Geostatistical analysis of surface soil texture from Zala county in western Hungary

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Presentation Outline

Ted Soil texture and its importance

Spatial variability of soil texture components

Research problem/Research objectives

Geostatistics/Kriging applications in soil studies

Spatial Prediction of soil Clay and Sand content and their associated Uncertainty

Conclusion and Recommendations
Soil Texture and Its Spatial variability

- Relative proportion of Sand, Silt and Clay content (Sand % + Silt % + Clay % \(\approx\) 100 %)

- Physical, Chemical, Hydrological, and other importance of Soil Texture (e.g. nutrient & \(H_2O\) storage and availability)

- Soil Spatial Variability - Inherent Natural Phenomena conditioned by Geological/Pedological Settings and others (e.g. Soil Mgmt, Erosion/deposition)

- Influence of Soil Texture and its Spatial Variability on Soil Functions and Soil Threats
Research Objectives

➢ To Analyze and Describe the Spatial Variability of Soil Texture content from the Topsoil (0-30 cm)

➢ To see the applicability of Geostatistics (Ordinary Kriging technique) in mapping Soil Texture components
Description of the Study area
Soil Data Preparation

- Soil data used from ESDAC (European Soil Data Center) of the JRC
  - 100 sampling points (covering $\approx 250$ sq. km)
  - Measured Physico-Chemical Properties from each identified Pedological horizons (*From Soil Surface to the Parent material excluding litters*)

- Sand and Clay content for the topsoil (0-30 cm) was derived from weighted average calculation
Soil Data Analysis

A. Statistical Analysis

- Descriptive statistics ($\text{Min}^m, \text{Max}^m$, Mean, Std. deviation, Coef. Variance, Skewness ($g_1$), Kurtosis ($g_2$) coefficients etc.)

- Frequency Histograms

- Normality test

  - 2 Students’ $t$-tests values ($t_1$ and $t_2$) with $H_0$: $g_1=0$, and $g_2=3$ and compared with $t_{0.05,99}=1.985$

  - (Q-Q plot)
Soil Data analysis

B. Geostatistical Analysis

- Spatial autocorrelation and Variogram

\[ \gamma(h) = \frac{1}{2N(h)} \sum_{\alpha=1}^{N(h)} \left\{ z(x_{\alpha} + h) - z(x_{\alpha}) \right\}^2 \]
Soil Data analysis (B) ..... Contd.

- Experimental variogram construction and Model fitting

![Experimental Variogram](dark squares)

- Fitted Theoretical model (continuous line)

Mathematical representation of Spherical model

\[
\gamma(h) = C_0 + C_1 \{1.5(h/a) - 0.5(h/a)^3\}, \quad h \leq a
\]

\[
\gamma(h) = C_0 + C_1, \quad h \leq a
\]
Soil Data analysis (B)  

- Relative nugget effect ($RNE$)  

\[ RNE = \left[ \frac{C_0}{C_0 + C_1} \right] \times 100 \]

- Ordinary Kriging ($OK$)  

**OK Estimator**  

\[ Z^*_{OK}(x_0) = \sum_{\alpha = 1}^{n(x_0)} \lambda_{\alpha} z(x_{\alpha}) \]

**Estimation Variance**  

(Error variance)  

\[ \sigma^2_{OK}(x_0) = \sum_{\alpha=1}^{n(x_0)} \{ \lambda_{\alpha} \gamma(x_{\alpha} - x_0) \} + \psi \]
Results and discussions

A. Statistical analysis

<table>
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<tr>
<th>S.N</th>
<th>Pro</th>
<th>No.</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Stdev</th>
<th>CV</th>
<th>SK</th>
<th>KR</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Sand</td>
<td>100</td>
<td>12.28</td>
<td>79.87</td>
<td>55.48</td>
<td>14.70</td>
<td>0.265</td>
<td>-0.996</td>
<td>0.846</td>
</tr>
<tr>
<td>1</td>
<td>Clay</td>
<td>100</td>
<td>5.24</td>
<td>60.54</td>
<td>21.36</td>
<td>9.55</td>
<td>0.447</td>
<td>1.514</td>
<td>3.410</td>
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<tr>
<td>2</td>
<td>Sand</td>
<td>99</td>
<td>12.28</td>
<td>75.03</td>
<td>55.24</td>
<td>14.56</td>
<td>0.263</td>
<td>-1.014</td>
<td>0.877</td>
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<tr>
<td>2</td>
<td>Clay</td>
<td>99</td>
<td>5.24</td>
<td>49.47</td>
<td>20.97</td>
<td>8.73</td>
<td>0.41</td>
<td>1.198</td>
<td>2.095</td>
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</table>

Histogram of Sand content (n=99)

Histogram of Clay content (n=99)
Results and discussions (A) ..contd

- Q-Q Plot with and without outlier (e.g. clay content)

- Normality check with Students’ $t$-test value

<table>
<thead>
<tr>
<th></th>
<th>Sand</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_1$</td>
<td>-4.12</td>
<td>4.86</td>
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<tr>
<td>$t_2$</td>
<td>-4.31</td>
<td>-1.83</td>
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</table>
Results and discussions

B. Geostatistical analysis

- Variogram cloud (Influence of outlier)
Results and discussions (B) .....contd

- Experimental variogram and fitted theoretical model (with variogram parameter values)

\[ C_0 = 35 \]
\[ C_0 + C_1 = 104 \]
\[ a = 2140 \]

\[ C_0 = 68 \]
\[ C_0 + C_1 = 228 \]
\[ a = 1960 \]

\[ RNE = 29.82 \% \] for sand content and 33.6 \% for clay content
Results and discussions

- Predicted maps - sand with associated variance (OK)
Results and discussions

- Predicted maps-clay with associated variance (OK)

![Clay distribution map](image1)

![Clay standard error map](image2)
Conclusions and Recommendations

- Our results show the application of Geostatistics (Ordinary Kriging technique) to study and analyze the spatial pattern of soil texture contents.

- The predicted maps thus produced could be useful for farm managers to design and implement any further land management and soil and water conservation plans.

- This result would also be of great interest to the Environmental scientists, Water quality and resources engineers, Climatologists and Decision makers.

- The mapping of either variables could be improved using co-variables like land use, topographic parameters and any other data influencing soil texture distribution.
Thank you for your attention!