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## WP3 DigiOmica collaborative learning in Integrated omics for environmental sustainability

Module 8: *Genomics approach to develop soil  
biomarkers*

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- **Educational goals:** the aim of this module is to present knowledge about the
  - Use of microorganisms as soil health biomarkers
  - Theoretical and practical insights in genomics/metagenomic studies of soil microbial communities
  - Modern applications of genomics towards soil health: One-Health approach, ecogenomics, and global inventory of soil microbiome

## ➤ Summary

Soil is responsible for providing Earth's ecosystems with vital services for their existence. Human activities and climate change effects negatively affect soil health. There is an urgent need for strategies empowering the minimization of these impacts and protecting the soils. A rational approach is the employment of bioindicators to characterize variations in soil health. Microorganisms are versatile biomarkers of soil health since soil microbiome responds rapidly to environmental changes. The application of genomics/metagenomics tools contributes to revealing the full potential of these biomarkers. Genomics/Metagenomic studies of soil microbial communities highlight the structural and functional microorganisms' diversity, species identification, characterization of new genes, and discovery of enzymatic activities and active compounds. Guided metagenomics (metabarcoding), shotgun metagenomics, One-Health approach towards soil health, eco-genomics, and global inventory of soil microbiome are impactful techniques that allow for exploration of the biodiversity, community structure, and potential functions of the soil microbial communities.

- **Expected learning outcomes:** Upon completion of this Module the learners will be able to:
  - Present the metagenomics as a bioindicator tool for soil health evaluation
  - Use soil metagenomics for association of specific members to the microbial communities with transformations that certain soils are experiencing
  - Understand the guided metagenomics (metabarcoding) principles and its advantages and disadvantages
  - Uprise the shotgun metagenomics technique to understand taxonomic composition and functional potential of soil microorganism communities
  - Use metagenomics approach in approximations of “OneHealth” and EcoGenomics

## ➤ **Provisional Table of contents:**

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5. Recommendations (conclusion)
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## ➤ Presentation of the learning content

### 1. Introduction

- **Employment of bioindicators** to characterize variations in soil health
- **Diversity of bioindicators** utilized in environmental studies (earthworms, beetle, nematode, and microorganisms)
- Proposed **methods** from the International Standardization Organization (ISO) **for analyzing soil quality**

## ➤ Presentation of the learning content

### 2. Findings

#### 2.1 Microorganisms – biomarkers of soil health

➤ **Soil microbiome** responses rapidly to environmental changes – literatures review and exemplary studies

➤ **“Golden ages”** of the study of soil bacteria:

➤ **Microorganisms’ importance** in the vital nutrient cycling

➤ **Metagenomics** as a tool to characterize the “non-culturable” microorganisms

## ➤ Presentation of the learning content

### 2. Findings

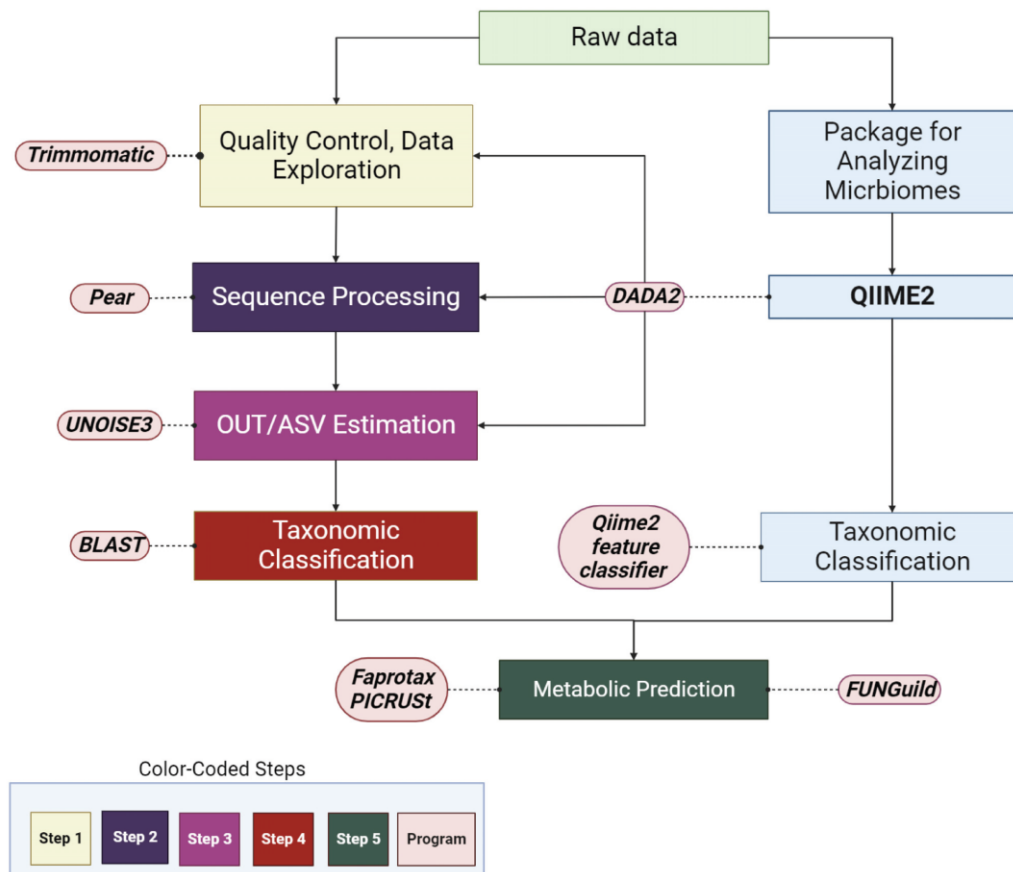
#### 2.2 Genomics/Metagenomic studies of soil microbial communities – theoretical and practical insights

- Metagenomics and its relationship with soil health:
  - Structural and functional microorganisms' diversity, species identification, characterization of new genes, and discovering enzymatic activities and active compounds
  - **Guided metagenomics** (metabarcoding) - studying the phylogenetic diversity and relative abundance of a molecular marker in an environmental sample
  - **Shotgun metagenomics** – determination of the total genomic content from a sample

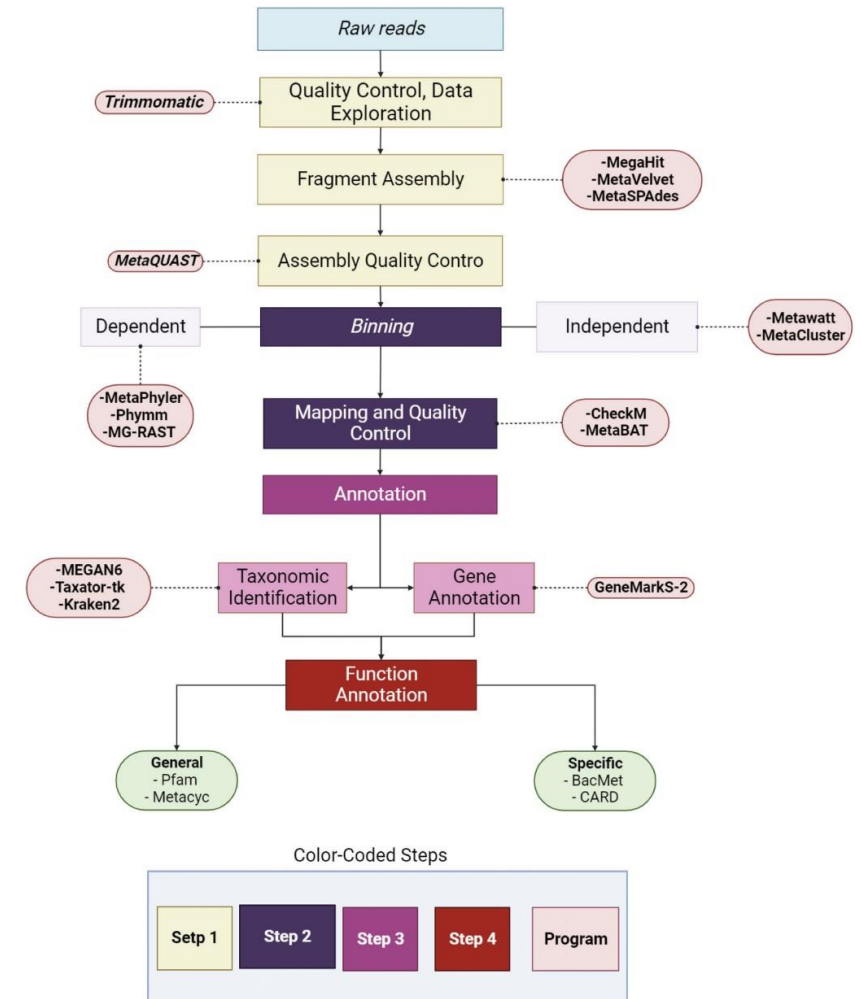


## ➤ Presentation of the learning content

### Guided metagenomics (metabarcoding)



### Shotgun metagenomics



## ➤ Presentation of the learning content

### 3. Alternatives

#### 3.1 Soil metagenomics limitations and challenges

- Physicochemical properties of the soil - the composition and function of soil microbiomes
- Research replication of the data generated
- A significant number of sequences or taxonomic units for which no information is currently available

## ➤ Presentation of the learning content

### 4. Solutions

#### 4.1 **One-Health** approach towards soil health

- Exploration of how microorganisms interact with their surroundings
- Exemplary implementation: Human Microbiome Project, variations in the H1N1 flu, and antimicrobial resistance counteract



## ➤ Presentation of the learning content

### 4. Solutions

#### 4.2 Global inventory of soil microbiome

#### ➤ The international projects TerraGenome and Earth Microbiome



## ➤ Presentation of the learning content

### 4. Solutions

#### 4.3 Ecogenomics

- **Metagenomics** allows to study the importance of the relationship between microorganisms and other living beings (plants and animals)
- **Metagenomics of wild animals** to formulate conservation strategies
- **Metagenomic study on plant phyllosphere** - phytopathology studies of microbial contribution

## ➤ Presentation of the learning content

### 5. Recommendations

- Metagenomics – an impactful technique that allows for an exploration of the biodiversity, the community structure, and the potential functions of the microbial communities from distinct environments.
- Enriching our understanding of specific groups of microorganisms and processes like bioremediation, agriculture, and human health
- Use of programs and tools integrated into bioinformatic workflows such as QIIME2, MOCAT2, and MetAMOS

## ➤ Presentation of the learning content

### 6. References

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