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Some opportunities of using inverse distance weighting for soil research of cambisols and fluvisols

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Abstract. *Four maps of major soil physical and chemical properties: clay content, soil organic content, soil reaction and total depth are presented in Pokrovnik village. The laboratory analysis is not sufficient for decision making. Only when it is in combination with the terrain locations an opportunity can be created for better decisions. The Inverse distance weighting method (IDW) is used. Digital Elevation Model (DEM) indicates the object of research in Blagoevgrad region with a diverse relief in the Middle Reaches of the Struma River (Southwestern Bulgaria). Descriptive statistics indicates the range of the soils. This can be used for recommendation and analysis of the development of the area.*

Keywords: land evaluation, Inverse Distance Weighting, Digital Elevation Model (DEM), humus, pH, clay content

Introduction

Often farmers analyze only their own portion of the land. Some of them do not want or do not have the resources to analyze the lands of the whole village where their land is located. But soil should be viewed as a provider of ecosystem services (Vereecken et al., 2016, adapted from Dominati et al., 2010), a very slowly renewable, practically non-renewable resource (Breure et al., 2018). A more systematic approach that combines physical, chemical properties and their geospatial distribution can give a more complete understanding.

Research objectives

1. Investigate the soil differences of a region with a diverse relief near a major river in Bulgaria using terrain and laboratory data.

2. Use GIS, DEM, IDW and descriptive statistics to make inferences about soils and their geospatial distribution.

Material and methods

There are several major indicators of the soil. Slowly changing and of high importance is the soil texture. The humus content is directly associated with the organic carbon and provides for the fertility of soil. The soil reaction is related to the growth of crops and the soil cation exchange capacity and soil as a buffer.

Pokrovnik village is situated in the Blagoevgrad region. It is close to the west riverside of the Struma river near Logodashka river (Guide Bulgaria, 2019). The area of Pokrovnik is 1866,21 ha according to the map.

There were sixteen soil profiles taken at different locations and then they were analyzed at

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the Institute of soil science, agrotechnologies and plant protection "Nikola Poushkarov" in Bulgaria (Mihaylov, 1993). The topsoil and the important for agriculture upper horizons of the soil were presented. The soil texture was analyzed according to Kachinski (1958) with particle size less than 0.01 mm, the humus content according to Turin method (Donov et al., 1974) and the soil pH is soil reaction in aqueous solution (pH in water extraction – measured potentiometrically (WTW 720 pH meter)). The upper horizon is used as it is most useful for crops.

The Digital Elevation Model (DEM) elevation in meters above sea level is based on Copernicus 1.1 EU DEM (Figure 1). It is a contiguous dataset divided into 1000 x 1000 km tiles, at 25 m resolution with vertical accuracy: +/- 7 meters RMSE (Copernicus, 2023).

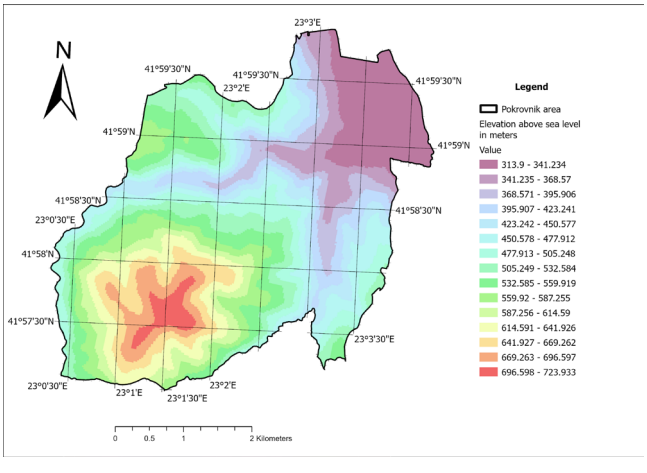

Figure 1. Digital Elevation Model (DEM) of the Pokrovnik village, Blagoevgrad region, Bulgaria

Descriptive statistics of the soil properties is presented.

The software used is ArcMap 10.2 and Statgraphics Centurion 18.1.01 using the inverse distance weighting method (IDW) (default parameters: power 2, 10 neighbors). IDW is used because of the small number of points. In IDW in comparison to kriging no statistical models are used without spatial autocorrelation and only known z values and distance weights are used to determine unknown areas. In IDW there is a relationship between the predicted point and the sampled points within the defined neighborhood based on the distance decay, where the influence of sampled points on the prediction increases as they approach the predicted point (Yasrebi et al., 2009).

Results and discussion

Georeferenced maps of Pokrovnik village, Blagoevgrad region in UTM 35N WGS 84 are presented. Sixteen soil differences are analyzed. The major soil types present in Pokrovnik according to the Bulgarian soil classification (Boyadzhiev, 1994) are Cinnamonic forest soils with average level of erosion, alluvial and delluvial soils with average depth. Cinnamonic forest soils in the Bulgarian soil classification correspond to Cambisols in the World Reference Base for Soil Resources (IUSS Working Group WRB, 2015; Teoharov et al., 2019; IUSS Working Group WRB, 2022). Other soils of significance in the area correspond to Fluvisols (IUSS Working Group WRB, 2015; Teoharov et al., 2019; IUSS Working Group WRB, 2022).

Table 1. Descriptive statistics of Pokrovnik village soils

	Clay sum<0,01	*pH(H2O)*	*Humus %*	*Total depth (cm)*
Count	16	16	16	16
Average	35.65	6.74375	1.8925	47.0625
Standard deviation	8.0909	0.476051	0.547278	31.5288
Coeff. of variation	22.6954%	7.05915%	28.9183%	66.9934%
Minimum	22.7	6.0	0.97	16.0
Maximum	46.7	7.6	2.89	100.0
Range	24.0	1.6	1.92	84.0
Stnd. skewness	-0.639495	0.273888	0.452276	1.06955
Stnd. kurtosis	-0.989492	-0.906274	-0.396704	-0.972337

The descriptive statistics of the properties is presented in the following Table 1. There is comparable similarity between the properties of the soil situated in the agricultural lands of Pokrovnik village. Standardized values of skewness and kurtosis are inside the range of +2 and -2 so there are no significant departures from normal distribution. Number 14 the shallow Cambisols (Cinnamonic forest soils) that have the lowest level of particles with less than 0.01 mm 22.7% also have medium to high erosion. The soils with the highest percentage of clay are number 16. They are Cambisols (Cinnamonic forest soils) with low to medium erosion. The soils with the most acidic reaction are number 2. This is relative because the soils minimum and maximum pH in Pokrovnik is between 6.0 and 7.6 – moderately alkaline and moderately acidic. Number 2 are Cambisols (Cinnamonic forest soils) with low to medium level of erosion. Number 15 is the most alkaline soil in Pokrovnik with pH in aqueous solution 7.6 and is represented by Fluvisols (Alluvial meadow soils) with medium depth. These soils are Fluvisols according to the WRBSR (IUSS Working Group WRB, 2015; Teoharov et al., 2019; IUSS Working Group WRB, 2022). It also produces effervescence with hydrochloric acid. Regarding humus content (%), the soil with the lowest level of humus is number 1 with level of 0.97% and with the highest is number 10 with level of 2.89%. The total depth varies. This is soil in the environment. The results may indicate the different types of soil, the closeness to a river and can be affected by anthropogenic activity.

Figure 2 indicates the location of Pokrovnik along the other objects – mountains, rivers, populated places.

Figure 2. 3D location of Pokrovnik village, Blagoevgrad region, Bulgaria

The Inverse distance weighting (IDW) map of the clay content, soil reaction and humus are presented below. The areas with the highest clay are in the southwestern part, and with the lowest in the northeastern close to the river Struma. There is more erosion, less clay and more sandy soils. The soil with the highest clay content has a grainy crumbly structure. The formation of clay processes sialitization, ferritization and fersialitization can be expected in Cambisols (Teoharov et al., 2019). (Figure 3).

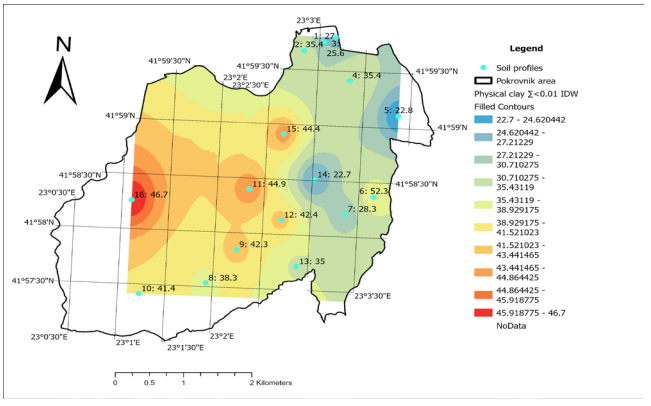

Figure 3. Inverse distance weighting map of clay content, Pokrovnik village, Blagoevgrad region, Bulgaria

The data shows that closer to the river there are more sandy soils. The well-developed soils have more clay content and can be used for agricultural crop production. They are located in the central and eastern part.

The areas that are the most basic are in the north-eastern and central parts comprising Fluvisols soils with an average depth and the most acidic in the south – Cambisols and Fluvisols. In the south the elevation is higher. (Figure 4).

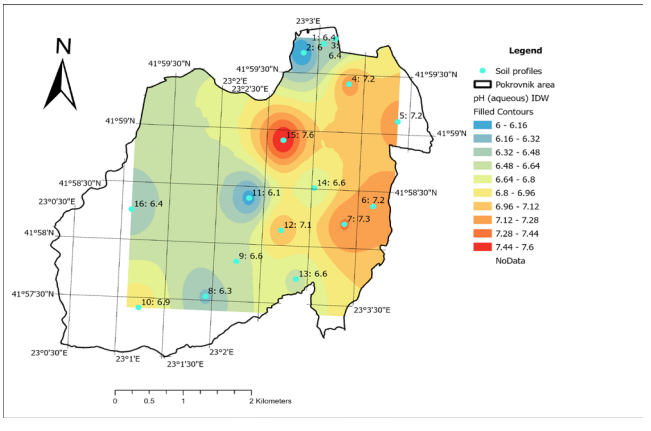

Figure 4. Inverse distance weighting map of soil reaction in aqueous solution, Pokrovnik village, Blagoevgrad region, Bulgaria

Soils with the highest humus content are in the southeast and southwest of the area. In the acidic soils there is less humus content as is in the northern part, they are also shallow and stony (Figure 5).

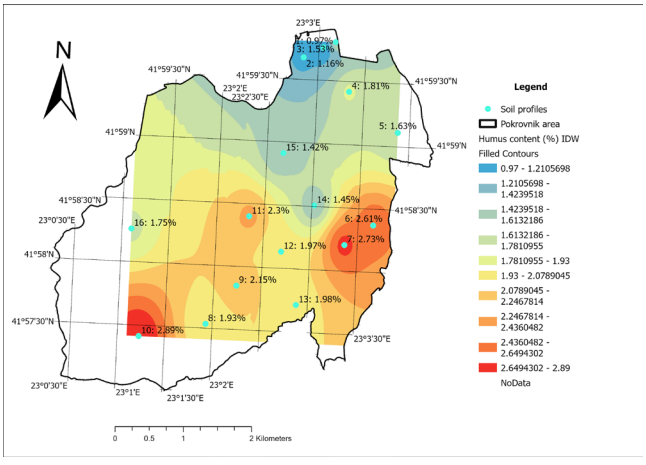

Figure 5. Inverse distance weighting map of humus content, Pokrovnik village, Blagoevgrad region, Bulgaria

The soils in the center and northern part have the highest total depth relative to the other soils. A soil with the lowest depth is soil profile 3 that also has a high a stone content (Figure 6).

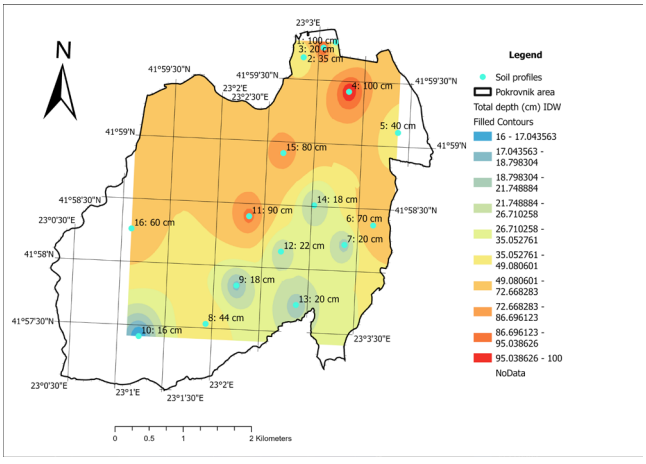

Figure 6. Inverse distance weighting map of total depth, Pokrovnik village, Blagoevgrad region, Bulgaria

Conclusion

The research objectives have been accomplished. From a research perspective the similarities between the different profiles indicate the homogeneity of the soil resource in the area of research. Balanced soils compared to the others are the Fluvisols with moderate depth and moderate clay content. Every crop has different requirements.

As an applied result, the combined physical and chemical properties and their geospatial distribution can be an aid in decision making about resource utilization and can be used for monitoring changes in time. In that way it is becoming a spatiotemporal distribution which can be done in further research. More soil profiles can be analyzed on the terrain and laboratory for a deeper understanding and in that case other methods such as kriging can be used.

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