

ASSESSMENT REPORT ON THE SURVEY OUTPUTS

WP T3, Deliverable D.T3.3.4

Version 3
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1. Introduction

The project AMIIGA - “Integrated Approach to Management of Groundwater quality in functional urban areas” is funded by the EU Interreg Central Europe program and running between September 2016 - August 2019. Central Mining Institute (Katowice, Poland) as a lead partner, together with 11 central European partners runs the project.

The project has been initiated due to the long-term and widespread use of contaminants in Central Europe urban areas, which has resulted in a significant contamination of groundwater aquifers. The goal of the project is to develop a strategic transnational management tool to deal with groundwater contamination, in order to reach the remediation targets in a reasonable time.

The focus of the technical work package 3 (WP T3) is to establish a groundwater management plan for each of the seven pilot areas, considering technical, financial and legal aspects. In a first step the framework conditions in each pilot area were assessed via a comprehensive questionnaire reported in D.T3.3.2. This report summarizes its results.

The Questionnaire and some following detail requests were answered completely by all partners. This enables an overall assessment about the situation in each partner area, availability of knowledge and current state of work. The report contains four chapters, including the introduction.

Chapter 2 provides, based on answers to selected questions, an overview about the situation in the partner areas.

Chapter 3 evaluates for each pilot area the quality and availability of data as a precondition for the establishment of a conceptual model.

Chapter 4 gives recommendations for the next steps to be prepared in the upcoming workshop.

2. Answered Questions - Overview

This Chapter gives an overview about selected answers, essential to reflect the different situations in the partner areas.

Problem and Targets (Question 1 of the Questionnaire)

All partners struggle with a severe groundwater contamination. Main contaminant of concern is CHC (Jaworzno, Milan, Novy Bydzov, Feuerbach, Parma), followed by nitrates, pesticides and heavy metals. Contrary to the other partners Zadar is fighting mainly with a bacterial contamination. Zadar is also facing the problem of sea water intrusion.

Long term target of all partners is the improvement of groundwater quality, as the reservoirs are mostly used for drinking water supply. Some of them follow this target directly by either implementing innovative remediation measures (like for example Jaworzno). Others plan to evaluate the possibility of natural attenuation measures (like for example Parma).

Besides these concrete remediation measures, the partners strive to improve their understanding and increase their knowledge about aquifer properties as well as groundwater quantity and quality. Understanding the contamination pattern enables them to identify the polluters.

Size of Working Area and FUA (Questions 2.1 and 2.2 of the Questionnaire)

The partners were asked to define the size of:

- Their Functional Urban Area (FUA), according to hydrogeologic criteria
- Their Working Area, where investigations take place and which will be covered by the groundwater management plan.

An overview about the answers is given below.

Pilot Area	Size of working area [ha]	FUA = Working Area?
Bokanjac-Policnik (Zadar)	24.500	Yes
Ljubljana	7.000	No
Milan	15.700	No
Piazzale Santa Croce (Parma)	still to be defined	
Novy Bydzov	3,6	No
Jaworzno	20.190	Yes
Stuttgart-Feuerbach	530	No

Jaworzno and Zadar define their working areas according to their FUA. The other partners indicate differing sizes:

- Stuttgart-Feuerbach: a much larger catchment area has to be considered for the FUA to explore the influence on deeper aquifers (4.810 ha)
- Ljubljana: The working area consists of four separate regions, where investigations take place. The FUA (ca. 25.000 ha) is defined by a common aquifer system and its recharge area.
- Novy Bydzov: The FUA (ca. 17.600 ha) corresponds to the catchment area of the river Cidlina.
- Milan indicated a slightly different definition. The working area, where investigations and measures within AMIIGA will take place, has a size of 15.700 ha. However the management plan will be defined for the complete FUA with a much larger size of 52.100 ha.

Contaminated Sites (Question 2.3 of the Questionnaire)

An overview about the number and kind of contaminated sites and contaminants to be tackled is given below.

Pilot Area	Number of contaminated Sites	Type of Site			Contaminants of Concern					
		Landfill or Dump	Industrial Site	Agriculture/Sewerage	CHC	Nitrate	Pesticides	Heavy Metals	Bacterial	Other
Bokanjac-Policnik (Zadar)	5	1	0	4					x	x
Ljubljana	4	1	1	2		x	x	x		x
Milan	6	1	5	0	x					
Piazzale Santa Croce (Parma)	1*	0	1	0	x	x				x
Novy Bydzov	1	0	1	0	x					
Jaworzno	8	7	1	0	x		x	x		x
Stuttgart-Feuerbach	9	0	9	0	x			x		x

* = area with multiple small enterprises

Mostly industrial sites and landfills are responsible for the contamination. Ljubljana and Zadar struggle with a severe problem from agriculture and/or sewage. Main contaminants of concern are CHC. Contrary to the other partners Zadar is fighting mainly with a bacterial contamination.

Involved Municipalities and Administrative Districts (Question 2.4 of the Questionnaire)

An overview about the provided answers is given below. The listed institutions will be part of the Regional Implementation Group (RIG), either immediately or later on in the project. The first column indicates the overall number of institutions involved. The other columns indicate the kind of listed authorities and institutions:

Pilot Area	Number of institutions involved	Municipalities	Regional Authorities	Ministries	Water Protection Authorities
Bokanjac-Policnik (Zadar)	4	1	1	1	1
Ljubljana	4	2	-	2	-
Milan	17	12*	5	-	
Piazzale Santa Croce (Parma)	7	6	1		
Novy Bydzov	3	1	1	1	
Jaworzno	> 10	> 5	2	-	-
Stuttgart-Feuerbach	8	7*	1	-	-

* = partly municipal districts

Mostly involved are municipalities and regional authorities. The situation in Jaworzno with more than ten involved institutions seems to be most complex. Furthermore, Parma even involved the industrial union.

Receptors and Subjects of Protection (Question 2.5 of the Questionnaire)

The majority of partners protect catchment areas of water wells or springs used for drinking water supply. Novy Bydzov and Parma protect the process and irrigation water supply from private wells and additionally the water quality of adjacent rivers.

Water Withdrawals (Question 2.6 of the Questionnaire)

An overview about the total withdrawal rates and the purpose of use is given below.

Pilot Area	Total withdrawal rate [m ³ /h, approx.]	Purpose of Withdrawal					
		Drinking Water	Process / Industrial Water	Remediation	Irrigation	Drainage for Building	Dewatering of Mines
Bokanjac-Policnik (Zadar)	5.200	x					
Ljubljana	> 3.300	x	x	x	x		
Milan	33.000	x	x	x			
Piazzale Santa Croce (Parma)	unknown		x		x		
Novy Bydzov	inoperative	x	x				
Jaworzno	5.800	x					x
Stuttgart-Feuerbach	65		x	x		x	

Most extraction wells are used for drinking and process water purposes.

Maps and Graphic Illustrations (Question 3 of the Questionnaire)

All partners provided maps of their working areas and FUAs with added information as far as available. Some partners did not provide geologic cross sections, as they have not been elaborated yet (Parma) and/or the available knowledge proved to be not sufficient (Zadar).

Hydraulic contour maps and other graphic illustrations are available for most pilot areas, however they frequently cover only part sections and not the complete FUA.



Geology and Hydrogeology (Question 4.1 of the Questionnaire)

An overview about information provided by the project partners is given below:

Pilot Area	Number of Aquifers considered	Overall Thickness [m approx]	porous	fractured	Karst	Vertical Interactions expected/known?
Bokanjac-Policnik (Zadar)	1	60-100		x	x	no knowledge
Ljubljana	2	100	x	x		yes
Milan	2	100	x			yes
Piazzale Santa Croce (Parma)	1	20	x			no knowledge
Novy Bydzov	1	1-3	x			no
Jaworzno	3	250	x	x	x	yes
Stuttgart-Feuerbach	7	180	x	x	x	yes

The underground in FUA Jaworzno consists of a highly complex sequence of fractured Triassic and carboniferous aquifers with a lot of faults and geosyncline structures. In some areas the upper quaternary aquifer is located directly on carboniferous strata, in others areas the quaternary aquifer is followed by Triassic strata underneath.

The underground in Stuttgart-Feuerbach is comparably complex with one thin shallow quaternary aquifer followed by a sequence of six Triassic, fractured, partly karstic strata with multiple tectonic faults.

In Zadar there seems to be only one, karstic aquifer, maybe further investigations will lead to a more differentiated structuring.

The underground in Ljubljana, Parma and Milan FUAs consists of series of quaternary aquifers, with intersecting layers of more permeable and less permeable strata. In Ljubljana the strata buildup differs regionally, partly with fractured aquifers in great depths. In Novy Bydzov there is only one, very thin, quaternary aquifer, with low permeable Mesozoic strata following below. In Parma the most relevant is the first aquifer layer of approximately 20 m thickness.

Remediation and Safety Measures (Question 5.3 of the Questionnaire)

An overview about running/finished or planned remediation or safety measures is provided below.

Three from seven partners are currently running or have finished measures. Mainly a classic approach is followed with groundwater extraction and excavation.

Pilot Area	Number of running or finished Measures	Kind of Measure	Number of planned Measures	Kind of Measure
Bokanjac-Policnik (Zadar)	-	-		-
Ljubljana	-	-		
Milan	4	Groundwater Extraction, Air Sparging	2	unknown
Piazzale Santa Croce (Parma)	-	-		
Novy Bydzov	2	ISCO, ENA	4	ISCO, ENA, reactive barrier, excavation
Jaworzno	-	-	1	bioreactive wall for passive groundwater remediation
Stuttgart-Feuerbach	5	Groundwater Extraction, Excavation		

Data Availability and Knowledge about the Site (Question 6 of the Questionnaire)

Milan and Stuttgart-Feuerbach have a comprehensive knowledge about their project sites and multiple data available.

Ljubljana also seems to have good quality data sets both for the geologic buildup and the contamination. However the information about groundwater conditions concentrates on the specific situation in four separate areas - an overall picture is not available.

Jaworzno also seems to have good quality data sets - however the information is mostly restricted to the upper quaternary aquifer in one main contaminated area.

Novy Bydzov has a lack of knowledge concerning hydraulic conductivities and groundwater withdrawal rates.

Parma seems to have a considerable data base concerning hydraulic and contaminant conditions - however currently there are no data available about hydraulic conductivities and water withdrawal rates.

In Zadar there are only very few data available, both for the geologic buildup and for the contaminant situation. Borehole logs are not available.

Legal Framework (Question 7.1 of the Questionnaire)

An overview about the answers to the question on compliance to the legal requirements is provided below:

Pilot Area	Compliance with legal Requirements	Reason for lacking Compliance
Bokanjac-Policnik (Zadar)	no	microbial contamination, seawater intrusion
Ljubljana	no	threshold value desethylatrazine exceeded
Milan	yes	-
Piazzale Santa Croce (Parma)	no	threshold value CHC exceeded
Novy Bydzov	no	threshold value CHC exceeded
Jaworzno	yes	-
Stuttgart-Feuerbach	no	threshold value CHC exceeded



The most frequent reason for lacking compliance is an exceedance of threshold values for CHC. However, the level of required thresholds is very different between the partner areas. In Jaworzno and Milan there is no direct problem of lacking compliance.

Jaworzno aims to ensure a reliable, stable future use of their groundwater resources by establishing a regional cooperation network and implementing targeted groundwater management measures.

In Milan an administrative procedure for each polluted site is running to remediate the contamination. However, the long-term, large-scale effect of these measures is not completely understood at the moment, as there are multiple sources and a widespread diffuse pollution within the FUA. Separating the diffuse from the punctual pollution and attributing plumes to sources will be the precondition to establish an efficient groundwater management system.

3. Conceptual Model of Pilot Areas - State of the Art and Level of Elaboration

This Chapter evaluates for each pilot area:

- How complete/incomplete is their conceptual model
- What are main challenges
- Remaining questions (if applicable).

Bokanjak-Policnik - Zadar

In Zadar detail knowledge is available for some subareas within the FUA, where wells have been drilled and pumping tests carried out. However essential knowledge gaps remain, especially in the southern part of the FUA. A groundwater contour map is not available.

The contamination, as far as known, is mainly bacterial, resulting from landfills, agriculture and damaged septic tanks.

The major challenge is to get a comprehensive understanding about hydraulic conditions and driving forces in the very complex karstic aquifer system. This is an initial step before evaluating the contamination and taking possible steps for their mitigation.

Ljubljana

Ljubljana already did numerous investigations within four separate areas in the FUA. The four areas differ in their geologic buildup, although they are all covered by alluvial quaternary aquifers. Additionally the contamination potential is different, due to different kinds of sources.

Conceptual models and partly numeric groundwater models have been established for each area separately, remaining open questions have been defined. However, no

comprehensive knowledge seems to be available about the geologic and hydraulic connection between these separate areas within the FUA.

Consequently the major challenges are from our point of view:

- Achieve an overall understanding for the hydrogeology and contaminant situation within the complete FUA taking in account possible interactions between the four areas
- Find out whether the diffuse contamination from sewage systems and agriculture (Nitrates, agriculture) is (like described in the questionnaire) really restricted to distinct areas or whether is it stretching throughout the whole FUA.

Milan

A conceptual model has been established and knowledge gaps have been defined concerning:

- Attribution of sources to plumes
- Diffuse pollution upstream the known sources.

A major challenge is the hydrogeology with two concerned quaternary aquifers down to a depth of more than 100 m which interact via hydraulic windows. In a first step a data collection and evaluation will be done and on this basis the further investigation need defined.

Experience is available about the development of a groundwater management plan for the north-eastern part of the FUA. For the AMIIGA project partners it would be essential to learn more about it concerning lessons learnt and recommendations for their further procedure.

Piazzale Santa Croce - Parma

The answered questionnaire leaves some knowledge gaps, major issues are still in a state of evaluation like defining the area of concern, the relevant sites, the geology, the contaminants of concern, etc. However, as we found out by requests, data seem to be available and they will now be evaluated within AMIIGA.

Nevertheless we summarize the major questions which arose after the evaluation of the questionnaire:

- Were the indicated PCE concentrations of 20 to 25 µg/l in Piazzale Santa Croce measured within a contamination source or within a plume?
- Is there any evidence about the existence of multiple sources or can efforts be focused on one single source?
- Is there any indication about other relevant contaminants apart from chlorinated solvents and nitrates?

Novy Bydzov

Novy Bydzov established a conceptual model as well as a numeric groundwater model in course of a groundwater remediation measure, resulting from a chlorinated solvents contamination. The source has been remediated by ISCO, but there is still a contaminated plume stretching towards the river Cidlina.

The challenge will be to evaluate the geologic/hydrogeological conditions not only for the working area with the former contaminant source, but also for the complete contaminant plume. This means that both the conceptual model and the groundwater model have to be extended accordingly. The following questions will have to be investigated:

- A groundwater model has been established, where are hydraulic conductivity and withdrawal rates taken from?
- Is there an essential difference in geology between the known conditions in the working area and the remaining FUA?
- Is there a necessity for additional investigations?
- Are any additional groundwater withdrawals to be taken in account?

Jaworzno

Jaworzno established a conceptual model with a detail knowledge about hydrogeology and contamination - but this knowledge is restricted to a small area within the FUA, which was investigated within EU project FOKS. However, this area inhibits presumably the major contamination with the FUA.

All other mentioned sites are landfill areas from former coal mines, which, from general experience, usually have no severe contamination potential, except they served as a deposit for industrial waste.

A conceptual model for the large-scale FUA needs to take in account:

- The complex geologic buildup with several fractured aquifers and vertical interactions to be expected,
- The complex hydrogeology with excavations from former coal mining and numerous infiltrations and groundwater withdrawals,
- Contamination to be expected in not investigated landfills due to historic sources.

Stuttgart-Feuerbach

A conceptual and a numerical groundwater flow models have been established for shallow aquifers of the working area within EU project MAGIC. They are the basis for further work.



Whereas the working area can be taken over from MAGIC, the extension of the FUA will be extended in space and depth. It includes the catchment area of the mineral springs, which have to be taken in account as a relevant receptor.

The mineral springs are fed from a deep aquifer. A major challenge within AMIIGA will be to find out more about a possible interaction between shallow and deeper aquifers. The geology is very complex with seven, mostly fractured aquifers and multiple tectonic faults.

Conclusions

Evaluating the state of work in the different pilot areas, three groups can be defined:

Group 1 with Milan, Stuttgart and Novy Bydzov has already established a comprehensive conceptual model. Remaining detail questions will be clarified within AMIIGA. Activities are running and a procedure comparable to MAGPlan can be followed.

Group 2 with Ljubljana, Jaworzno and Parma has a rich abundance of available data. However, it still needs some time and effort as well as additional detail investigations to establish a comprehensive conceptual model. The further steps for developing a groundwater management plan will have to be discussed in the upcoming workshop.

Group 3 with Zadar still has essential knowledge gaps. Establishing a detailed model like in Stuttgart or Milan is not a realistic target. However, a simplified conceptual model can serve as further working tool and help to define the next steps.

4. Recommendations and Next Steps

The aim of the next step within WP 3 is to elaborate a draft management plan for each pilot area. It will be prepared in the upcoming workshop and training in Milan.

The evaluations from above based on the answered questionnaire. In many pilot areas the situation may be different in the meantime due to a comprehensive data evaluation and the establishment of a framework report. Nevertheless, this report delivered to all partners in advance will give some guidance and enable the partners to reflect on the stated questions and assessments.

Main issues for the workshop are from our point of view:

- Evaluation of answers to questionnaire, discussion of our reflections and assessments
- Presentations of each partner about recent activities: FUA, RIG, framework and background.

The training in the afternoon should address issues as follows:

- Preparation of next RIG workshop - key issues and topics
- Achievable targets, main priorities and related work steps
- Cornerstones and key issues for local management plan.



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