5.0 l/s
Q_b	43 m^3/d	1.8 m^3/h	0.5 l/s
Q_{24}	473 m^3/d	19.7 m^3/h	5.5 l/s

Q_d	624 m^3/d	26.0 m^3/h	7.2 l/s
Q_h		50.2 m^3/h	14.0 l/s
Q_{max}		50.2 m^3/h	14.0 l/s

Concentration and pollution load

Biochemical oxygen demand (BOD5)	456 mg/l	216.0 kg/day
Chemical oxygen demand (COD)cr	800 mg/l	378.2 kg/day
Suspended solids	350 mg/l	165.9 kg/day
N-NH4	55 mg/l	26.1 kg/day
Total nitrogen	70 mg/l	33.1 kg/day
Total phosphorus	10 mg/l	4.7 kg/day
P.E.	3,600	

Waste water collection

Transport of waste water from households into a centralized waste water treatment plant can be addressed in two basic ways:

Individual transport of waste water with sewage tank vehicles.

Individual transport of waste water would mean transport from places of its origin (houses, businesses and others) to the waste water treatment plant. In order to make this alternative work, approximately two sewage tank vehicles would need to be purchased or rented. Each house (or a group of houses) would need to have a storage tank at its disposal, to be regularly emptied (1-3 days interval). During longer intervals, stagnation of waste water in the storage tanks might occur, accompanied by unpleasant odor near the houses. Daily transport of about 400 m^3 of waste water would be quite challenging for several reasons:

- Permanent operation of waste water tank vehicles in municipalities (including weekends and holidays).
- A potential source of air pollution, accident and leakage of the tank.
- A need to construct accumulation tank in waste water treatment plant in order to store waste water transported by the tank vehicles.

Gravity collecting network

The standard solution for waste water transport is a gravity collection network which is an optimal solution for both municipalities. Total length of the collection network for Richnava is about 4,500 m and 6,300 m for Kluknava. Also, length of connections needs to be added to the overall length of the collection network.

In the case of the centralized network of waste water collection and treatment, rain water will be solved separately, outside the main collection system. Optimal solution would be surface drainage.

Common waste water treatment plant for Richnava and Kluknava

It is necessary to ensure adequate waste water treatment for 4,550 inhabitants in both villages. Taking into consideration requirements for quality of treated waste water according to the Government Decree 296/2005 and the amount of waste water, biological method is clearly reasonable. There are relatively large number of inhabitants, a large volume of waste water produced and finally a high level of water pollution. It would be extremely difficult to solve the amount of waste water with other treatment technology than biological activation. Using e.g. natural methods would require large areas and the result of treatment would be questionable.

In order to ensure proper waste water treatment as required by the Government Decree 296/2005 and on the basis of the above mentioned considerations, it is necessary to consider activation volume of approximately 900-1,000 m^3 and a sediment tank volume of about 400 m^3. Other necessary facilities needs to be planned as well (rough pretreatment, sludge processing, blowing plant, etc).

The proposed technology provides necessarily preconditions for such a concentration of selected parameters on runoff which comply with the limits set by the Government Decree 296/2005 for settlements under 10,000 P.E. according to the Annex 1 and 3 for sensitive areas. Treated waste water would be drained directly into the Hornád River.

The alternative of construction of the common waste water collection and treatment for Richnava and Kluknava villages is vulnerable in one parameter – connection of people living outside Richnava and Kluknava into the common system.

Consultation made so far as well as understanding of the current situation (as described in other chapters of the study) have clearly shown that at present we can not count with official and realistic connection of people living in the Roma settlement into waste water collection and treatment system. Therefore, the optimal solution is connecting only Richnava and Kluknava inhabitants to the network and solving the settlement in an alternative way with a connection to waste water collection and treatment network in the next 5-10 years (after solving legal issues, property rights and social relations the territory of today's settlement). In this case, it would be possible and optimal to implement such a technical solution which provides for two thirds of waste water treatment plant capacity immediately after the construction for inhabitants of Richnava and Kluknava. One third of the remaining capacity would be constructed after solving situation of the Roma by implementing state program for inclusion of marginalized population in Slovakia.

Temporarily, the Roma settlement would be solved as a decentralized area with specific way of waste water collection and treatment (see the chapter Decentralized solution).

Financial assessment of the alternative (rough estimate):

- Construction of the waste water collection network:

  Common network for Richnava and Kluknava villages – 2.8 million € - network length 10,800 meters

- Construction of waste water treatment plant for Richnava and Kluknava – 2 million €
- Waste water collection network operational costs 6,600 € per year
- Waste water treatment plant operational costs 12,000 € per year

4.2.1.2 Centralized waste water collection and treatment system for municipality of Richnava

Alternatively, we can consider separate waste water collection and treatment plant for Richnava village, independent of the solution for Kluknava. This might happen in case of disagreement between the two municipalities or respectively, if economic situation in one of the villages does not allow funding construction and operation of a common waste water collection network and treatment plant. This situation is indeed possible given relatively high financial burden which common investment imposes on both municipalities.

Fig. 4.3 Overview of Richnava village with the Roma settlement (Source: Google)

4.2.1.2.1 Defining quality and quantity of waste water separately for Richnava village for 2040

Table 4.4 gives figures on actual and projected number of inhabitants in Richnava village, and average quantity and quality of waste water for the year 2040 as estimated by study authors.

We considered specific pollution load for Richnava village in the amount of 50g BOD_5/per person/day and 40g BOD_5/per person/day for the settlement in Richnava. In terms of flow, we assumed daily water production in the amount of 110 l/per person/day for Richnava and 75 l/per person/day for the Roma settlement. Based on these specific values, we defined daily waste water flow and its quality, shown in the table bellow:

Tab.4.4 Estimated population, the quantity and quality of wastewater for the year 2040

Local municipality	**Number of inhabitants**		**BOD5 (kg/day) 2040**	**Flow (m^3/day) 2040**
	Year 2010	Year 2040		
Richnava village	800	850	42.5	93.5
Richnava settlement	1,600	2,000	80.0	150.0
SPOLU	**2,400**	**2,850**	**122.5**	**243.5**

Data in the table are based on assumptions of future population growth and take into account expected increase by 2040. The result is that the capacity of reconstructed and extended waste water treatment plant Richnava is planned for the pollution load of 122 kg BOD_5 per day, which represents the value of 2,050 P.E. This means that basic parameters of waste water treatment plant Richnava and further technological calculations should take into account forecasted pollution load.

Waste water flows

Waste water discharge			243.5 m^3/day	2.8 l/s
Ballast water (10%)			24.4 m^3/day	0.3 l/s
TOTAL waste water			**268.0 m^3/day**	**3.1 l/s**
Q_{24m}	244	m^3/d	10.1 m^3/h	2.8 l/s
Q_b	24	m^3/d	1.8 m^3/h	0.3 l/s
Q_{24}	268	m^3/d	11.2 m^3/h	3.1 l/s
Q_d	353	m^3/d	14.7 m^3/h	4.1 l/s
Q_h			28.4 m3/h	7.9 l/s
Q_{max}			28.4 m^3/h	7.9 l/s

Concentration and pollution load

Biochemical oxygen demand (BOD5)	456 mg/l	122.5 kg/day
Chemical oxygen demand (COD)cr	800 mg/l	214.3 kg/day
Suspended solids	350 mg/l	93.7 kg/day
N-NH4	55 mg/l	14.7 kg/day
Total nitrogen	70 mg/l	18.7 kg/day
Total phosphorus	10 mg/l	2.7 kg/day
P.E.	2,050	

4.2.1.2.2 Waste water collection

Similarly to the previous alternative, transport of waste water from households into a centralized waste water treatment plant can be addressed in principle in two basic ways:

Individual transport of waste water with sewage tank vehicles.

Individual transport of waste water would mean transport from places of its origin (houses, businesses and others) to the waste water treatment plant. In order to make this alternative work, approximately one sewage tank vehicle would need to be purchased or rented. Each house (or a group of houses) would need to have a storage tank at its disposal, to be regularly emptied (1-3 days interval). During longer intervals, stagnation of waste water in the storage tanks might occur, accompanied by unpleasant odor near the houses. Daily transport of about 270 m^3 of waste water would be quite challenging from the several reasons:

- Permanent operation of the waste water tank vehicles in municipalities (including weekends and holidays).
- A potential source of air pollution, accident and leakage of the tank.
- A need to construct accumulation tank in waste water treatment plant in order to store waste water transported by the tank vehicles.

Gravity collecting network

The standard solution for waste water transport is a gravity collection network which is an optimal solution for the municipality a given conditions. Total length of the collection network for Richnava village is about 4,500 m plus length of necessary connections.

4.2.1.3 Individual waste water treatment plant for Richnava village

It is necessary to ensure adequate waste water treatment for 2,850 inhabitants in Richnava village. Taking into consideration requirements for quality of treated waste water according to the Government Decree 296/2005, and the amount of waste water, **biological method of treatment with active system clearly shows as appropiate**.

In order to ensure proper waste water treatment as required by the Government Decree 296/2005, it is necessary to consider activation volume of approximately 500-600 m^3 and a sediment tank volume of about 200 m^3. Other necessary facilities needs to be planned as well (rough pretreatment, sludge processing, blowing plant, etc).

The proposed technology provides necessarily preconditions for such a concentration of selected parameters on runoff which comply with the limits set by the Government Decree 296/2005 for settlements under 10,000 P.E. according to Annex 1 and 3 for sensitive areas. Treated waste water would be drained directly into the Hornád River.

Similarly to the previous alternative, construction of the waste water collection and treatment system for Richnava village is vulnerable in one parameter – connection of people living in the Roma settlement in Richnava into waste water collection network.

Consultations have done so far as well as understanding of the current situation (as described in other chapters of the study) have clearly shown that at present we can not count with official and realistic connection of people living in the settlement into waste water collection and treatment system. Therefore, the optimal solution is connecting only Richnava inhabitants to the network and solving the settlement in an alternative way with a connection to waste water collection and treatment network in the next 5-10 years after clearing out legal issues and property rights in the territory of today's settlement. In this case, it would be possible to implement such technical solution which provides for half of waste water treatment plant capacity immediately after the construction for inhabitants of Richnava, while the second half would be constructed after inhabitants of the settlement connect into the network. In the meanwhile, Roma settlement would be temporary solved as a decentralized area with a specific waste water collection and treatment (see chapter on decentralized solutions).

Financial assessment of the alternative (rough estimate):

- Construction of waste water collection network:

  Richnava village only – 1.2 million € - network length 4,500 meters
- Construction of waste water treatment plant Richnava – 1.3 million €
- Waste water collection network operational costs 5,000 € per year
- Waste water treatment plant operational costs 9,000 € per year

4.2.1.4 Individual reed bed waste water treatment plant for Richnava village without Roma settlement

In case that connection of the Roma settlement into the village waste water treatment system is not foreseen in the future, we could consider construction of a different kind of waste water biological treatment for 850 inhabitants, e.g. reed bed waste water treatment plant. Planned area of the reed bed plant is about 5-10 m^2/per inhabitant. This means that there should be available around 4,000-8,500 m^2 of land for reed bed plant proper plus additional area for mechanical pretreatment (pumping station, screenings) and other operations associated with operation of this type of the treatment plant. It is clear that the construction and operation of this kind of treatment plant is less expensive than the standard biological level with activation.

Note: Roma settlement would be solved separately; the proposals are described in other parts of the study.

Financial assessment of the alternative with reed bed waste water treatment plant (rough estimate):

- Construction of waste water collection network:

  Only for Richnava village (without Roma settlement) - 1.0 million € - network length 3,500 meters

- Construction of reed bed waste water treatment plant Richnava - 0.5 million €
- Waste water collection network operational costs 3,000 € per year
- Reed bed waste water treatment plant operational costs 2,000 € per year

4.2.2 Decentralized system

Basic principles of a decentralized system, its comparison, advantages and disadvantages have been already presented in previous text. Below is a proposal of the decentralized system taking into consideration conditions in Richnava village and the nearby Roma settlement.

4.2.2.1 Decentralized system in Richnava village

Figures 3.4 and 4.4 clearly show that Richnava village is relatively compact in terms of its build up area, without eccentric or separate parts. Residential houses are stretch along local roads in relatively compact build up areas. The whole village is made up of one major stretch, consisting of the main street with two parallel side streets on both sides, cross-linked in some places.

Roma settlement in Richnava village is situated outside the village about 500 meters away from the village boundaries, behind Hornád River, which is indeed significant and positive factor for a proposal of alternative system of waste water collection and treatment. In terms of the settlement built up area, it is a separate “urban unit”, which should be taken into account when designing and implementing complex sanitation infrastructure, including drinking water supply. Existence of the Hornád River and the Main Road No 547 makes a common solution for both parts of the village economically and technically unreasonable and unrealistic.

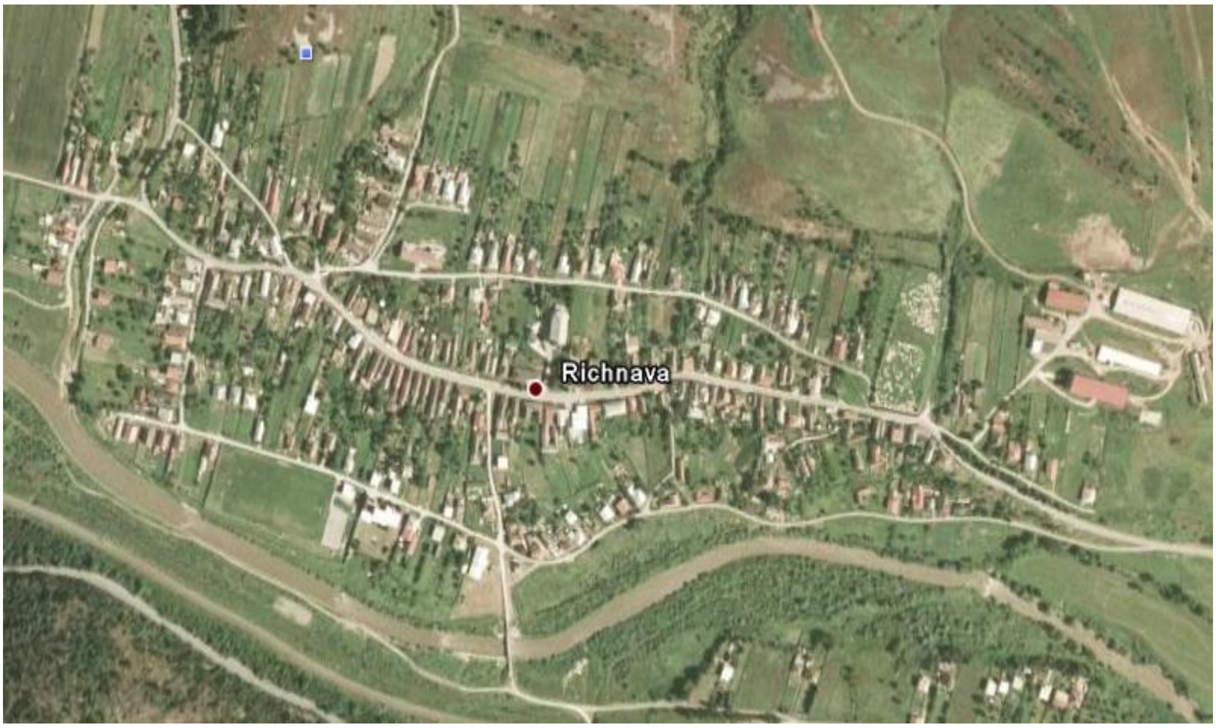


Fig. 4.4 View of Richnava village (Source: Google)

For this reason, main decentralization line in Richnava area dividing the village and the Roma settlement is a natural boundary formed by the Hornád River and the Main Road. In many ways (presented in other chapters of the study) is necessary to consider split of sanitation systems for the village and the Roma settlement.

4.2.2.2 Totally decentralized system of waste water collection and treatment in the village

<u>For each house separately</u>

Completely decentralized system of sanitation for Richnava, consisting of waste water treatment plants for each house separately, would require approximately 250-300 home waste water treatment plants, saving costs of the collecting system, but on the other hand, operation of 250-300 home waste water treatment plant would be technically almost impossible. An important aspect is quality of treated water and a method of its drainage into the recipient. The problem would be infiltration of treated waste water into the ground in order to protect groundwater quality, which is actually a source of drinking water for the entire village. Private wells are according to local municipality officials a priority for its population. Loose drainage of treated waste water into "storm" collection network is not an ideal solution from hygiene, environmental and legislative point of view. In this case it would be necessary to build collection system for treated waste water and its common drainage in the Hornád River. Overall, this solution can not be considered as appropriate for Richnava conditions. One waste water treatment plant costs around 1,500 € (including quantity discount), a total of 250 waste water treatment plants would cost 0.375 million € and 300 waste water treatment plants about 0.450 million €. Residents of the village would operate waste water treatment plants on their own.

Group alternative of the full decentralization

In the case of the full decentralization of sanitation systems within Richnava boundaries (without Roma settlements) construction and operation of a group of home waste water treatment plants can be considered, each for a maximum of 10-50 people. It would mean about 20-60 separate treatment plants with capacity of 10-50 P.E. The advantage of such a system is that it does not require a full collection system for the entire village, however, a "small" sewage for a group of 2-20 houses would be needed. Length of the collection system would be significantly reduced, nevertheless, it is still necessary. To a smaller extent, apply all the considerations and arguments that were used in the previous alternatives. This solution is workable despite complex maintenance and operation of the whole system and possible problems related to permitting process for each group of houses separately.

One group waste water treatment plant would cost around 10,000 € (including quantity discount), which means 0.2 million € for a total of 20 waste water treatment plants and about 0.6 million € for 60 waste water treatment plants. Residents of the village would operate these waste water treatment plants on their own.

Some form of decentralization is also possible in case when the entire village is split into two separate systems: the municipality itself, without the Roma settlement and the Roma settlement itself. Alternatives for collection and treatment of waste water in local municipality have been described in previous chapters of the study. **The following text describes alternatives for collection and treatment of waste water exclusively for the Roma settlement.**

4.2.2.3 Decentralized system in the Roma settlement near Richnava

Analysis of the state of sanitation in the Roma settlement

Waste water treatment from the Roma settlement is a complex issue, closely linked to the problem of housing in this location and its illegal settlement, which has a poor standard and does not meet even the lowest acceptable living conditions in the EU. Obsolete and poor houses lack a direct connection to drinking water, waste water network and in most cases, electricity. Because of all these reasons individual houses and the settlement as a whole do not meet basic hygiene requirements. Objects are manually supplied with water from two wells. There are only dry toilets directly at homes, or in some cases, dry outdoor toilets for a group of houses. Some houses are connected to cesspits or septic tanks that drain into the rain ditch, located along the panel road that stretches along the entire village. The decisive factors for the selection of solutions and technologies for this settlement are built up area compactness and density as well as high height differences between different parts of the settlement caused by relatively large and rapidly changing terrain gradient.

A possible solution of the waste water collection and treatment can range from a fully decentralized system for each house separately, to a centralized system for the entire village with actual capacity of 1,600 P.E and the projected capacity of 2,000 P.E for the year 2040. Prospective figure for 2040 is only theoretical, because the situation of the Roma should already be resolved outside the current settlement. Different waste water treatment technologies can be applied such as traditional centralized activation, extensive semi-decentralized or alternative solutions consisting of composting toilets. Extensive waste water treatment uses multiple levels of biological treatment similar to natural filtration processes for already pre-treated water. Because we considered future water consumption in the settlement is the amount of 75 l/per person/day, it is possible to reduce area needed for waste water treatment plant construction by 30-40% in comparison to an area normally required for e.g. reed bed waste water plant 5 m^2/per person, natural filter 2 m^2/per person and a stabilization tank 5-7 m^2/per person.

According to existing legislation, all residential buildings (except one) are illegally built on unsettled land belonging to different land owners. In order to solve any waste water treatment system (including its implementation) legally, it is necessary to obtain construction permit and then water construction permit. Before obtaining necessary permits it is necessary to obtain consent of landowners, also referring to all illegal structures that are built on their land.

Approximate number of 2,000 P.E. connected to waste waster collection network presents quite large load of waste water. In municipalities over 1,000 P.E., biological activation is recommended. Therefore, extensive waste water treatment is suitable only after split of the settlement, i.e. decentralization into at least two or more separate zones with a proper level of waste water treatment.

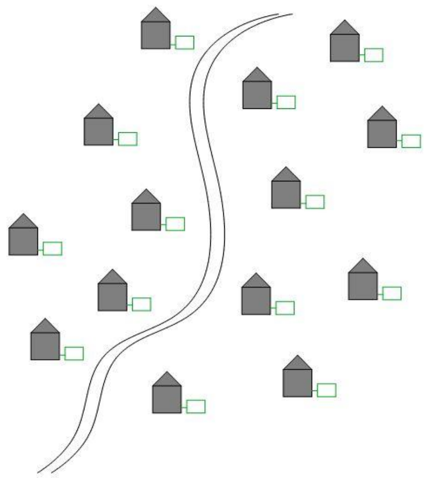
Calculations of water consumption have been based on the assumption that households use flush toilets with water consumption of 3-6 liters in one flush. Flush toilettes are not currently used in the settlement, where exist only dry toilets, located outside houses. There are two common wells from which households manually supply water in buckets and barrels. Water consumption per person is then reduced to a level of 40 l/per person/day, due to lack of baths, showers and wash basins in many houses. Therefore, it would advantageous to divide black waste water (water from toilets) and gray water (water from bathrooms and kitchens); in order to reduce financial demands on the volume of treated waste water and type of waste water treatment technologies. Therefore, we propose composting process for black water or possible separation of yellow water (urine) using special toilets where the urine is collected into a separate tank, from which, after filling up the tank, pumped and transported to be used for irrigation purposed in agriculture. Gray water may be treated in reed bed waste water treatment plant, natural filters or stabilization ponds.

It is appropriate to consider the following alternatives for the Roma settlement:

4.2.2.3.1 Total decentralization

Total decentralization means to provide waste water treatment for each housing unit (shack) separately. This alternative takes into account some equipment existing at each household, i.e. dry toilet as a minimum. It also corresponds to the actual situation when houses lack water brought by pipeline. However, it is necessary to divert gray water from the kitchen, eventually from the shower, wash-basin or bath tub. Since there are living about 50 to 20 people in a single household who change continuously, it is necessary to design a solution which is resistant to high fluctuation in waste water treatment plant affluent. In this case, the black and gray water is treated together or a split system of gray and black water will be installed, which reduces amount of waste water and simplify treatment technology. With this method and capacity of water, treated water can drain into drainage area around waste water treatment plant and therefore, save significant costs in comparison with alternative which drains treated water into the recipient. Even better solution would be to compost black water with the use of a composting toilet, thus eliminating costly treatment of black water. This leaves only considerably reduced amounts of gray water, which is then drained e.g. into a root field, followed by a drainage soak pit. This alternative eliminates collection of treated waste water into a common collector which would have to be kept underneath the main road No. 547 with drainage into the Hornád River, located about 350 meters from boundaries of the Roma settlement.

Total decentralization scheme (Author: M. Arch. Róbert Zvara):



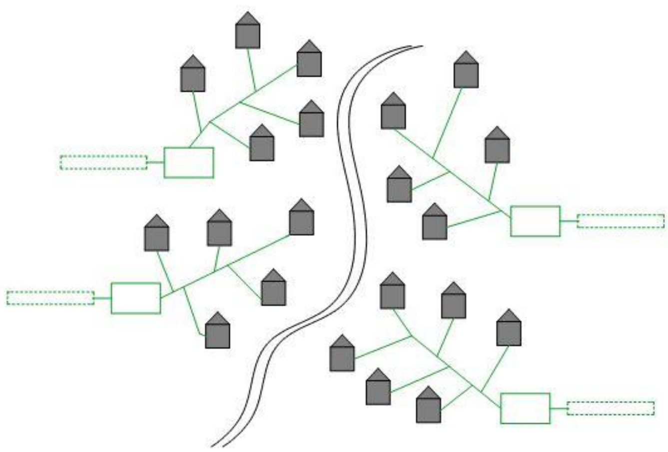
Financial assessment of the alternative (rough estimate):

- Construction of individual household reed bed waste water treatment plants - 0.3 million €
- Construction and installation of composting toilets - 0.3 million €
- Reed bed waste water treatment plants operational costs 4,000 € per year

4.2.2.3.2 Cluster (group) system

It is proposed to collect waste water from a group of 3-6 homes (according to location, altitude and number of P.E.) into one septic tank, followed by a root field or sand filter and the final drainage. This system also allows separating black water, which can be treated locally for each home, and collect gray water from 50-10 homes to treat it with above mentioned way. The group system with joint black and gray water alternative can use existing cesspits and septic tanks. After their reconstruction, they can serve as a first biological step for pretreatment of waste water. Treated water can be either collected into a common collector of the sewage system, drained into fields planted with fast growing willows or drained into a nearby forest.

Cluster (group) system scheme (Author: M. Arch. Róbert Zvara):



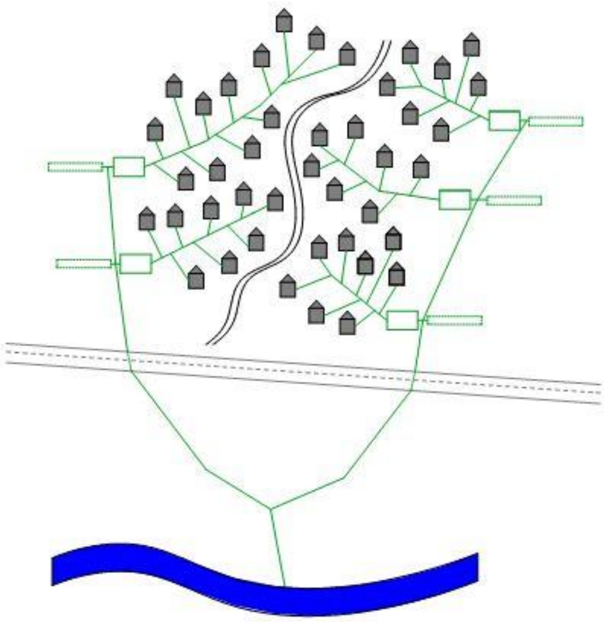
Financial assessment of the alternative (rough estimate):

- Construction of waste water collection network: 0.2 million €, length of the network approximately 800 meters
- Construction of pre-treatment and reed bed waste water treatment plants as well as modification of existing septic tanks and cesspools 0.55 million €
- Construction of drainage soaking pits with drainage - 0.15 million €
- Waste water collection network operational costs 1,000 € per year
- Reed bed waste water treatment plants operational costs 3,000 € per year

4.2.2.3.3 Semi-decentralization I

This alternative expects construction of five extensive waste water treatment plants with a capacity of 300 to 400 P.E. (under condition that households are supplied with water through pipes and equipped with flush toilet). Each wastewater treatment plant will be set up as a field planted with fast-growing willows, similar to reed bed waste water treatment plants with emergency sink into the recipient. This option can be implemented only after households are connected to water supply system through pipes. The fields would be located along and near the settlement on both sides. Waste water would run down to the fields by gravity, infiltrate into soil or drain into the surrounding forest. The advantage of this option is that it fits well into uneven terrain; more water can be recycled for irrigation and less drained into the recipient.

Semi-decentralization scheme (Author: M. Arch. Róbert Zvara):



Financial assessment of the alternative (rough estimate):

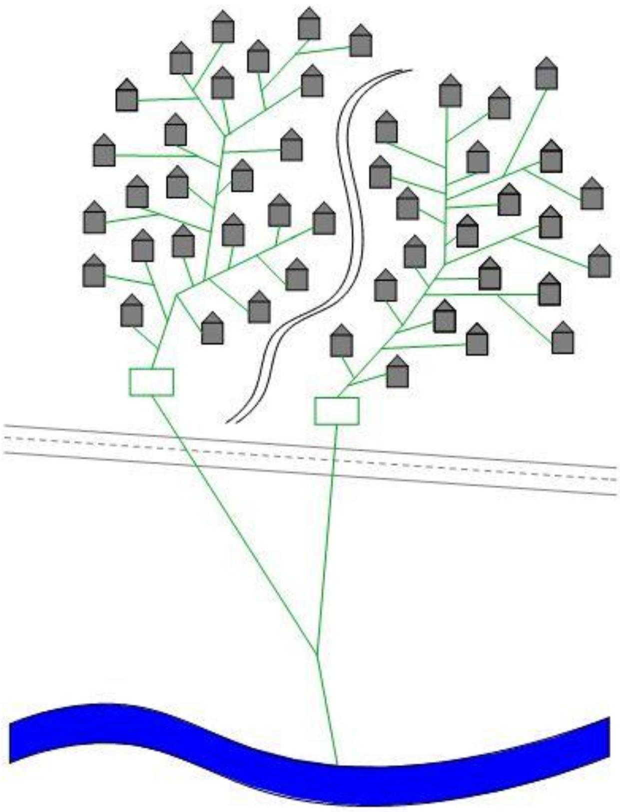
- Construction of waste water collection network: 0.5 million € - length of the network 2,000 meters
- Construction of reed bed waste water treatment plant Richnava - 0.5 million €
- Waste water collection network operational costs 2,500 € per year

- Reed bed waste water treatment plants operational costs 2,000 € per year

4.2.2.3.4 Semi-decentralization II

In this alternative, the area will be divided between two extensive waste water treatment plants with capacity 800 to 1,000 P.E. (under condition that households are supplied with water through pipes and equipped with flush toilets). The system allows construction of stabilization ponds or root fields. It requires drainage of treated water to the nearest recipient, which in this case means construction and maintenance of the collection system in the length of 350 meters, crossing under the Main Road No 547 through unsettled land and finally ending up in the Hornád River.

Semi-decentralization scheme (Author: M. Arch. Róbert Zvara):



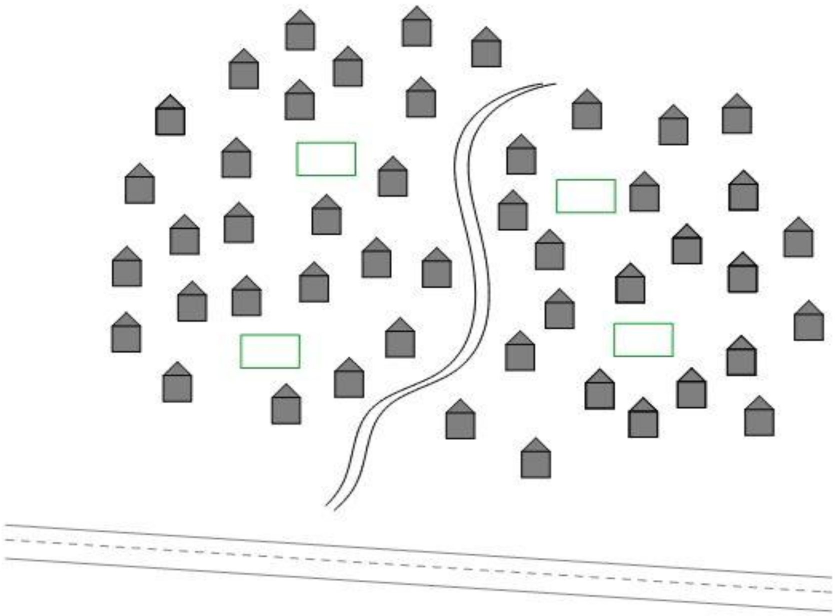
Financial assessment of the alternative (rough estimate):

- Construction of waste water collection network: 0.5 million € - length of the network 2,000 meters
- Construction of waste water treatment plant 0.4 million €
- Waste water collection network operational costs 3,000 € per year
- Reed bed waste water treatment plant operational costs 1,800 € per year

4.2.2.3.5 Semi-decentralization III (composting)

This alternative presents installation of common toilets for the community, i.e. 4 composting units, each with five toilet bowls and two urinals. Units can be supplied with water from wells and equipped with wash basins and eventually showers. Grey water from households and from 4 units would be drained through a root field and then left to infiltrate in the drainage. This option addresses existing situation of low standard housing and requires minimum intervention into existing system. It improves health conditions and does not require financially and operationally costly collector within waste water collecting system.

Semi-decentralization scheme – composting (Author: M. Arch. Róbert Zvara):



Financial assessment of the alternative (rough estimate):

- Construction of composting units and reed bed waste water treatment plants: 0.15 million €
- Composting units operational costs 5,000 € per year
- Household reed bed waste water treatment operational costs 3,000 € per year

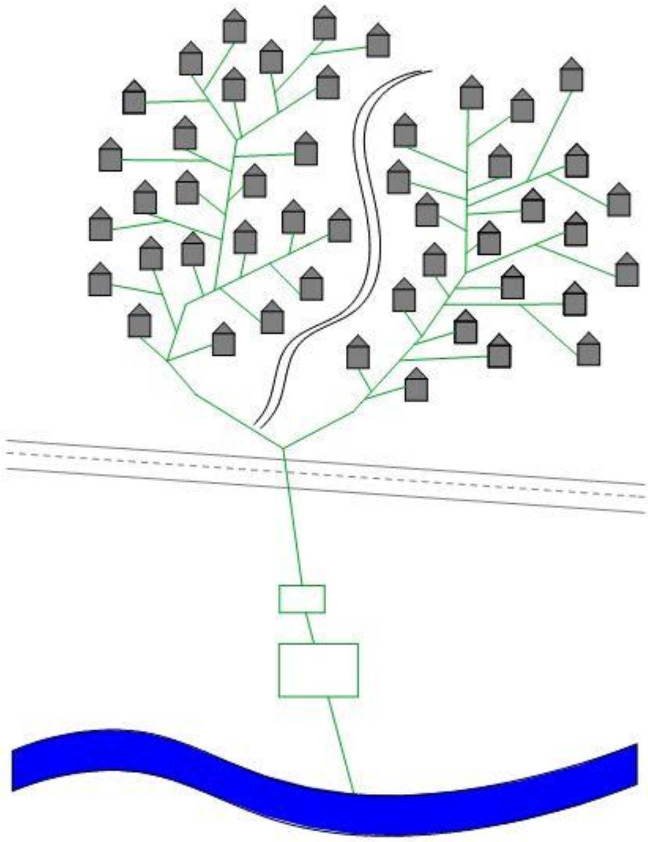
4.2.2.3.6 Centralization (in frame of decentralization of the village and Roma settlement)

This alternative seeks to build waste water collecting system and its connection to one waste water treatment plant. In this case, households are expected to connect into public drinking water supply and their household equipment is expected to upgrade into standard of majority population in Slovakia. Subject to maintaining existing status of the population in the Roma settlement, the water treatment plant will be designed for 1,000 P.E.

Because the settlement is compact and as a whole densely built up on a relatively small area with a large vertical elevation, it has suitable conditions for gravity collecting network. It should cross under the Main Road and end up behind it where exists a space for installation of waste water treatment plant with drainage into the recipient.

Note: This is only a theoretical option, because in the long run, which is a prerequisite for a centralized waste water treatment system, the Roma settlement does not have a perspective in the locality. Over the next few years, it should be gradually closed out and its citizens will be included in the majority population of Slovakia.

Centralization scheme (Author: M. Arch. Róbert Zvara):



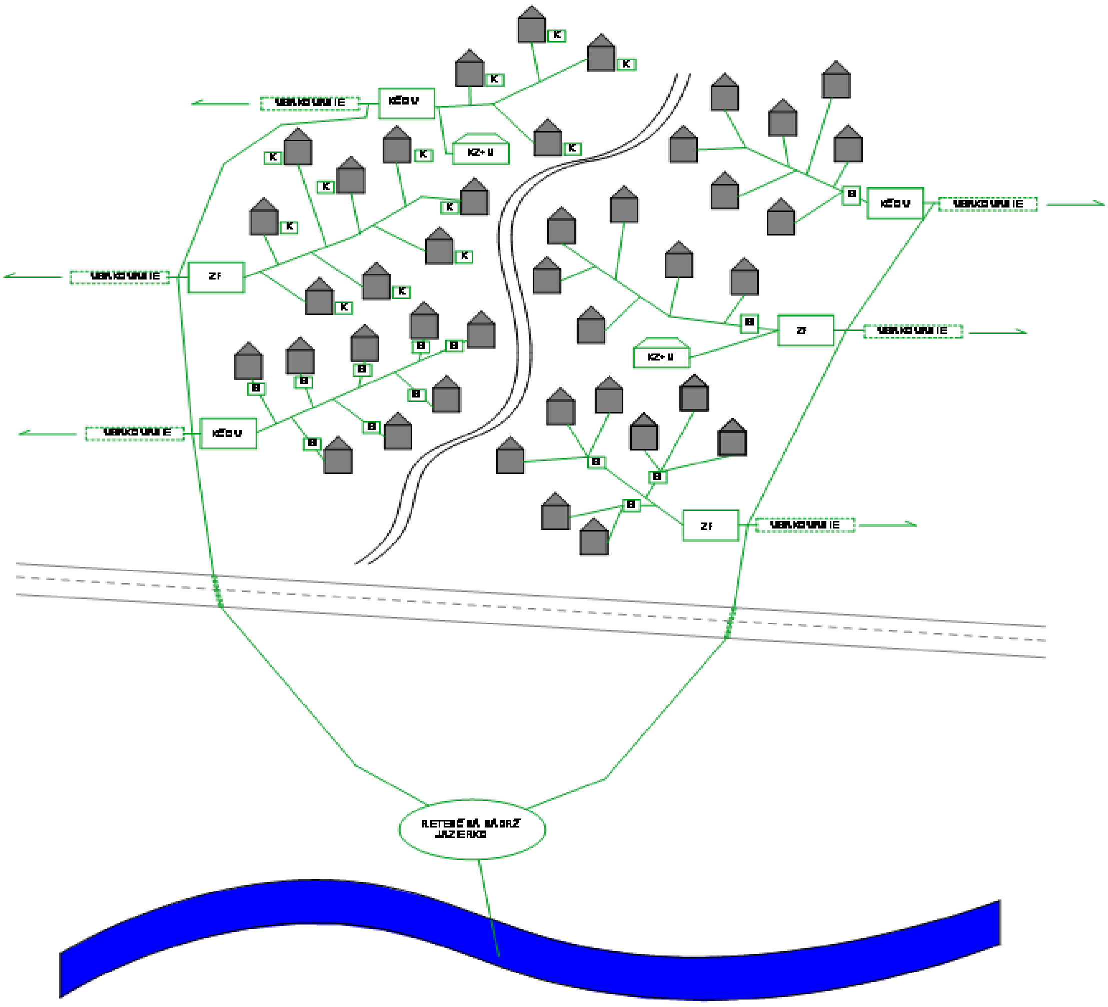
Financial assessment of the alternative (rough estimate):

- Construction of waste water collection network: 0.45 million € - length of the network 2,000 meters
- Construction of waste water treatment plant 0.6 million €
- Waste water collection network operational costs 3,000 € per year
- Waste water treatment plant operational costs 6,000 € per year

4.2.2.3.7 Combined system

The combined system decentralize the area into 5-6 individually solved zones, each of which is proposed for other extensive treatment of waste water and takes over a combination of all previous technologies (except centralization). This solution offers the possibility of using more sustainable and effective technologies in practice, as well as their testing. The combination of technologies enables flexible and optimal installation from the point of potential use of the technology in a challenging terrain. This model could serve as a pilot project for use and testing extensive technology in demanding environmental conditions and as a model project for sustainable sanitation solution for small and medium-sized communities with a significant proportion of marginal groups within rural population.

Combined system scheme (Author: M. Arch. Róbert Zvara):



Legend:

S Three-chamber septic tank – the first stage treatment
K Composting
ZF Natural filter - the second stage treatment
KČOV Root field - the second stage treatment
KZ+U Composting toilettes + wash-basins – composting units
VSAKOVANIE (DRAINAGE) Drainage field, planted with e.g. fast-growing willow
RETENCNA NADRZ – JAZIERKO (RETENTION RESERVIOR – POOL) For rainwater and overflow from individual water treatment plants during maximum load caused by extreme flows to the waste water treatment plant

Financial assessment of the alternative (rough estimate):

- Construction of waste water collection network: 0.40 million € - length of the network approximately 2,000 meters
- Construction of waste water treatment plant 0.55 million €
- Waste water collection network operational costs 2,000 € per year
- Waste water treatment plant operational costs 4,000 € per year

5 Financing options for waste water collection and treatment project

Currently, main financial sources for the project of waste water treatment plant and collection can come from:

- Own resources
- Credits
- EU funds - Operational Programme Environment for the programming period 2007 – 2013
- State Environmental Fund
- Funds of advanced “old” Europan Union and Europan Economic Area (EEA) member states to support new Member States in catching up with more developed EU Member States.

5.1 Own resources and credits

Financing from own sources is not realistic given limited potential of Richnava village to gather sufficient funds primarily for the investment part of any system of waste water treatment and collection. The same applies to loans which Richnava local municipality can not finance on its own.

5.2 Operational Programme Environment for 2007 - 2013

According to program manual of the **Operational Programme Environment for the programming period 2007-2013**, water management sector can be supported by funding water protection projects which relate to fulfillment of responsibilities of the country, negotiated during European Union accession process. Financial subsidy can be awarded in the **Priority axis 1 - Integrated Protection and Rational Use of Water** under which eligible activities are projects for collection and urban waste water treatment introduced in the operational objective **1.2 - Collection and treatment of urban waste water according to obligations towards the EU**, i.e. activities to support building and extension of collection and waste water treatment plants.

In order to achieve operational objective 1.2 (according to its focus) of the program manual, eligible activities are classified into four groups (in line with agglomeration size) under the **National Programme of Slovakia for the Implementation of Council Directive 91/271/EEC, which is based on the Plan for Development of Public Drinking Water and Collecting Systems for the Slovak Republic, development plans of individual regions, river basin management plans and the Slovak Water Plan.**

Agglomeration Richnava together with Kluknava falls into agglomeration category IV which includes construction, extension and increase the capacity of waste water treatment and collection system **in agglomerations from 2,000 to 10,000 P.E.** The same applies to alternative of the Richnava village with the Roma settlement.

General principles of eligibility

- The starting point for determining eligibility is Article 56 of the Council Regulation (EC) 1083/2006 of 11 July 2006 laying down general provisions on the European Regional Development Fund, European Social Fund and Cohesion Fund.
- Time frame for eligibility of expenses is determined in a way that expenses incurred during the period of 1 January 2007 - 31 December 2015 are considered eligible.
- Minimum and maximum duration of the project has not been specified.
- Minimum amount of awarded financial subsidy to the project has not been specified.
- Maximum amount of awarded financial subsidy to the project is contingent indicative financial allocation to the given operational objective and will be further clarified in a call for projects.
- Eligible expenses in relation to the activities supported by the Operational Programme Environment overall, and within its individual priority axes or operational objectives are set out further and in more detail in Guidelines of Managing Authority concerning eligibility of the expenses for the Operational Programme Environment.

Procedure for obtaining financial subsidy and its amount is set out in state aid scheme. Under financing strategy for the period of 2007-2013, local municipalities as eligible recipients can receive 85% of total eligible costs from the EU and national public funds and 15% from internal resources. In case of Operational Programme Environment, the applicant (local municipality) receives 95% co-financing from the EU and national funds while the rest 5% is coming from their own sources.

For more information on the Operational Programme Environment for the programming period 2007-2013, please visit www.opzp.sk.

5.3 State Environmental Fund

Act 587/2004 on Environmental Fund and amending certain laws, as amended, was adopted in 2004 and came into force on 1 January 2005. This Act has established the Environmental Fund as a state fund for implementation of state environmental protection to support activities focused on achieving objectives of the state environmental policy at national, regional or local levels.

According to §4 of the above mentioned Act, resources of the fund may be provided and used to:

a) **Promote activities focused on achieving objectives of the state environmental policy at national, regional or local level.**

b) Support survey, research and development focused on identification of environmental problems and improvement of the state of environment.

c) Promote environmental education, training and awareness rising.

d) Support to solving extremely serious environmental situation.

e) Support to elimination of accident relief[10] and significant deterioration of water quality or extraordinary threat to water quality[11] threatening or damaging the environment (hereafter referred to as the “accident”).

f) Management of the fund (§ 2 Art. 1).

g) Levy of tax revenues in respective financial year.

h) Cover the costs of public service under the decision of Minister of the Environment.

Provision and use of the Environment Fund resources shall be in accordance with the priorities and objectives of the State Environmental Policy approved by the Government of the Slovak Republic

Under §6 of the above mentioned Act, the beneficiary can be:

a) A natural person who is a citizen of the Slovak Republic, has a permanent residence in the Slovak Republic, reached 18 years and has a regular income, and/or

b) A legal entity and a natural person-entrepreneur based in the Slovak Republic.

Provision of the Environment Fund funding is done through support in the form of a grant or a loan.

Under §8 of the above mentioned Act, an applicant who is a legal person that does not run a business, local municipality, self-governmental region, subsidized organization, civic association, association of interest legal persons, foundation, non-investment fund or a non-profit organization providing public services for environment or church and religious organization, can request support under §4 Art 1 a) and d) in the form of loans or grants, including a combination of these types of support and according to §4 Art 1 b) and c) only in the form of subsidies.

5.4 Support funds of advanced EU member states

Funding may change if it appears that it is more appropriate and rational to divide Richnava municipality into the village itself and the Roma settlement. If “legal issues” of the Roma settlement are temporarily solved, likelihood of obtaining subsidy for its waste water treatment and collection system by extensive cleaning methods will have relatively high chance for success. In such cases it’s possible to consider particularly support from the "old" Europan Union and European Economic Area member states, such as Switzerland, Federal Republic of Germany and Norway.

In general, however, the legal person such as Richnava village may request support or subsidy from the national or international funds only if the project for waste water treatment and collection is ready. In this respect the choice of alternatives (or combination of alternatives) from those listed in the feasibility study and subsequent project development, is crucial to the financing and implementation of any waste water treatment and collection system in Richnava.

6 Conclusions and recommendations

"Study of alternative solutions for waste water treatment in Richnava local municipality" contains chapters, primarily focused on the analysis of pollution sources, legal issues and a proposal of waste water treatment and collecting alternatives. The study describes and assesses 13 real alternatives that are workable from technical point of view. Their economic assessment is however, only approximate and may vary significantly from calculation of investment and operating costs in a detailed project, which should be developed on the basis of this study, and finally selected by local municipality. Therefore, economic analysis in the study serves only for comparison between different alternatives that indeed are sufficient for the level of study, because costs were calculated by the same methodology based on known unit prices for various technologies. This applies to alternatives, as well as extensive waste water treatment systems.

One of the uncertainties is existence of illegal Roma settlement which must be in accordance with existing legislation taken into account when dealing with waste water collection and treatment in the village. Roma in the village are officially registered in the Richnava and although they in fact have homeless status, they are citizens living in the area. Therefore, they have to be included into numbers of population producing waste water. A particular feature of these homeless people is that there are whole families - children, adults and elderly. Moreover, homeless population is twice as big as the population of Richnava village. It is clear that the problem of the Roma can not be solved immediately, however, their living conditions can not be considered as a final. For a number of reasons (human rights, the possibility of epidemics, which may spread further into neighboring settlements, inappropriate location for permanent settlement, etc.) a temporary but effective solutions how to help Roma must be sought. If any of the proposed alternatives for the Roma settlement is implemented, it is essential to involve local municipality leadership and government bodies that have to find solutions together.

Implementation of a national program addressing inclusion of Roma population in Slovakia, to which unfortunately authors did not have access to, may significantly influence thoughts presented in the study. In order to make decisions in the future, Richnava local municipality should obtain the necessary information otherwise it would not be possible to choose any waste water treatment and collecting alternative for Richnava either with or without Roma settlement.

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