Detection and quantification of microplastic in soil using a 3D Laser Scanning Confocal Microscope

Tabea Zeyer and Peter Fiener, University of Augsburg
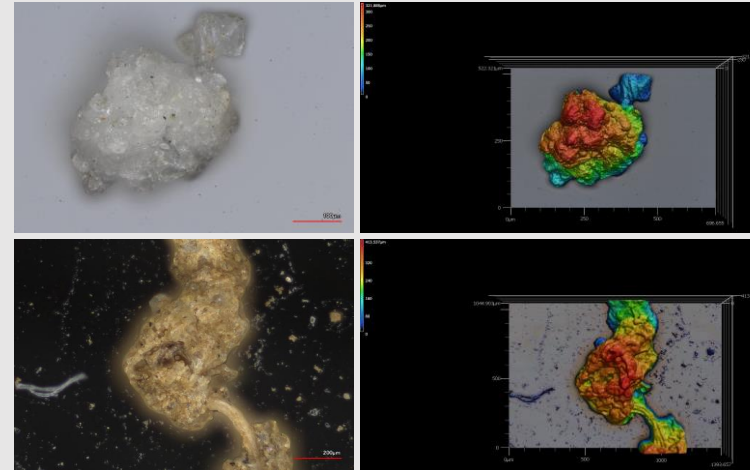
Functional Surface 🤖 – click [⬉]

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INTRODUCTION

Three major challenges in detection of microplastics in soil:

I. **Extraction:** The separation of plastic particles from soil matrix.

II. **Detection:** The measurement is disturbed by residues from the soil matrix.

III. **Particle size analysis:** The analysis of a comparable unit for the unshaped microplastic particles - necessary ecotoxicology data.

👉 **A robust method** to determine microplastic in soils with an extensive particle size analysis **is needed.**

💡 **3D Laser Scanning Confocal Microscope** (Keyence VK-X1000, Japan):

- **Shows differences for microplastic and soil particles:**
  - Optical
  - Surface characteristics (roughness)
- **Robust against disturbances:**
  - Residues from the soil matrix
  - External vibrations
- **Non-destructive method**

🎯 To produce a **robust, operational and automated method** for the analysis and detection of microplastics in soil with an extended particle size analysis.

Plastic fiber

Soil aggregate
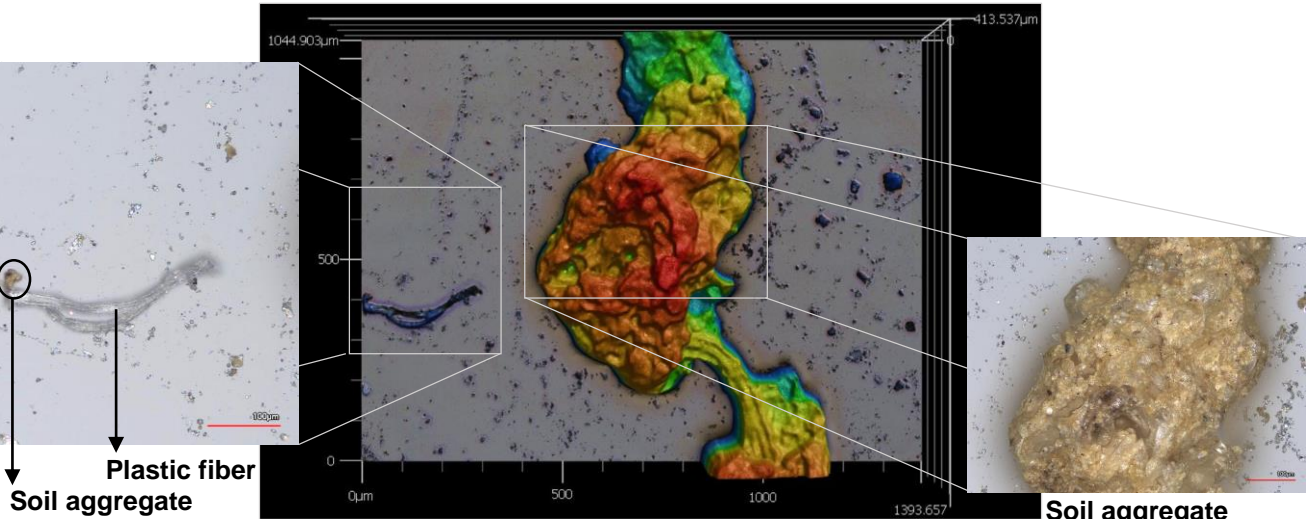
Soil aggregate

A plastic fiber and residues from the soil matrix (soil aggregates and inorganic soil particles) in 240 times zoom, after a separation process.

MATERIALS AND METHODS

Universität Augsburg University

Mic Bin

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

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MATERIALS AND METHODS

SOIL PROPERTIES

Loamy sand:
72% sand, 18% silt,
10% clay, 0.9% organic carbon
Homogenized ⌀ 2 mm

MICROPLASTIC

High Density Polyethylene (HDPE)
50 – 100 µm; 250 - 300 µm

SAMPLE PROCESSING – DENSITY SEPARATION

I Mixing
20 gram soil
+ 400 ml dist. H_2O
(Ultrasonic bath)

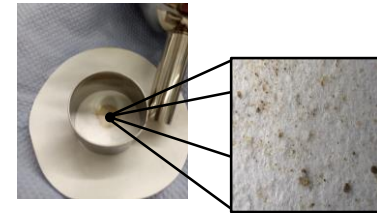**II Centrifugation**
2 min – 2000 g

III Freezing
~ 8 h
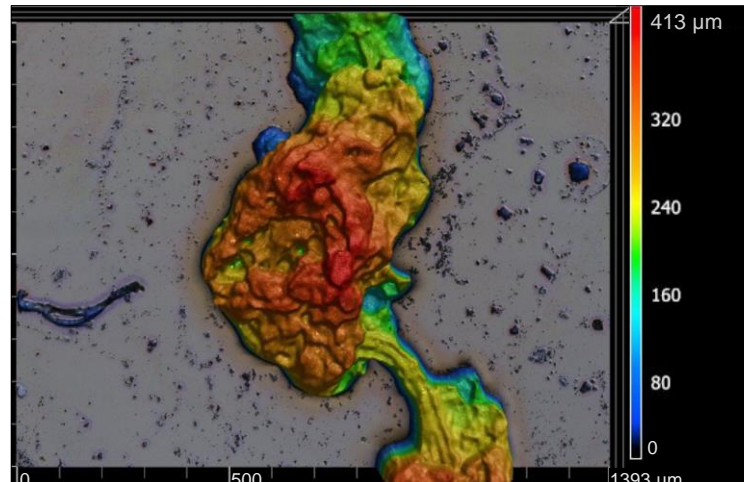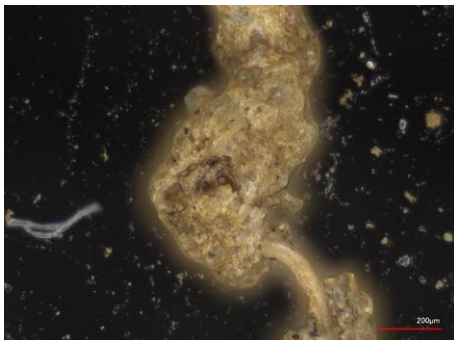
IV Separation
Cut off the upper layer

V Concentration
Melting it in a funnel to a paper filter - ⌀ 1 cm circle area

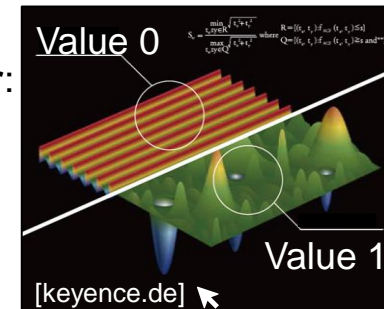## 3D LASER SCANNING CONFOCAL MICROSCOPE (Keyence VK-X1000, Japan)

- Depth of field
- Semiconductor:
  Laser 404 nm

413 µm
320
240
160
80
0 µm

0   500   1393 µm

Analysis tool: VK-X 1000 Multiple File Analyzer

- It determines surface characteristics using a **surface roughness parameter.**

- For example, the **Str-Parameter**:

  - Specifies the aspect ratio of the surface creases

  - The smaller the parameter, the uniform the creases.

Value 0

Value 1

[keyence.de]

PRELIMINARY RESULTS

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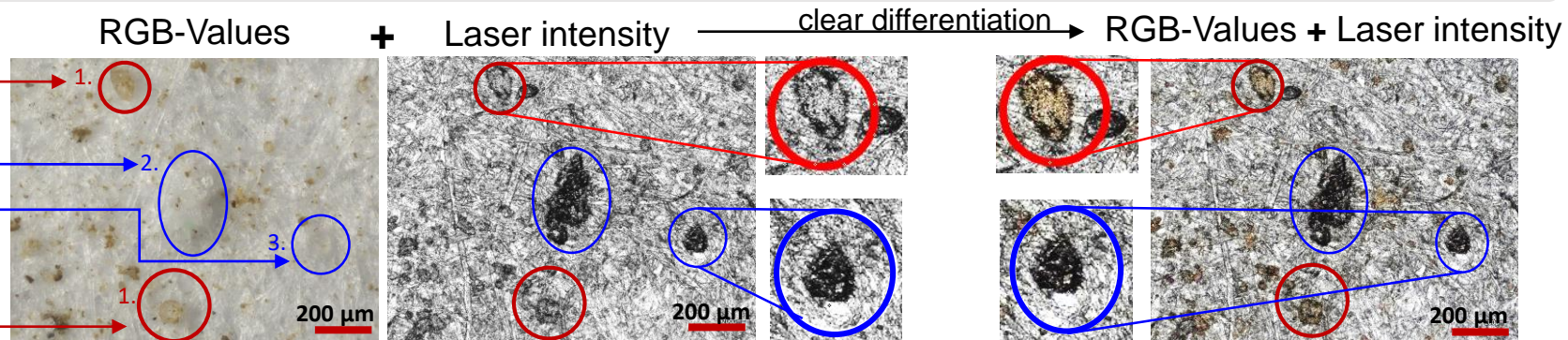BMBF

PRELIMINARY RESULTS
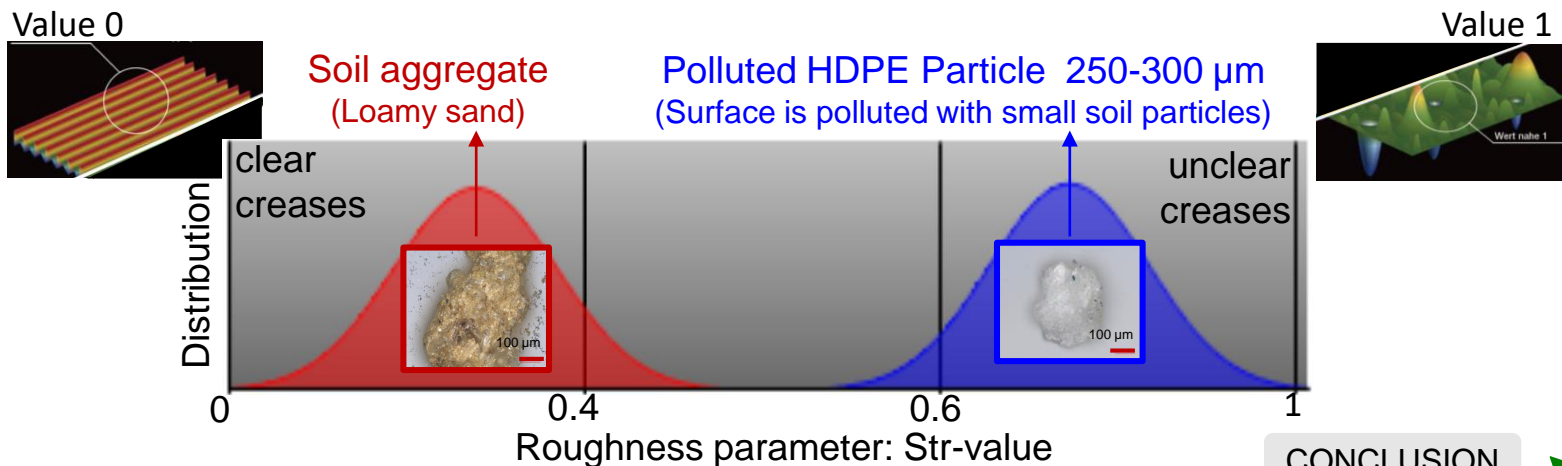
Optical results (x 240 zoom)

Section of a sample:

1. Inorganic soil particle (light fraction)
2. Aggregate of HDPE 50 - 100 µm particles
3. HDPE 50 - 100 µm particle

Background: White paper filter

Surface characteristic (x 240 zoom)

RGB-Values + Laser intensity → clear differentiation → RGB-Values + Laser intensity

200 µm

Surface roughness parameter (Str-Parameter)

Value 0

Value 1

Soil aggregate (Loamy sand)

Polluted HDPE Particle 250-300 µm (Surface is polluted with small soil particles)

clear creases

unclear creases

100 µm

100 µm

Distribution

0   0.4   0.6   1

Roughness parameter: Str-value

CONCLUSION

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CONCLUSION

Compared to previous methods, 3D laser scanning confocal microscopy can provide an robust, automated and operational analysis to detect microplastic in soil, but **more research is needed**

SUMMARY

Sample material:
- **Agriculture bulk soil**

Sample processing:
- **Density separation**

No hazard substances

Robust measurement device

Combinability with other methods
- **Non-destructive method**
- For example a combination with **mass spectrometric methods**

Quantification:
- **Optical diffrences**
- **Surface characteristics**
- **Particle size**

Limitation:
- **Max. 20 gram sample**
- **Resolution:** $\updownarrow$ **0.5 nm and** $\leftrightarrow$ **1 nm**

Time:
- **~ 2 h / scan**
- ∅ 1 cm circle area with a x 240 zoom

NEXT STEPS

- Data processing to **result in number and mass** of microplastic particles with:
  - Cloud Compare
  - Neural networks or machine learning

- **Validation runs** to obtain a comparison of previous methods
  Materials:
  - Sandy and clayey soil
  - HDPE 50 - 100 and 250 - 300 µm
  - LDPE < 50 and 200 - 800 µm
  - PS <100 µm
  - PBAT/PLA < 2 mm

- Analyzing **weathering processes in soil**

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