АГРОЭКОЛОГИЯ

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ГЕОЭЛЕКТРИЧЕСКИЕ ИЗМЕРЕНИЯ В СОЧЕТАНИИ С ТРАДИЦИОННОЙ ПОЛЕВОЙ КАРТОГРАФИЕЙ КАК СРЕДСТВО СНИЖЕНИЯ ТРУДОЁМКОСТИ ПРИ КАРТОГРАФИРОВАНИИ ЗЕМЕЛЬНЫХ УЧАСТКОВ

GEOELECTRIC MEASUREMENTS COMBINED WITH TRADITIONAL FIELD MAPPING ENABLE SAMPLE REDUCED SITE MAPPING

Ключевые слова: *цифровая картография почв, геоэлектрическая проводимость, кластерный анализ, разность почвы, карта поля.*

Необходимым условием для успешного точного земледелия является знание вариаций свойств почвы (таких как разновидность почвы). Например, ограниченный песчаный участок должен быть обработан другим способом, чем участок с торфянисто-песчаной или суглинистой почвой. Оценка участка с использованием классических методов взятия почвенных проб спиральным буром будет очень трудоёмкой. Используя приборы для геоэлектрического тестирования и статистическую интерпретацию (кластеризацию) полученных результатов, взятие проб почвы можно свести до минимума. Посредством кластерного анализа полученные геоэлектрические величины группируются по классам. Величина электрической проводимости в классах различна. Относительно крупные участки, отнесённые к разным классам, впоследствии исследуются традиционным способом. В сравнении с систематической пространственной схемой взятия проб это означает значительное сокращение объёма работы без ущерба качеству. Приведённый в работе пример показывает, что метод кластеризации позволяет осуществлять маломасштабное моделирование ограниченных участков.

Keywords: *digital soil mapping, geoelectric conductivity (EC), cluster analysis, type of soil, small-scale field map.*

A prerequisite for successful precision farming is the knowledge of small scale variations in the soil (e.g. soil type). For example a partial area with sand should be farmed in a different way compared to an area with peaty sand or loamy soil. Based on the classical soil sampling techniques by using an auger sampler a site assessment would take a lot of effort. By using geoelectric test sets and statistical interpretation (clustering) of the obtained results the soil sampling can be minimized. Through a cluster analysis the obtained geoelectric values are grouped in classes. The electrical conductivity (EC-value) differs in different classes. Relatively large areas allocated to different classes are subsequently probed in the traditional way. Compared to a systematic spatial sampling scheme this means a dramatic reduction of work without compromising quality. The example presented here shows that the clustering method allows for a small scale patterning of partial areas.

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Introduction

The agriculturally oriented pedological field mapping of agricultural crop land aims for an evaluation of an area or partial area with respect to crop production. A correlation between the soil type and the yield level exists (e.g. Scheffer & Schachtschabel 2002). To take advantage of this knowledge a soil map has to be used. The goal of the mapping described herein is the small scale assessment of the soil type and the organic matter content, respectively. In the presented example a classical soil sampling using an auger sampler at specific sites has been performed. To minimize the effort the sampling has been guided by three different geoelectric test sets. The electrical conductivity (EC-value) of the soil has been recorded. The relationship between EC-values and soil type as well as organic matter content is well known. (see e.g. Hinck, 2009; Jung et al. 2005; Perron et al. 2002; Johnson et al. 2001; Baton et al. 1997). But it is also known, that different EC-values merely indicate different soil characteristics (e.g. soil type, organic matter content) (Lьck et al. 2002). The actual reason for EC-value differences has to be investigated by subsequent mapping in the field.

Using cluster analysis, classes of EC-values may be defined. Subsequently these classes are used to set out partial areas. These partial areas exhibit differences in harvest potential, soil type or nutrient content. (see e.g. Altdorff & Dietrich 2010; Guastaferro et al. 2010; Hinck et al. 2009; Hinck et al. 2006)

Materials and methods

Studied area. The examination has been carried out in the Elbe-Weser region in the local subdistrict Ebersdorf on a field called „Eschkorn" which has a size of 11.7 ha. From the German soil taxation map the soil type has been expected to be peat, sand (partially above peat), see fig. 1. The soil types have been established through the glacial period (sand) and the Holocene (moor), see fig. 2. Till the 1980s the area was used as grassland for dairy cattle. Since then it is used as cropland.

Used geoelectrical measurement systems. The two commercially available systems EM 38 (horizontal mode) and Veris 3100 have been used besides our own system BOs-1EP. EM38 and Veris 3100 have been used March 3, 2012 while BOs-1EP has been used April 4, 2012. The obtained EC-values reflect different depths from the soil surface as given in the following table:

System	mode	depth from surface
EM 38	horizontal mode	0-60 cm
Veris 3100	measurement set-up shallow	0-30 cm
Veris 3100	measurement set-up depth	0-90 cm
BOs-1EP	direct measurement in the top soil	0-8 cm

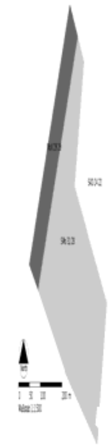

Figure 1. German soil taxation map of the field „Eschkorn" (reference: LBEG)

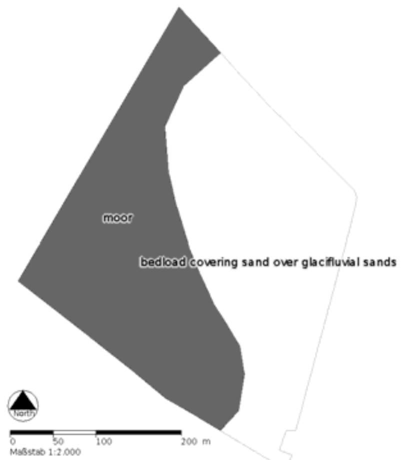

Figure 2. Geological map of the field „Eschkorn" (reference: LBEG)

Processing of obtained data. The measurement results have been edited by means of the GIS-program OPENJump and interpolated using the Kriging method (Brьning et al. 2007). Separation of the partial areas has been performed using cluster analysis (k-mean method). The specific locations for the sampling using an auger sampler have been chosen following the cluster analysis. The soil type has been determined by finger test.

Results

From the measurement results it becomes clear that the area can be divided in small scale partial areas by using the EC-values and the auger sampler mapping. The zones dominated by sand are identified by all of the three measurement systems through the low level of the EC-value. Sand above peat and peat are characterized by medium and high leves of the EC-value, respectively. The spatial distribution of the EC-values given by the three systems is very similar (see Tab. 1). Please note that the EC-values from EM 38 und Veris / depth reflect mainly the situation within one meter from the surface. The so called shallow measurements reveal differences in the top soil (0-30 cm depth) in greater detail.

Table 1

Comparison of the EC-values from the three measurements systems (Spearman Correlation coefficient)

	BOs-1EP	Veris/ shallow	Veris/ depth	EM 38/ hor. mode
BOs- 1EP	1	0,73	0,67	0,70
Veris/shallow		1	0,90	0,89
Veris/depth			1	0,92
EM 38/hor. mode				1

The cluster analysis yields three clusters for the deep measurements and four clusters for the shallow measurements. The spatial distribution of the clusters exhibits very similar results for the four measurements presented here. The shallow measurements show more detailed structures in areas with low EC-values in comparison to the deep measurements. The results obtained by the BOs-1EP show larger clusters for low EC-values compared to Veris 3100 in the shallow mode. As an example the mapping of the results obtained for the top soil is shown in fig. 3 to fig. 6.

19 locations have been selected for soil sampling by an auger sampler. The exact position of those locations has been chosen based on the cluster classes (see fig. 7 and fig. 8).

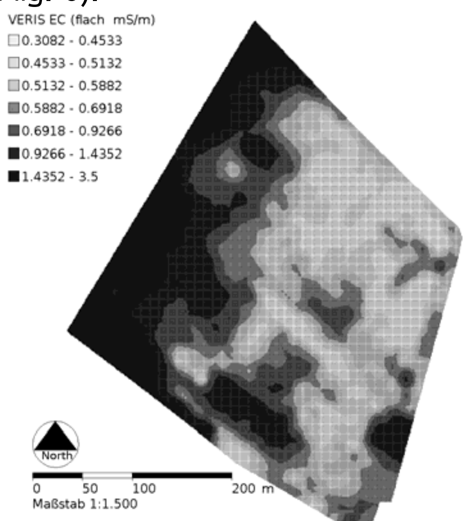

Figure 3. EC-value Veris/shallow (0-30 cm measurement depth)

Locations exhibiting a low EC-value, represented by cluster 1, generally exhibit sandy soil. EC-values in the medium range (cluster 2) may represent transition regions to areas with high EC-values. Areas with medium EC-values surrounded by low EC-value areas represent sand with high peat content or peaty sand.

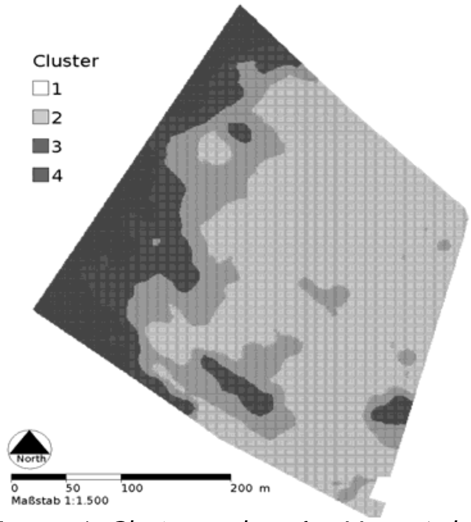

Figure 4. Cluster analysis for Veris / shallow

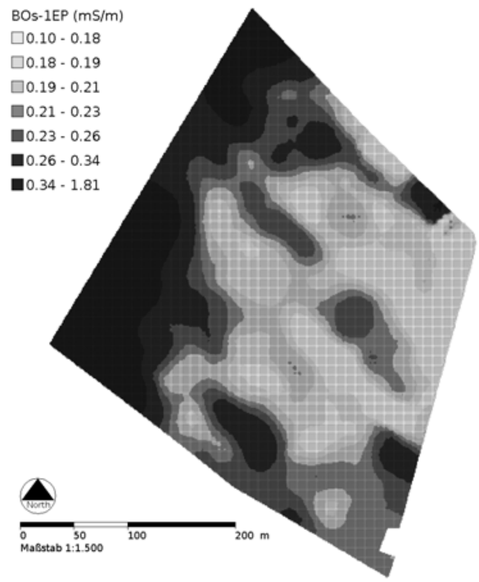

Figure 5. EC-value BOs-1EP (0-8 cm measurement depth)

Figure 6. Cluster analysis for BOs-1EP

Clusters 3 and 4 in the shallow measurement in the top soil correspond to peaty soil (see fig. 7 and 8).

Sampling point 19 shows a noticeable behaviour no matter which measurement system has been used. This is a deposit site for cattle manure. The soil type there is sand.

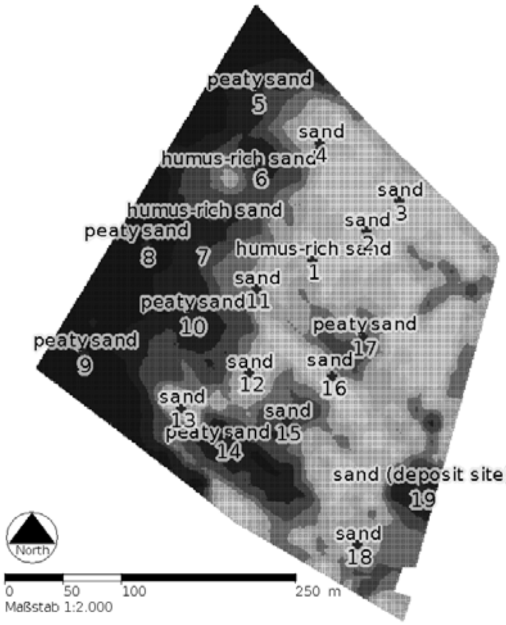

Figure 7. EC-value Veris / shallow (0-30 cm measurement depth) and mapped soil type (top soil (0-30 cm)

The high EC-values can be explained by nutrient-rich leakage water from the deposit. In that way nutrients may be concentrated in the soil leading to elevated EC-values (see fig. 7 and fig. 8).

Mapping point 15 shows a medium level EC-value using Veris/ shallow. At this very location sand above peat has been found (see fig. 7). Using BOs-1EP a low EC-value has been found. The sandy top soil has been correctly recognized there (see fig. 8).

Contrary to this finding the BOs-1EP system detected a medium EC-value at mapping point 4 where sand has been found again.

For mapping location 1 the sandy soil with high organic matter content is clearly detectable using BOs-1EP through medium EC-values (cluster 2) surrounded by low EC-values (cluster 1) (see fig. 8). Veris and EM38 failed to detect this special spot.

Using information from the German soil taxation map, EC-values, cluster-analysis and classical mapping using an auger sampler, a small scale field mapping of the top soil type can be generated. The procedure is scetched in figure 9.

In our example presented herein the following correspondence has been found:

Cluster 1 sandy soil
Cluster 2 sand soil with high content of organic matter or peat
Clusters 3 and 4 peaty sand (see fig. 10).

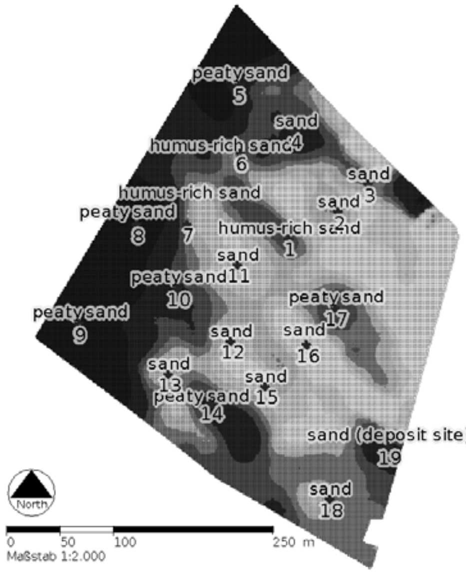

Figure 8. EC-value BOs-1EP (0-8 cm measurement depth) and mapped type of top soil (0-30 cm)

The generated small scale soil field map is much more detailed than the German soil taxation map (see fig. 1 and fig. 10 for comparison).

Discussion

Through geoelectric measurements small-scale disparities within an area can be seen. In the context of this investigation the evaluation of measured EC-values clearly points to variations of the soil type (sand or peat) and of the organic matter content. These results have been verified using an auger sampler. Generally speaking, the higher the organic matter content of the soil the higher becomes the EC-value, as it has already been reported (e.g.: Hinck 2009, Jung et al. 2007, Banton et al. 1997).

Cluster-analysis enables the classification of EC-values by statistical means. This approach has already been used by different authors (e.g.: Altdorff & Dietrich 2010; Guastaferro et al. 2010; Hinck et al. 2009). The clusters define partial areas, which differ in their particular soil type (sand or peat) and organic matter content (peaty sand), respectively. By combining geoelectric measurements and conventional soil sampling it is possible to detect small-scale differences in soil properties. A subsequent pedological mapping facilitates a detailed interpretation. Finally an EC-value may be assigned to a special soil type, leading to the generation of a small-scale soil map for a special agricultural field.

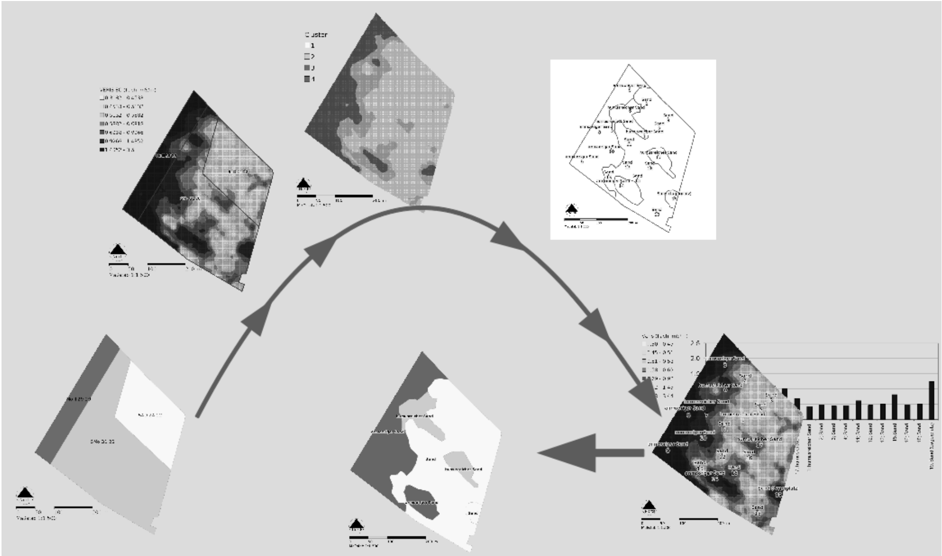

Figure 9. Procedure to generate a small-scale field map showing the soil type

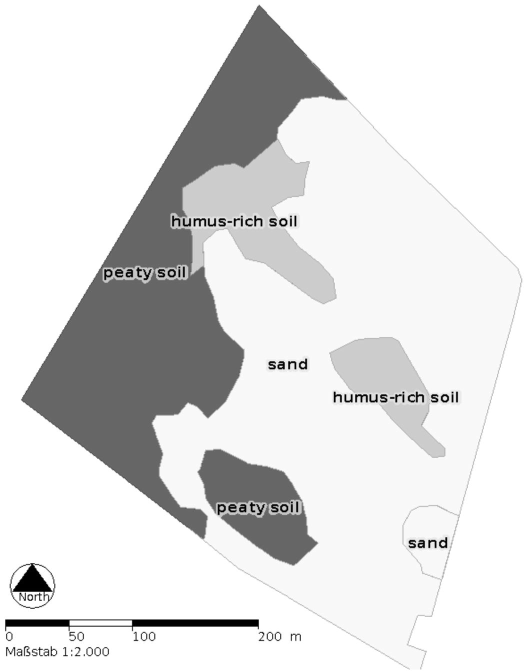

Figure 10. Small-scale field map with the soil type

A small scale soil field map may be used by the farmer for soil sampling to determine the nutrient content of the soil in the identified partial fields (with different soil types). With the knowledge of the different soil types in the partial fields, also the pH-value can be optimized. Similarly the water storage capability within a partial area may be estimated. This information should be used to assess the yield level potential.

Conclusions

The described procedural method combines the advantages of the geoelectric measurement method, which can delineate small-scale on-site variations, and the auger sampling, which delivers specific site related information, e.g. the top soil type. To achieve these advantages firstly an EC-value mapping is carried out. This map is then used to direct further specific soil mapping at selected locations. This can be done favourably using an auger sampler. The resulting soil map is highly accurate and detailed for a special field. That map contains considerably more information compared to the German taxation soil map.

The final small scale soil map is a crucial input for precision farming decisions.

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ФЕРМЕНТАТИВНАЯ АКТИВНОСТЬ ЧЕРНОЗЕМОВ УМЕРЕННО-ЗАСУШЛИВОЙ КОЛОЧНОЙ СТЕПИ В СВЯЗИ С ВНЕСЕНИЕМ НАВОЗНЫХ СТОКОВ В УСЛОВИЯХ АГРОЦЕНОЗОВ

ENZYME ACTIVITY OF CHERNOZEMS OF TEMPERATE-ARID FOREST-OUTLIER STEPPE RELATED TO THE APPLICATION OF MANURE IN AGROCENOSIS

Ключевые слова: *ферментативная активность почвы, каталаза, инвертаза, уреаза, нитрификационная способность, натуральные и кавитированнные навозные стоки.*

Ферментативная активность является одной из важнейших составляющих биологической активности почв. Синтез и разложение органических веществ, микробиологические процессы, мобилизация элементов питания растений в почве происходят в результате сложнейших реакций, обусловленных содержащимися в ней ферментами. Целью работы явилось изучение ферментативной активности почвы в связи с внесением разных доз натуральных и кавитированных навозных стоков под кукурузу, ячмень, однолетние травы. Объекты исследования: натуральные и кавитированные навозные стоки, почва – чернозем обыкновенный среднемощный малогумусный среднесуглинистый с рНв 6,8-8,9; содержание гумуса – 3,2-5,0%; нитратного азота – 7,8-27 мг/кг, подвижного фосфора – 71,5-240 мг/кг, обменного калия – 55-116 мг/кг, что соответствует низкой обеспеченности азотом, высокой – фосфором и калием. Под действием как натуральных, так и кавитированных навозных стоков в изучаемых дозах повышались содержание элементов питания в почве, ферментативная активность и нитрификационная