GROUNDWATER RESOURCE MANAGEMENT FOR NON-POTABLE WATER PURPOSES, BASEMENT PROTECTION, AND HEATING - PILOT APPLICATION

L Katsifarakis[1], A Basdeki[1], K Angelou[2], I Avgoloupis[1], M Kanetidis[2], M Maragakis[2], P Argyrakis[2] and K L Katsifarakis[1,*]

[1]School of Civil Engineering, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece
[2]School of Physics, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece
[*]Corresponding author: klkats@civil.auth.gr

Abstract

Efficient water as well as energy management is a common challenge in the Greece-Bulgaria cross border area. In the framework of the GREEN PUMP project, supported by the COOPERATION PROGRAMME INTERREG V-A, GREECE-BULGARIA 2014-2020, we have studied and planned use of local urban groundwater resources, in order to cover: a) water demand for secondary uses and b) energy demand for space heating.

The project participants are the following: a) Aristotle University of Thessaloniki, Greece (lead partner), b) South-West University "Neofit Rilski", Bulgaria, c) International Hellenic University, Greece (incorporating initial partners Technological Educational Institute of Central Macedonia and Eastern Macedonia and Thrace Institute of Technology), d) Municipality of Pilea-Hortiatis, Greece, e) Municipality of Petrich, Bulgaria.

In this poster, we present some outcomes of the contribution of the Aristotle University of Thessaloniki team, on the following issues: a) Site selection criteria. We stress the role of "soft" information in locating shallow aquifers in urban areas, b) Technical implementation problems to existing buildings, in densely built areas. Our remarks are based on the experience gained from the construction of a pilot installation at the Hydraulics Laboratory of Aristotle University of Thessaloniki, Greece, c) Simplification of legal procedures. We discuss the obligation to reinject geothermal water to the aquifer after its use. We suggest that legislation should allow for decision on reinjection for every particular project, based on well-defined criteria.

Moreover, preliminary results on the quality of pumped water and its suitability for secondary uses are discussed.

The main conclusions of the paper are the following: a) "Soft" information can be useful in selecting proper sites for development of local groundwater resources in urban areas, b) Installation of ground source heat pump systems to urban areas and to existing buildings, in particular old ones, presents specific challenges, which should be carefully considered, c) Planning of construction works should allow for adaptation to unexpected conditions, d) The strictest environmental legislation is not always the best for the environment.

1. Introduction

Efficient water and energy management in the Greece-Bulgaria cross border area is a common challenge. Cooperation, which is literally indispensable in the case of transboundary resources, is still very helpful in many other cases, when physical and legal conditions are similar in the two countries. For instance, meeting the domestic water and energy demand is a top priority in both countries, requiring water/energy transport to urban centers from rather long distances. The EU Directive 2000/60 (Water Framework Directive - WFD) foresees full cost recovery of water that is provided to the consumers, as a means to curb unnecessary demand. However, water is a social good as well, and an increase of its price beyond a certain limit would be socially unacceptable, especially in times of financial crisis. A significant part of domestic water is consumed for secondary uses, which do not require potable water quality. It would serve the spirit of WFD, to meet this demand with local water resources of quality inferior to potable, but still suitable. The main advantages of this approach are: a) Exploitation of additional water resources and b) Conservation of energy and chemicals, which are required to treat raw water to potable water quality. Additionally, pumping of excess water might be necessary in areas of high groundwater table, in order to protect basements of buildings from flooding.

Groundwater is a source of renewable thermal energy as well, which can be used for space heating purposes, by means of heat pumps. Increase of the penetration of renewables in the energy mix is a primary target for EU countries and the whole world, in order to combat climate change. In most urban regions of the Greece-Bulgaria cross border area, ground water temperature remains close to 15°C both in winter and summer, even at depths as small as 5 to 10 meters, namely the conditions for thermal exploitation of shallow aquifers are favourable.

In the framework of the GREEN PUMP project, supported by the COOPERATION PROGRAMME INTERREG V-A, GREECE-BULGARIA 2014-2020, we have studied and planned the use of local urban groundwater resources, to cover: a) the water demand for secondary uses and b) the energy demand for space heating. Therefore, the GREEN PUMP project is directly connected to the Sustainable Development Goals of the UN. Some of the project outcomes are presented in this paper.

2. Project participants and outline

The project participants are the following:

a) Aristotle University of Thessaloniki, Greece (lead partner)
b) South-West University "Neofit Rilski", Bulgaria
c) International Hellenic University, Greece (incorporating initial partners Technological Educational Institute of Central Macedonia and Eastern Macedonia and Thrace Institute of Technology)
d) Municipality of Pilea-Hortiatis, Greece
e) Municipality of Petrich, Bulgaria.

The targets of the project include:

1. Elaboration of criteria for site selection (groundwater quality, aquifer depth, vicinity to prospective users, basement flooding risk, etc.).
2. Study of technical implementation details to existing and new buildings and cost estimation.
3. Construction of one complete pilot installation in Thessaloniki, Greece, and secondary water use ones in Blagoevgrad and Petrich, Bulgaria, and Pylaia, Greece.
4. Recording of practical problems and possible pitfalls during the construction phase in densely populated areas.
5. Elaboration of monitoring program for such systems and monitoring of the pilot installations.
6. Evaluation of the environmental and social benefits. Optimization of the design per user needs.
7. A policy document on the simplification of the legal procedures.

In the following sections, we briefly present outcomes of the contribution of the team of the Aristotle University of Thessaloniki.

3. Results obtained by the Aristotle University of Thessaloniki team

3.1. Site selection criteria

In our project we aimed at using local groundwater resources to cover the demand for secondary water uses and heating of public or municipal buildings in the investigated areas. The basic prerequisite, then, was the existence of a shallow aquifer at the vicinity of possible targets.

In densely built urban areas, geophysical research, which is cheap, may be hindered by adjacent buildings. We faced this problem, when investigating the area around the Hydraulics Laboratory of the Aristotle University of Thessaloniki: The available open space was not enough to get a ground cross-section at the required depth.

To come up with a preliminary estimate, "soft" information, which could be collected by a local survey or a literature review, was useful. Such information includes:

a) Flooding of basements of adjacent buildings. This is a common problem in the campus of Aristotle University of Thessaloniki.
b) Existence of traditional wells. Although such wells have been abandoned in modern urban areas, where potable water is provided by the pertinent authorities, they can serve as indicators of local shallow aquifers.
c) Existence of urban streams close to the site which is being investigated. One should even search for old stream beds, currently converted into closed conduits. Such a conduit exists in a rather small distance from the Hydraulics Laboratory.
d) Recordings of the local vegetation. Tree species (e.g. plane-trees), which require large water quantities, may also serve as indicators.

3.2. Details about the technical implementation in existing buildings in densely built areas

This section is based on the experience gained from the construction of the pilot installation at the Hydraulics Laboratory of the Aristotle University of Thessaloniki, Greece. This is a rather old building, consisting of a basement, a ground floor (hosting laboratories) and two additional floors with offices and a classroom. The building itself is shown in the photo of Figure 1, while the design of the building is shown in Figure 2. In Figure 3, a photo of the construction process of the installation is shown.

Figure 1. *The Building of the Hydraulics Lab, Aristotle University of Thessaloniki.*

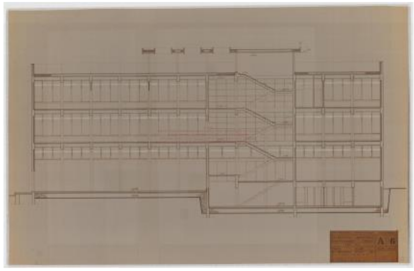

Figure 2. *Vertical cross-section of the Hydraulics Lab, Aristotle University of Thessaloniki.*

Figure 3. *A moment of the construction process, by the Hydraulics Lab, Aristotle University of Thessaloniki.*

During the construction of the installation many technical problems had to be solved. Such problems may arise in urban environments, with narrow streets and old buildings. A brief account follows.

1. Due to the location of the Hydraulics Laboratory, access to it proved to be very difficult for large and heavy vehicles, for the following reason: The building is located next to one of the main hospitals of Thessaloniki. It can be approached only by a one-way street, which carries heavy traffic because of the hospital, while its available width is curtailed by parked cars. The first day of the works, a heavy track was blocked for more than an hour, 200 meters away from the building. From then on, it was decided that heavy machinery would approach the building during weekends only. This situation caused some delay to the completion of the installation.
2. The weight of each heat pump (TERRA SW Max GROUND SOURCE HEAT PUMP) is 600 kg and its dimensions 2019x1066x774 mm. Moreover, during transportation it should not form an angle larger than 15 degrees from the upright position. Carrying the heat pumps to the ground floor of the building was comparatively easy. The next step, though, namely putting them at their prescribed location at the basement, proved to be a formidable task, given the aforementioned restriction. The elevator of the old building was too small to be used. Finally, they were carried to the basement through a rear door, which had to be dismantled and reconstructed after the operation was completed.
3. The initial plan for one water tank at the roof of the building had to be modified, and two smaller ones were placed instead, in order for the additional load to be distributed more evenly. The selection of their shape and their exact location (on beams) was dictated by similar thoughts. The two tanks are shown in Figure 4.
4. Small local subsidence of soil under the load of the heavy drilling machinery delayed the well construction, as better preparation of its support was required.
5. Securing public safety during the well construction, causing the smallest possible nuisance, required special consideration. The constructors had to completely close a certain pedestrian passage, since some people failed to adhere to safety rules.
6. The cleaning of the well after its completion presented some difficulties, because of the urban environment. Water with high mud content was disposed to a nearby flower bed, while special care was taken to avoid its splitting to the area around it. Later on, cleaner water was disposed to an inlet of the sewer network, without creating any problems to its function.

Figure 4. *The water tanks properly placed on the roof of the building.*

3.3. Simplification of legal procedures

The simplification of legal procedures is necessary, at least regarding the Greek side. For this reason, certain specific recommendations were created. Here only one issue is being discussed, the one which may have more general implications, regarding the development of the use of geothermal energy in Greece.

Greek law dictates injection of geothermal water to the initial aquifer, to fully protect the environment, namely to avoid: a) land subsidence and b) pollution of surface water bodies by harmful substances, contained in the geothermal water. The aforementioned risks, though, do not exist, if the quality of the geothermal water is good, and the hydraulic head in the respective aquifer remains high. In such cases the injection of the used geothermal water back to the respective aquifer, will increase construction and operational costs of the geothermal system and may eventually hinder the development of a renewable energy source. In our opinion, legislation should allow for the decision on the reinjection in every particular project to be made based on well-defined criteria.

3.4. An interesting by-product of the project

The suitability of locally collected groundwater depends on its quality. For this reason, we conducted measurements of physical, chemical and microbiological parameters of water samples, collected from shallow wells, in the Aristotle University campus.

According to our results, the values of some physicochemical parameters exceeded the limit for potable water in some sampling sites. Moreover, pathogenic microorganisms such as enterococci, e-coli and total coliforms were identified in all microbiological analyses. The aforementioned results are rather alarming and indicate that specific research is needed, to check the suitability of the local water resources for the foreseen secondary uses or to establish measures to protect the quality of the local aquifers.

4. Conclusions

From the previous sections, the following conclusions can be drawn:

"Soft" information can be useful in selecting proper sites for the development of local groundwater resources in urban areas.

The difference between theory and praxis can be substantial. Seemingly trivial details may pose considerable difficulties and may delay construction.

The installation of ground source heat pump systems in urban areas and in existing buildings, particularly old ones, presents specific challenges, which should be carefully considered.

The planning of the construction works should allow for adaptation to unexpected conditions.

The strictest environmental legislation is not always the best for the environment.

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