

Olive groves soil geochemistry of the island Brač

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KNOWLEDGE FUND

Introduction

The island of Brač (picture 1.), located in the central part of the Adriatic Sea, is part of the central Dalmatian island group. Olive oil is one of most important agricultural product of the island. The complex pedological structure of the island is caused by a great variability of its karst features. Multielemental composition of soils is primarily inherited from the parent material. Dominant parent materials on island Brač are carbonate sedimentary rocks, limestone and flysch. Trace metals occur naturally in rocks and soils, but increasingly higher quantities of metals are being released into the environment by anthropogenic activities. The objective of this study was to determine geochemical soil composition (multielemental analysis) of major soil types (anthropogenically modified lithosol, terra rossa-rhodic cambisol and rendzic leptosol) on which the olive trees are cultivated.

Materials and methods

Topsoil (0-30 cm) and subsoil (30-60 cm) samples were collected from island Brač and their basic chemical and physical properties were determined. Locations were selected according to soil type and parent material. 7 olive groves were included in study: 3 in Nerežišća on terra rossa developed from limestone, 2 in Bol on rendzic leptosol developed from flysch and 2 in Postira on anthropogenically modified lithosol developed from limestone.

The multielement analysis of soil samples was performed by High Resolution Inductively Coupled Plasma Mass Spectrometry (HR ICPMS) using an Element 2 instrument (Thermo, Bremen, Germany). Prior to multielement analysis subsamples (0.05 g) of soils were subjected to total digestion in the microwave oven in a two-step procedure consisting of digestion with a mixture of 4 mL nitric acid (HNO₃) - 1 mL hydrochloric acid (HCl) - 1 mL hydrofluoric acid (HF) followed by the addition of 6 mL of boric acid (H₃BO₃) (Fiket et al. 2016). After digestion soil samples were further diluted 10-fold, acidified with 2% (v/v) HNO₃ and indium (In, 1 µg/L) was added as internal standard. All samples were analyzed for total concentration of 45 elements (Al, As, Ba, Be, Bi, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Gd, Ho, K, La, Li, Lu, Mg, Mn, Mo, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Sm, Sn, Sr, Tb, Ti, Tl, Tm, U, V, Y, Yb, Zn and Zr). Plant available elements (K, Ca, Mg and Mn) were determined on ICP-MS after extraction with 1M NH₄NO₃.

Results and discussion

The concentrations of elements (table 1.) in the soil at all three locations are consistent with literature sources (Geochemical Atlas of Europe-FOREGS). If we compare each location separately, elements concentrations did not significantly differ for the analyzed samples (1-2-3 for Nerežišće, 1-2 Bol and 1-2 for Postira), with RSD <20% (normal variability in soil) for most elements. Because of different parent material (flysch) what result in distinct soil texture characteristics values of most elements from the location Bol are lower than those measured for other two locations, with the exception of Ni, Sr and Cr. Chromium is the only element that is present in the all soil samples in approximately equal concentrations, regardless of location. Different fertilization history could be reason for higher values and variability of K on all locations. Higher values of Cu on location Nerežišće and Bol are result of the intensive application of Cu fungicides in last decades. Plant available K (table 2.) correlate with total soil K, while available Mg showed lower concentration on Bol due to high carbonate content.

Picture 1. Map of island Brač and locations of olive groves



Conclusion

Obtained results demonstrate how different soil types developed from different parent material of the studied olive growing region differ in geochemical composition. Such differences should be one of the mayor factors causing differences in olive oil multielemental composition and consequently one of the principal ways for establishing the olive oil geographic traceability. Anthropogenic influence (mineral fertilization and fungicide use) can cause changes in soil multielemental composition.

Table 2. Concentrations (mg/kg) of available plant nutrients of olive groves on island Brač

| | Ca | Mg | Mn | K |
|------------------|------|-----|------|-----|
| Nerežišća | 3666 | 231 | 4,71 | 479 |
| Bol | 3210 | 76 | 0,63 | 103 |
| Postira | 3830 | 229 | 0,29 | 394 |

Table 1. Concentrations (mg/kg) of selected major, trace and rare earth elements of olive groves on island Brač

| | Na | Mg | K | Al | Fe | Mn | Mo | Li | Sn | Pb | Cr | Cu |
|------------------|------|------|-------|-------|-------|------|-------|-------|------|-------|--------|-------|
| Topsoil | | | | | | | | | | | | |
| Nerežišća | | | | | | | | | | | | |
| AVG | 5606 | 5199 | 10518 | 65880 | 36155 | 1140 | 1,27 | 52 | 3,97 | 47,82 | 135,03 | 56,71 |
| STD | 1034 | 559 | 1989 | 6195 | 3566 | 212 | 0,16 | 6,82 | 0,40 | 6,59 | 12,81 | 16,90 |
| RSD | 18 | 11 | 19 | 9 | 10 | 19 | 12,32 | 13 | 9,97 | 13,79 | 9,48 | 29,80 |
| Bol | | | | | | | | | | | | |
| AVG | 2643 | 5371 | 6004 | 27364 | 17917 | 502 | 0,31 | 18,16 | 1,62 | 18,04 | 135,37 | 42,80 |
| STD | 467 | 773 | 1805 | 3194 | 2208 | 44 | 0,05 | 2,03 | 0,15 | 1,89 | 27,39 | 7,20 |
| RSD | 18 | 14 | 30 | 12 | 12 | 9 | 16 | 11 | 9 | 10 | 20 | 17 |
| Postira | | | | | | | | | | | | |
| AVG | 2476 | 5202 | 9565 | 58440 | 31368 | 956 | 1,77 | 49,67 | 3,45 | 46,43 | 127,39 | 25,22 |
| STD | 271 | 2399 | 2222 | 7088 | 3490 | 270 | 0,63 | 5,50 | 0,36 | 4,03 | 20,08 | 4,86 |
| RSD | 11 | 18 | 23 | 12 | 11 | 19 | 17 | 11 | 10 | 9 | 16 | 19 |
| Subsoil | | | | | | | | | | | | |
| Nerežišća | | | | | | | | | | | | |
| AVG | 3634 | 6997 | 26661 | 99096 | 48301 | 1464 | 1,69 | 71 | 3,66 | 35,47 | 155,59 | 55,19 |
| STDEV | 710 | 932 | 3745 | 17338 | 6385 | 305 | 0,26 | 11,82 | 0,43 | 4,34 | 21,91 | 14,66 |
| RSD | 20 | 13 | 14 | 17 | 13 | 21 | 16 | 13 | 12 | 12 | 14 | 27 |
| Bol | | | | | | | | | | | | |
| AVG | 2179 | 8752 | 16550 | 43771 | 24240 | 679 | 0,40 | 22,61 | 1,29 | 13,75 | 184,65 | 43,40 |
| STDEV | 564 | 1107 | 2027 | 2268 | 2137 | 51 | 0,03 | 1,92 | 0,25 | 1,98 | 30,12 | 5,33 |
| RSD | 26 | 13 | 12 | 5 | 9 | 7 | 9 | 9 | 19 | 14 | 16 | 12 |

Acknowledgments:

We greatly appreciate financial support from the Unity through knowledge fund(UKF grant: 1B, contract no. 23/15.).