Groundwater Dynamics in Drained Soils of the Biđ-field District

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Summary

The main goal of five-year stationary investigations (2001-2006) was to assess groundwater dynamics in the Biđ-field district, as well as the type of soil moistening of agricultural soils spreading over 5838 ha. Detailed hydropedological investigations were carried out in 2000 and a soil map of the region was produced (scale = 1:10000) using universal kriging. Soil investigations identified six pedosystematic units: alluvial-gley, semigley-pseudogley, eugley hypogley, humogley, eugley amphigley and drained soils. Based on permanent monitoring of piezometer groundwater (piezometer depth up to 4.0 m) in the period from 2001 to 2006, the following major soil moistening types and subtypes of the separated soil units were determined: semigley-pseudogely, hypogley, humogley, amphigley and drained. Using the correlation method, more intensive groundwater communication was determined in the studied soil profiles with the River Biđ water (r = 0.65-0.69) than with the River Sava water (r = 0.23-0.69), notably in hypogley soils, which cover 54.3% of the studied area. Analysis of the obtained piezometer water level curves indicated a very strong mutual correlation between the groundwater level dynamics in monitored hydrogeological piezometers of 9 m depth (r = 0.87-0.98), as well as a strong correlation (r = 0.75-0.94) between hydrogeological and hydropedological piezometers of 4 m depth. A particularly strong correlation (r = 0.85-0.94) was recorded between hydrogeological and hydropedological piezometers installed in hypogley soil. These data confirm marked vertical communication of groundwater in the deep aquifer with water of the shallow soil aquifer, indicating that the surface layer of the studied area, mainly made up of silty clay loams to silty clays, is not impervious.

Key words

Biđ-field, groundwater level, piezometer, correlation

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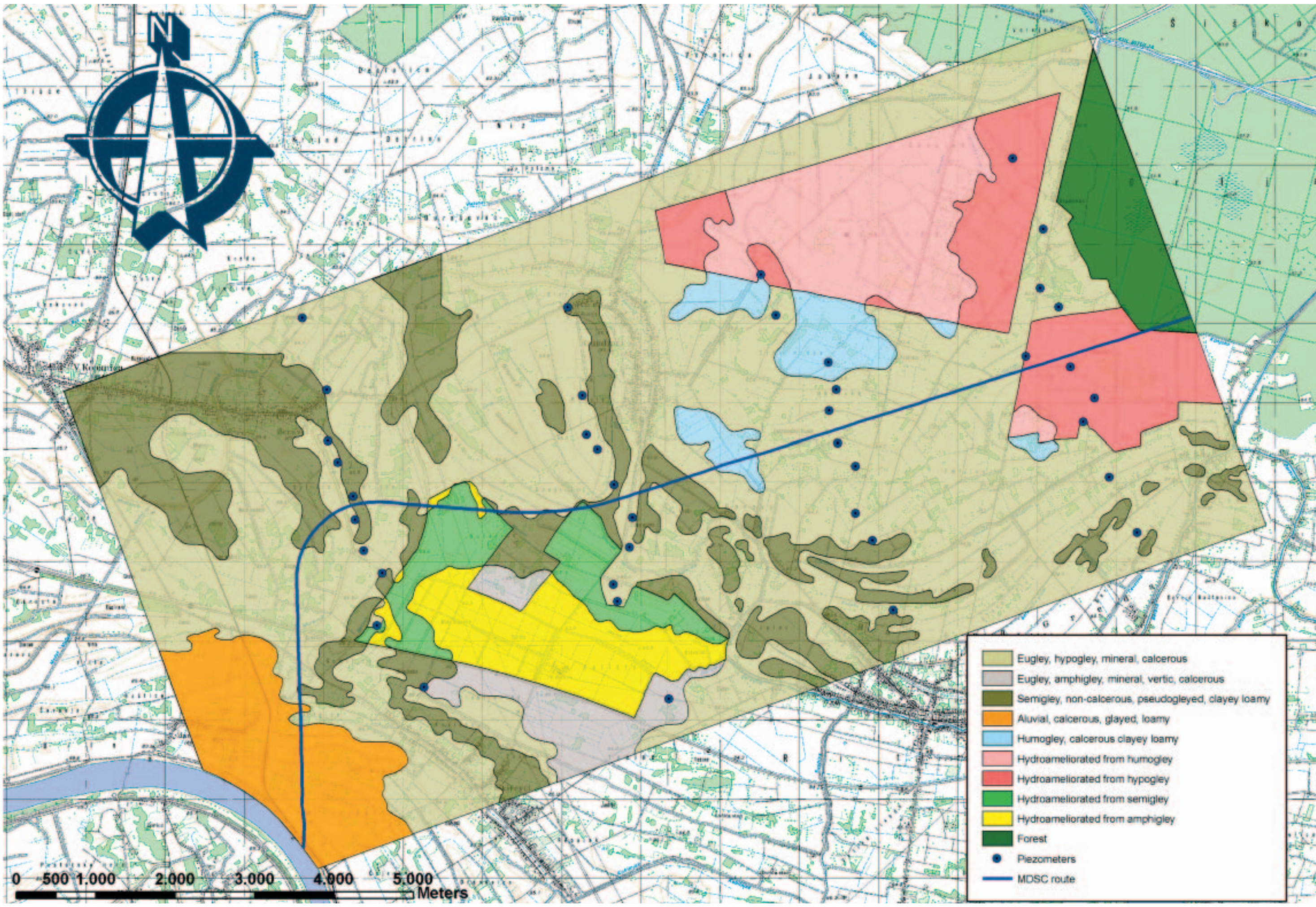


Figure 1. Soil map of the studied region

Introduction

Groundwater regime of hydromorphic soils in the Sava river valley has been the main object of a number of studies to date. Pušić and Škorić (1965) have confirmed the presence of permanent groundwater in the whole Sava basin. Water level rarely drops more than 5 m below the soil surface, in dependence on the distribution, composition and potency of water-bearing horizons (aquifers). Groundwater fluctuations are higher along the River Sava and other watercourses and lower in their hinterland (Srebrenović, 1971).

Biđ-field is part of the large Sava valley, delineated by the boundaries of the River Biđ catchment area. Dams protect the area from the high Sava waters. In this study, groundwater dynamics was monitored in the Biđ-field section between the settlements Velika Kopanica (in the west), Babina Greda (in the east), Sikirevci (in the south) and Kladavca (in the north) in a total area of 5838 ha. The region is hydrotechnically protected against external water, flood and watershed water. Problems are still caused by excess internal water (ground and surface water) occurring periodically as a consequence of specific climate features, relief and hydrography.

The route of the future multifunctional Danube–Sava Canal passes through the centre of the studied region. It is also noteworthy that the largest reserves of best-quality drinking water in Eastern Slavonia are found in this narrow strip of land (Urumović and Mihelčić, 2000). The region is hydropedologically very heterogeneous, with prevalence of hydromorphic soils with specific moistening, different stratigraphic and textural solum structure and nonuniform vertical and horizontal hydraulic conductivity (Petošić, 2002).

Material and methods

Detailed hydropedological investigations of the studied region, including production of a soil map (scale 1:10000), were performed in 2000. Within the investigations, more than 80 pedological profiles were opened and about 190 exploratory hydropedological boreholes were drilled. Soil profiles were opened to a 200 cm depth, that is, to the parent material. Soil stratigraphy, physiologically active depth, parent material depth and type, prevailing type of moistening and soil pedosystematic affiliation were determined in opened soil profiles. From genetic

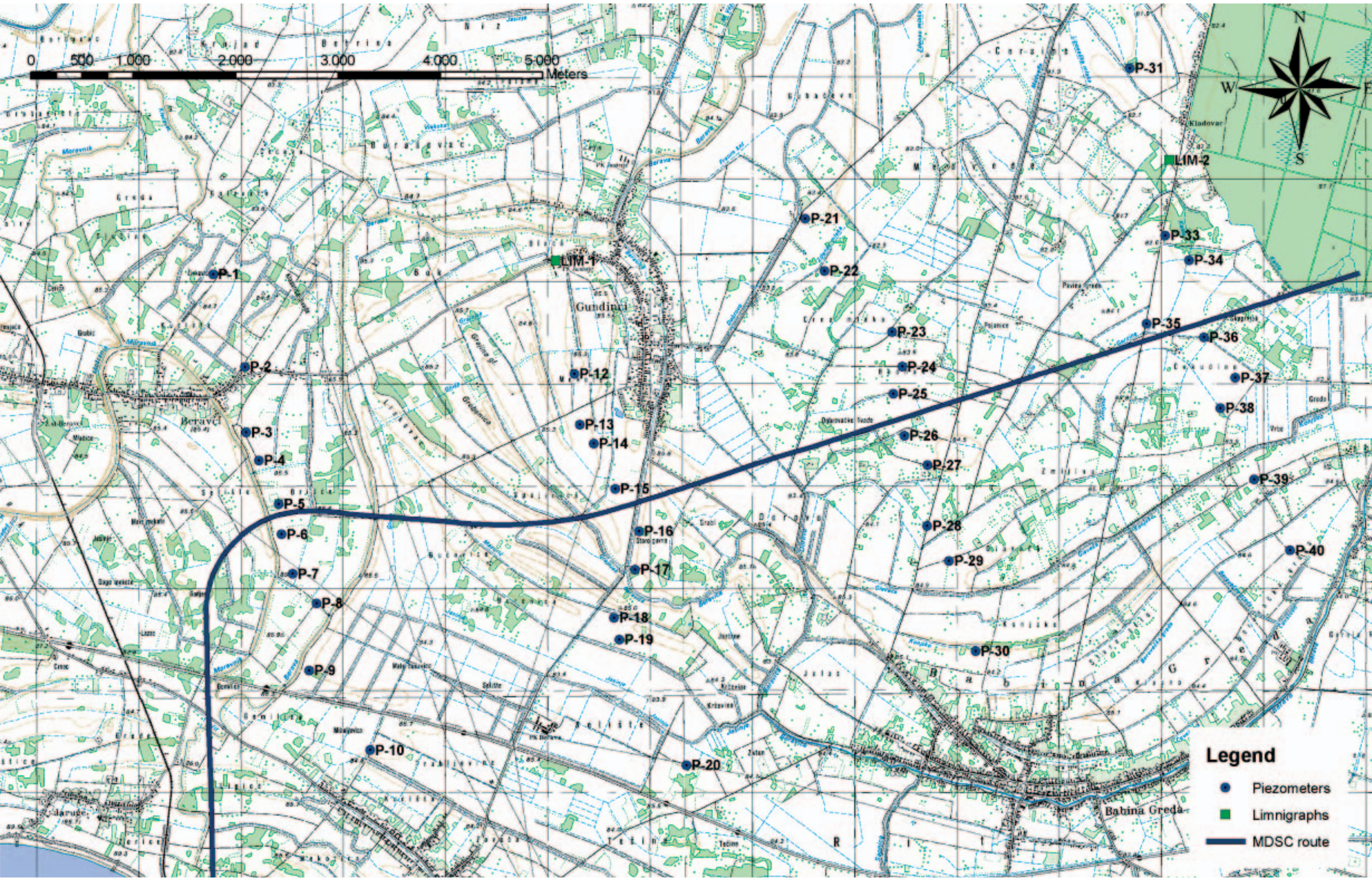


Figure 2. Detailed map of the studied region

horizons, soil samples for laboratory analyses were taken in disturbed or undisturbed **condition**. On average, 3.5 soil samples per profile, or about 280 samples from the entire studied region, were taken and analyzed. The soil map of the region (Figure 1) was made using ArcMap V.9.1, with universal kriging

Continuous monitoring of groundwater dynamics in the studied region, focusing on groundwater level fluctuation in the soil profile to 4.0 m solum depth, was carried out from 2001 to 2006 with the aid of hydropedological piezometers. For this purpose, 40 hydropedological piezometers were installed at 4.0 m depth, and data was collected every 10 days, namely three times a month (Figure 2). Automatic Orphimedes limnimeters were mounted on two hydropedological piezometers to follow the groundwater level fluctuation on a daily basis. Data recorded every three days in five hydrogeological piezometers at 9.5 m depth was used. Piezometer depth enables their penetration into the more pervious sandy-silty materials overlying the gravelly aquifer. Measurements were done by the authorized surveying office "Mjernik" of Vinkovci, which had also installed the piezometers.

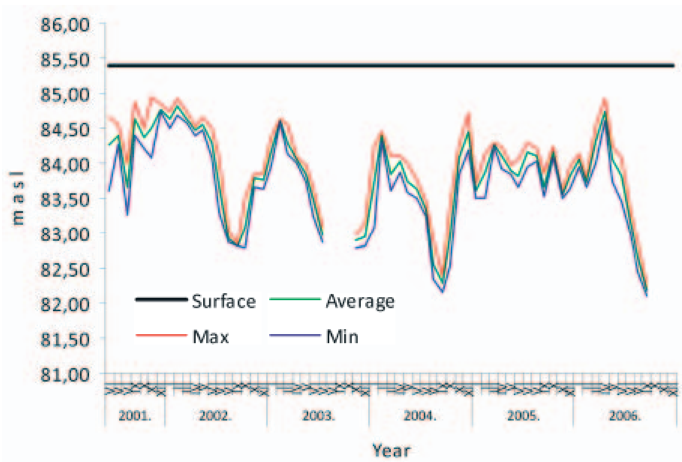
From numerical data on the groundwater levels in piezometers, basic and decade series of hydrological values were formed and submitted to mathematical-statistical processing, using the statistical SPSS Statistics V.17.0 program. Basic statistical series were used to determine statistical parameters. Interdependence of water levels in hydrogeological piezometers within the studied region as well as the interdependence of groundwater levels between individual hydrogeological and hydrogeological piezometers were determined by correlation (Srebrenović, 1986).

Results and discussion

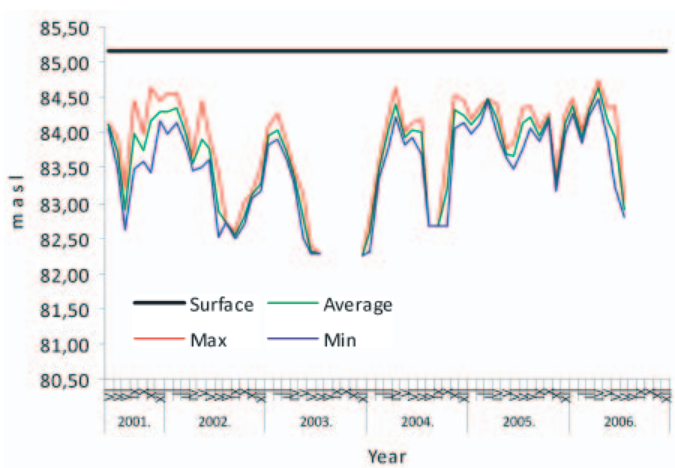
The soil map of the studied region, scale 1:10000, (Figure 2) was made on the basis of detailed hydropedological investigations done in 2000 and according to relevant soil classification of Republic of Croatia (Škorić et al., 1985). Five pedosystematic units were sorted out (Table 1). It can be seen from Table 1 that the prevailing pedosystematic unit is eugley, hypogley, mineral, calcareous soil, which covers an area of 3329 ha or 57% of the studied region.

Table 1. Distribution of pedosystematic units in the studied region

Entry No.	Name of pedosystematic unit	Area ha	Area %
1.	Semigley, noncalcareous, pseudogleyic, clayey loamy	740	12.7
2.	Eugley, hypogley, mineral, calcareous	3 329	57.0
3.	Humogley, calcareous, loamy clayey	227	3.9
4.	Eugley, amphigley, mineral, vertic, calcareous	137	2.3
5.	Drained soil	1 405	24.1
Total		5 838	100.0

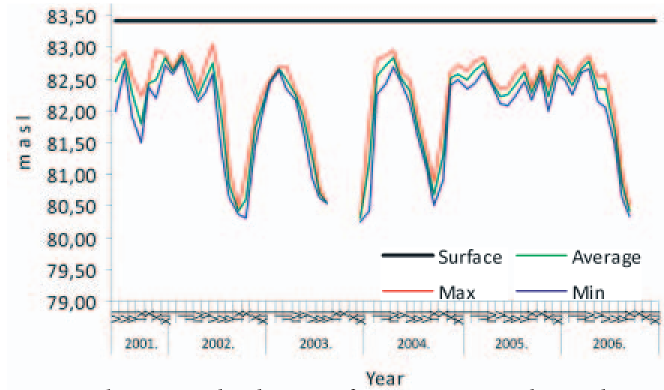


Graph 1. Water level curve of piezometer10 – amfigley moistening

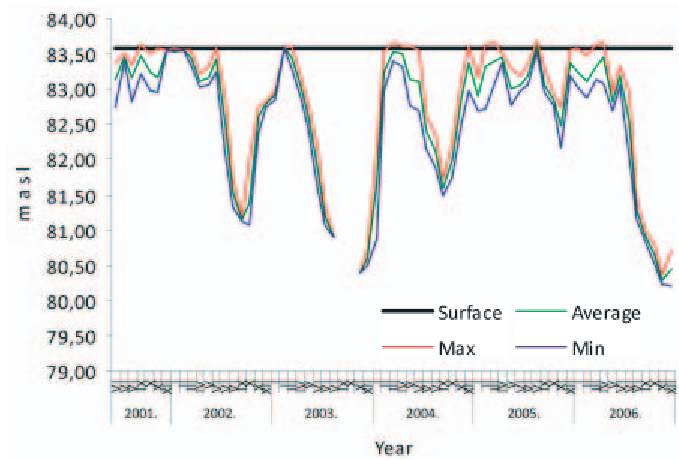


Graph 2. Water level curve of piezometer 15 – semigley moistening

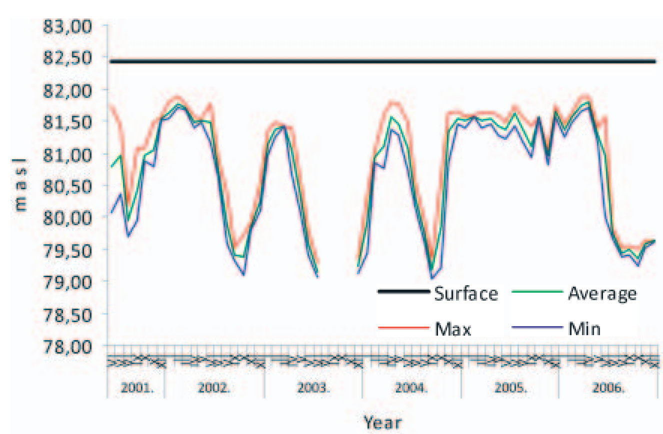
Multi-year monitoring (2001-2006) of groundwater levels in the studied region confirmed the major moistening types of agricultural soils (semigley, hypogley, humogley, amphigley and drained soil) that were diagnosed during the mentioned detailed hydropedological investigations. Piezometers P-10, P-15, P-23, P-24 and P-36 were selected for the analysis of groundwater level fluctuation and confirmation of the diagnosed basic types of moistening in separated types and subtypes of agricultural soils. Water level curves of the listed piezometers are represented in Graphs 1, 2, 3, 4 and 5.



Graph 3. Water level curve of piezometer 23 – humogley moistening



Graph 4. Water level curve of piezometer 24 – hypogley moistening



Graph 5. Water level curve of piezometer 36 – drained soil moistening

Based on relevant indicators, obtained by multi-year monitoring of groundwater levels, maps of the studied region were produced, showing groundwater depths (hydro contour lines) at maximal, medium and minimal water levels (Figures 3, 4 and 5).

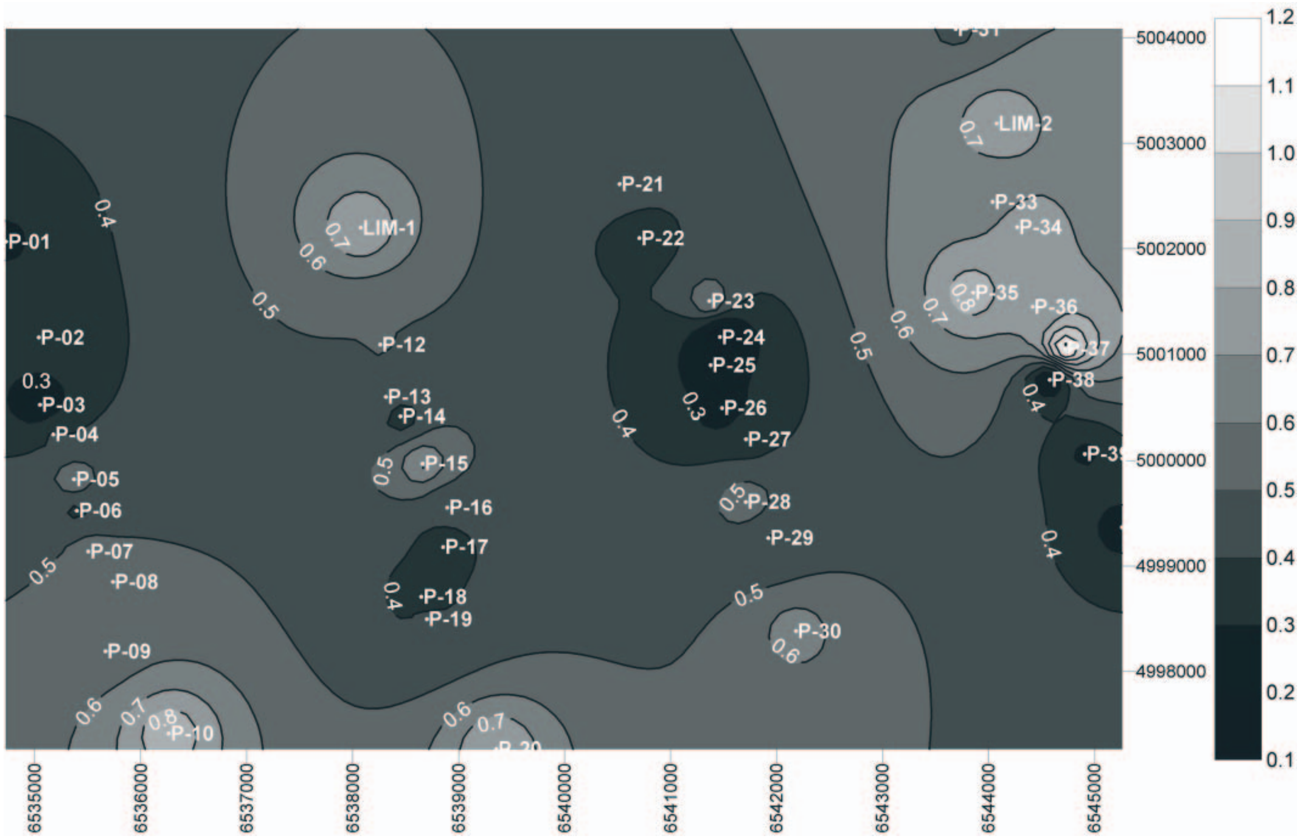


Figure 3. Map of the studied region with hydro contour lines of maximal groundwater levels

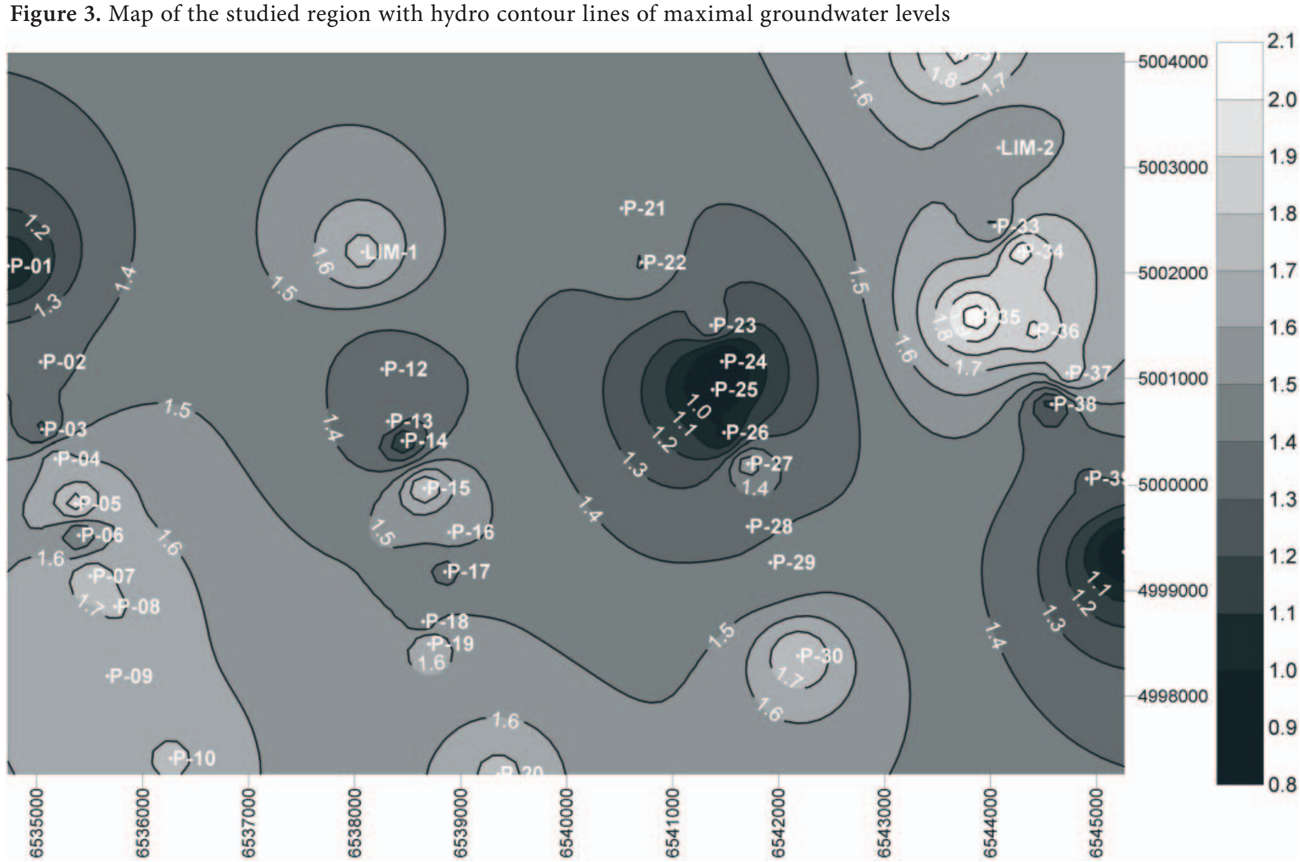


Figure 4. Map of the studied region with hydro contour lines of medium groundwater levels

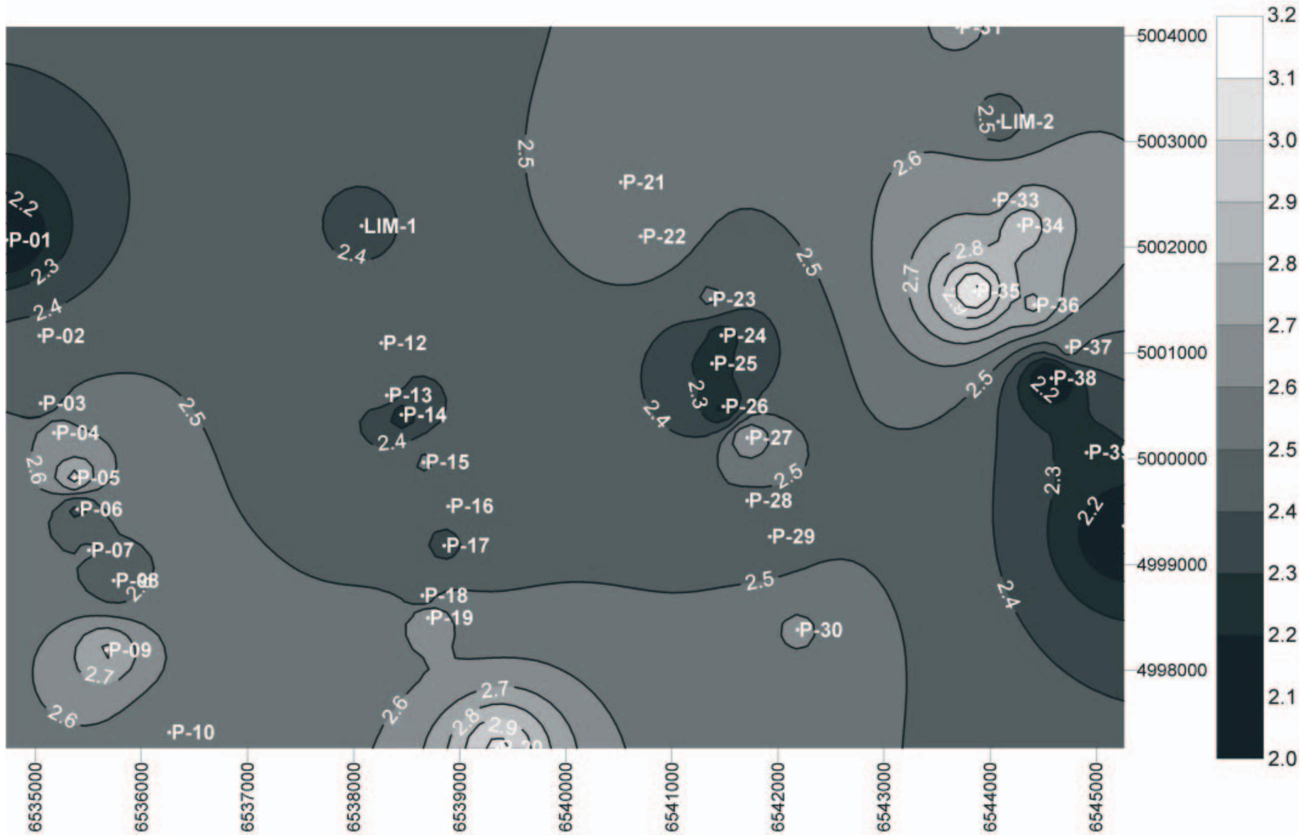


Figure 5. Map of the studied region with hydro contour lines of minimal groundwater levels

It was found that annual groundwater level fluctuation shows a regular seasonal pattern, with shallow soil aquifer being filled mostly in spring, and emptied in the summer-autumn period. Similar results for the River Sava valley were obtained by Pušić and Škorić (1965) and Dolanjski et al. (1999). Nešić et al. (2010) obtained similar results for hydromorphic soils of aluvial plain in middle part of Danube basin.

Using the correlation method, a very strong mutual correlation was determined between the groundwater level dynamics in monitored hydrogeological piezometers of 9 m depth (r = 0.87-0.98). Strong correlation (r = 0.75-0.94) was also determined between hydrogeological and hydropedological piezometers of 4 m depth. A particularly strong correlation (r = 0.85-0.94) was determined between hydrogeological and hydropedological piezometers installed on hypogley, which was also confirmed by investigations done by Mustać (2004, 2009).

Conclusions

This study covered a total area of 5838 ha. Multi-year monitoring (2001-2006) of groundwater level dynamics in the studied region revealed that 740 ha or 12.7% of soils have semigley moistening, 3 329 ha or 57.0% hypogley, 227 ha or 3.9% humogley, 137 ha or 2.3% amphigley and 1405 ha or 24.1% drained soil moistening.

In the monitored hydrogeological piezometers of 9 m depth was determined a very strong mutual correlation between the groundwater level dynamics (r = 0.87-0.98). Strong correlation (r = 0.75-0.94) was also determined (r = 0.75-0.94) between hydrogeological and hydropedological piezometers of 4 m depth. A particularly strong correlation (r = 0.85-0.94) was determined between hydrogeological and hydropedological piezometers installed on hypogley, indicating marked vertical communication of groundwater in the deep gravelly aquifer with that of the shallow soil aquifer. The obtained results corroborate the assumption that the covering layer (solum to 4.0 m depth) of the studied region, mainly made up of silty clay loam to silty clay, cannot be considered water impervious.

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