Doctoral School on Engineering Sciences
Università Politecnica delle Marche

Extended summary

The Aspio basin: geo-structural settings, geomorphology and hydrogeology in the analysis of hydrogeological hazards.

Curriculum: INGEGNERIA DEI MATERIALI, DELLE ACQUE E DEI TERRENI, XII° ciclo

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Date: 6-March-2014

Abstract. Provide a short description of the work in approx. 2.000 characters, including spaces.

The main purpose of this study is to investigate landslides, floods and groundwater pollution in a small watershed characterized by high hydrogeological hazard, high population density and widespread industrial and commercial settlements. Geological-structural, geomorphological and hydrogeological aspects of the Aspio basin are analyzed, as this area can be considered as a prototype of many territories of the region, both for natural and anthropic issues related to the risks. The geological-structural study, based on geological surveying and on geophysical and geognostical data, shows a good correspondence between deep pliocenic structures and surface geological-structural elements, at least in some areas, demonstrating that there is still an active tectonics, at least up to the deposition of the pleistocenic units. Several examples of matching between faults and landslides are shown. With respect to geomorphology, the sliding areas are examined. Correlations between occurrences of landslides and lithology and slope are evidenced, through GIS software. The alluvial plain is densely populated and the natural equilibrium is compromised. All these features amplify the potential risks of flooding. In respect of the hydrogeology, the hydric circulation of the Aspio River alluvial aquifer is recognized through piezometric measurements.

This study leads to the evaluation of the aquifer vulnerability and the potential risk of pollution of the underground water, caused by so a dense concentration of people and activities. In the R. Scaricalasino sub-basin, the maps of the lythological coverings, the corresponding thicknesses and a geological-geomorphological scheme is tracked.
The coverings, in fact, play a major role in the hydrological processes and in the landslides.
In addition, the hydrological geomorphological features of the basin are analyzed, in order to predict the response of the system to the meteorogical events. The hydraulic conductivity of soils is determined through infiltrometric measurements. It is also shown, through granulometric analysis, that such soils feature high and moderately-high conductivity. The hydrogeological analysis of the valley bottom aquifer has produced piezometric maps. The table aquifer, fed by rain, feeds the R. Scaricalasino. The presence of silts and sandstone close to the ridges, the body of the Offagna silty paleo-landslide and the powerful eluvial-colluvial covers fed the valley bottom aquifer, even during the dry periods.

Finally, the analysis of the floods, occurred in the years 2011-2012 and Jan. 1013, have been made in order to determine the hydrogeological response of the basin and investigate the relation rainfall-runoff and the aquifer level variation in order to understand whether the piezometric level would play a significant role in the formation of the sharp increase of stream stage.

Keywords. floods, groundwater pollution, hydrogeological hazard, landslides, watershed.

1 Problem statement and objectives

The main purpose of this study is to investigate landslides, floods and groundwater pollution in a small watershed characterized by high hydrogeological hazard, high population density and widespread industrial and commercial settlements. Geological-structural, geomorphological and hydrogeological aspects of Aspio River basin are investigated, because this area can be considered as a prototype of many territories of the Marche region, both for natural and anthropic issues related to the risks. In particular, the study is focused on the Scaricalasino sub-basin, which with an area of 29 km^2, is a high flood risk. The subbasin is very interesting for its significant anthropization, which enhances the hydrogeological risks and causes significant damage to structures and environment, even without heavy rainfall.

2 Analysis and discussion of main results

The geological-structural study, based on geological surveying and on some processing of geophysical and geognostical data, shows a good correspondence between deep pliocenic frameworks and surface geological-structural elements, at least in some areas, demonstrating that there is still an active tectonics, at least up to the deposition of the pleistocenic units.
Several examples of matching between faults and landslides are shown.
With respect to geomorphology, the sliding areas are examined. Many correlations between occurrences of landslides and lithology and slope are evidenced, through GIS software. The river environment is densely populated and the natural equilibrium is compromised.
All these features amplify the potential risks of flooding. In respect of the hydrogeology, the hydric circulation of the Aspio River alluvial aquifer is recognized through piezometric measurements. This study leads to the evaluation of the aquifer vulnerability and to the potential risk of pollution of the underground water, caused by so a dense concentration of people and activities.
In the R. Scaricalasino sub-basin, the maps of the lithological coverings, the corresponding thicknesses and a geological-geomorphological scheme is tracked.
The coverings, in fact, play a major role in the hydrological processes and in the landslides.
A typical element of Adriatic basins can be found in the Aspio and Scaricalasino watersheds, i.e. the presence of thick eluvial-colluvial covers, which easily produce landslides (like the Offagna landslide and the S. Stefano landslide, which are still active) and host a shallow groundwater system contributing to the recharge of rivers and streams throughout the year. In the Scaricalasino subbasin the eluvial-colluvial covers, being up to 25 m thick, are made of sands, silty-sands and clayey silts.
In addition, the hydrological geomorphological features of the basin are analyzed, in order to predict the response of the system to the meteorological events. The hydraulic conductivity of soils is determined through infiltrometric measurements. It is also shown, through granulometric analysis, that such soils feature high and moderately-high conduc-

tivity. The hydrogeological analysis of the valley bottom aquifer has produced piezometric maps. The water table, fed by rain, feeds the R. Scaricalasino. The presence of silts and sandstone close to the ridges, the body of the Offagna silty paleo-landslide and the powerful eluvial-colluvial covers fed the valley bottom aquifer, even during the dry periods.
Continuous and discrete measurements have been performed to determine which natural phenomena produce hydrogeological risk in the watershed. These measures began in 2011 and were performed until the beginning of 2013.
The measurements have facilitated firstly the evaluation of the relation between groundwater and surface water, in order to have an indication of flood risks; secondly, the calculation of a water balance in the hydrographic basin and the rainfall-runoff relation. Usually, events with short duration and high intensity produce the most critical situation in the Scaricalasino subbasin. High intensity and short duration seem to be typical features of those rainfall events which determine a dramatic rise of the hydrometric level of the river.
To realize the connection between changes in the hydrometric level of the Scaricalasino river and fluctuations of the water table of the alluvial aquifer in the lower valley, a specific comparison between rainfall, runoff and groundwater is considered to be essential. This aquifer, which recharges both the Aspio and the Scaricalasino river, is mainly made up of silty-sandy clay, based on a clayish-marly bedrock. Close observation of the piezometric head map highlights the ability of the thick slope covers to store large amounts of infiltration water, and thereafter recharge the alluvial aquifer in the lower valley.
The groundwater table is always above the river stage, even in the presence of high flood events. After the discharge peak, when the flood hydrograph starts to drop, groundwater contributes to keeping the hydrometric level rather high, especially in the winter season when soil moisture is elevated.

3 Conclusions

The experimental investigation of a little hydrographic basin (like the Aspio catchment) and its subbasin (i.e. the Scaricalasino catchment) allows to gain knowledge necessary to identify and possibly forecast hydrogeological risks.

In addition, these studies can be applied to other basins with similar features.

References

Tazioli A., Mattioli A., Nanni T., Vivalda P.M.,"Natural hazard analysis in the Aspio equipped basin", *Engineering Geology for Society and Territory* IAEG XII Congress - Torino, September 15-19, 2014.