INTRODUCTION TO ENVIRONMENTAL MICROBIOLOGY

BARBARA KOŁWZAN
WALDEMAR ADAMIAK
KAZIMIERZ GRABAS
ADAM PAWEŁCZYK

Reviewers
Andrzej Noworyta
Zdzisław Szulc

The publication was prepared based on delivered materials

ISBN 83-7085-880-5

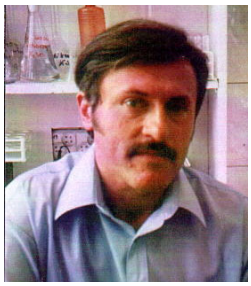
Oficyna Wydawnicza Politechniki Wrocławskiej
Wybrzeże Wyspiańskiego 27, 53-370 Wrocław
http://www.oficyna.pwr.wroc.pl
oficwyd@pwr.wroc.pl

INTRODUCTION TO ENVIRONMENTAL MICROBIOLOGY

The INTRODUCTION TO ENVIRONMENTAL MICROBIOLOGY has been developed by academic teachers from Wroclaw University of Technology, Poland in the frame of international project Socrates Minerva CELL TALK–88091–CP-BE-2000-Minerva-ODL realized together with partners from Belgium, Ireland, Bulgaria, Portugal and Netherlands. The project was coordinated by prof. Chris van Keer from Katholieke Hogeschool Sint Lieven in Gent, Belgium. The book is addressed to students of environmental engineering, biology, biotechnology, biochemistry and to students of other specializations interested in increasing their knowledge about microorganisms living in environment and in solving environmental problems with the use of microorganisms capable of degrading xenobiotics.

Authors

Barbara Kołwzan graduated from the University of Economics in Poznan, the Food Commodity Science specialization. She received her Ph.D. at the Wroclaw University of Technology, the Institute of Environment Protection Engineering. She worked as a research assistant at the Toxicology Laboratory at the Institute of Environment Protection Engineering and as a research and didactic assistant at the Biology and Ecology Group. At present she is a head of Research associate at the Biology and Ecology Group, Institute of Environment Protection Engineering.
barbara.kolwzan@pwr.wroc.pl



Waldemar Adamiak received his M.Sc. degree in biology from the Wroclaw University. Now he works as a lecturer on the Department of Environmental Engineering at the Technical University of Wroclaw. His main research interests are the biological waste gas treatment (biofiltration), the microbiological contamination of air and evaluation of the mutagenicity of airborne particles.
waldemar.adamiak@pwr.wroc.pl

Kazimierz Grabas received his M.S. in chemical engineering and Ph.D. in chemical technology from Wroclaw University of Technology. He worked at the Institute of Inorganic Technology, the Faculty of Chemistry at the WUT. Since 1992 he is Head of Research Support Office of the WUT and additionally he works at the Faculty of Chemistry in cooperation with the Institute of Environmental Protection Engineering. His main research interests are bioremediation of hydrocarbons, and environmental impacts of uranium mill tailings.
kazimierz.grabas@pwr.wroc.pl

Adam Pawełczyk received his M.S degree in chemistry from Wrocław University of Technology and a Ph.D. also in chemistry from the same university. He is an assistant professor at the Institute of Inorganic Technology, Wroclaw University of Technology. His main interests are chemical and biochemical treatment of different organic and inorganic wastes, particularly biochemical processing of organic wastes into mineral-organic fertilizers and other useful products. His recent work focuses on environmental hazard and remediation of grounds polluted with chemicals.
adam.pawelczyk@pwr.wroc.pl

Acknowledgements

The authors express their gratitude to M.Sc. Maria Pawlik, M.Sc. Agnieszka Trusz, Barbara Umińska, M.Sc. Henryk Małysa, dr Aleksandra Obara and dr Marta Chyla for technical assistance and research cooperation.

Contents

1. Microbiology of soil

Contents

Aims

After studying this chapter you should know what kind of microorganisms exists in soil, what physical, chemical and biological factors influence their development. You should be familiar with the roles microbes play in soil development and which forms of interactions we can observe in soil biocenosis. Most importantly, this chapter will provide you both a full data in understanding the role of microorganisms in the soil environment and a basic information about the known possibilities of soil remediation.

Orientation

In this chapter we have characterised the soil environment and discussed the soil microorganisms in combination with factors influencing their activity and development. Also, the relations between organisms living in soil are presented.

Prior knowledge

Do you know what viruses, bacteria, fungi, algae and protozoa are? What is their morphology? What can you say about metabolism in microrganisms? In first instance you have to take care to know the catabolic reactions performed by the microorganisms.

Study advice

First you have to read the whole chapter. Then look at the glossary at the end and try to explain all unknown words. If you have any problems with understanding of the presented material you should return to the chapters describing the cell structure and metabolism.

1.1. Soil

What is soil?

Soil is the top layer of the Earth's lithosphere, formed from weathered rock that has been transformed by living organisms.

Soil formation factors

The process of soil formation that starts from the host rock, soils' base component, may follow a different course depending on the following soil formation factors:
- climate
- water
- living organisms
- surface configuration
- human activity and
- time (soil's age)

Soil functions

Soil is a complex formation that allows the functioning of soils' ecosystems.
- It takes part in primary biomass production and it allows anchoring for plants, supplying them with water as well as the essential mineral products.
- There the decomposition processes of the organic matter and the accumulation of humus take place.
- Due to its chemical composition and physical properties soil forms a habitat for massive amounts of microorganisms and other living organisms.
- Within this habitat soil serves various filtration and buffering functions which protect the ecosystems against the excess flow of unwanted substances from other biosphere elements.

Soil's composition

Soil is composed of mineral and organic solid particles, air, soil solution, and living organisms which occur in this - edaphon. The proportions of particular components within soil stay more or less at the same level for the given kind of soil (Fig. 1.1).

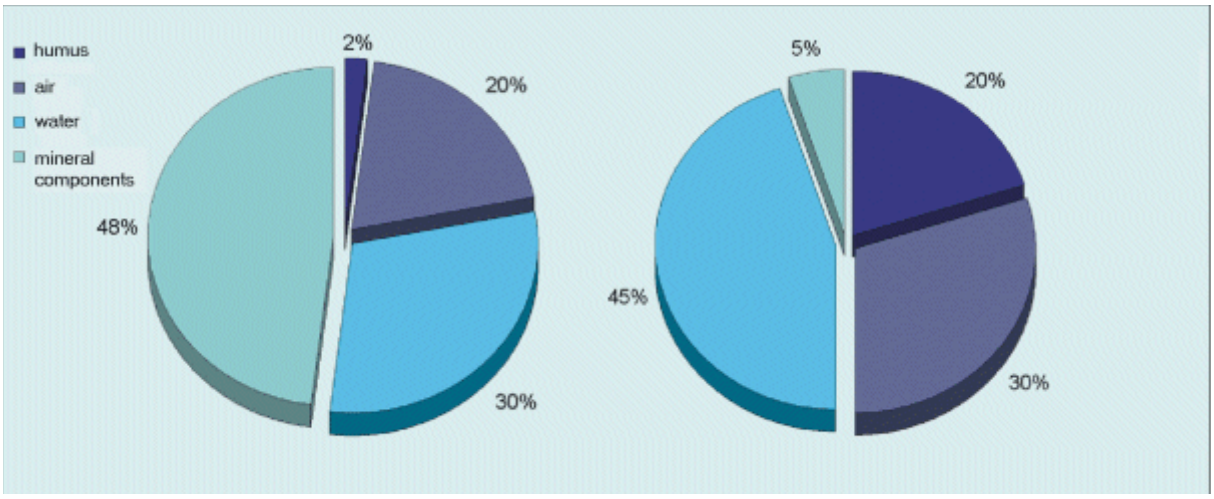


Fig. 1.1. Average fraction of particular phases of the soil: mineral (on the left) and organic (on the right)

Mineral compounds

- They occur in soil in a form of particles of various sizes.
- The smallest fraction consists of mineral colloids built from the aluminosilicates, hydrated silica, aluminium and iron hydroxide.
- Soil colloids strongly absorb oxygen, water and crucial nutrients, while they also create habitat for microorganisms. The colloids are a soil component that determines the water-air relationship.

Organic substances

- Soil's organic substances are created by a residue of dead plants, animals and microorganisms, which are decomposed by the soil-inhabiting microorganisms.
- Decomposition of the organic substances consists of different microbiological and physical-chemical processes called humification and its end-products are humic substances (humus) which are partially in a colloidal state.
- The organic colloids are a source of food for the microorganisms. Moreover, in the connection with silty particles, they give soil an adequate structure. Humus favours the growth of higher plants due to the ability to absorb water as well as the adsorption and exchange of the mineral compounds.

Soil solution

The soil solution consists of water with dissolved organic and mineral substances as well as gases. The water is held in soil due to the capillary forces acting within its aggregates. The chemical composition of the soil solution constantly changes, depending on, among other things, the temperature fluctuations and the amount of water which either dilutes or concentrates the soil's solution. Nevertheless the microorganisms that live there have constant access to the ammonium, phosphate and potassium salts as well as the nitrates. Moreover, easily available organic compounds such as monosaccharides and amino acids are found in the soil solution. Soil water provides favourable conditions for various organisms (not only for microorganisms but also for plants):

- It transports building and energy substances along the capillaries,
- It influences the aeration, the amount and the quality of nutrients, the osmotic pressure and the pH of the soil solution.

Soil atmosphere

- Soil atmosphere is the air in soil that fills out water-free spaces between the solid particles. Moreover the air saturates the soil colloids.
- The amount of air in soil varies between 8-35% of the soil's volume. Gases that constantly occur in the air are: N_2, O_2, and CO_2. The transient gases are: NH_3, H_2, CO, NO_x, SO_2, H_2S, CH_4 ,C_2H_6 as well as other volatile organic substances (butyric acid, alcohol, esters).
- Soil air is usually saturated with water vapor and contains 10 times more CO_2 than air in the atmosphere.
- The change from the oxygen to oxygen-free metabolism (the reduction of sulfate, denitrification) occurs in soil when the concentration of O_2 falls below 1%. As a result, we can observe the growth of the anaerobic microorganisms.

Edaphon

- The organisms living in soil create a community called the edaphon. These are bacteria, fungi, unicellular algae, vascular plants and animals especially invertebrates that occur in the surface layer of soil.
- Due to the variety of their metabolic abilities the soil microorganisms ensure the permanence (continuity) of element cycles in nature.

The effect of their activities is not only the mineralization of organic compounds but also the changes of mineral compounds, which have a big impact upon the development of the green plants.

- Edaphon constitutes about 1-10% of the dry mass of the soil organic matter (Fig. 1.2).