Contents

Introduction	1
.1 The approach followed in this book	1
.1.1 Statics and kinetics	1
.1.2 Dynamic approach	2
1.1.3 Balance approach	3
.1.4 The system in thermodynamics	4
1.1.5 Fundamentals of the theory of potential	6
1.1.6 The macroscopic approach	8
1.1.7 Aggregation and buffering	9
1.1.8 The term "model"	10
1.2 Classifying the processes in the soil	10
1.3 The organization of this book	11
1.4 Literature	12
2 Heat conduction in soils	14
2.1 Significance of heat dispersion in soils	14
2.2 Phenomena of heat dispersion	14
2.2.1 Examples of daily temperature courses in soils	14
2.2.2 Example of an annual course of the temperature	16
2.3 Heat conductivity and capacity in relation to soil composition	
and structure	17
2.4 Deriving the transport equation using local balance and	
principle of causality	20
2.4.1 Local balance for matter and energy without transformation	20
2.4.2 One-dimensional transport equation of matter and energy	
in a rigid system with continuous pores	21
2.4.3 The equation for heat transport	22
2.5 Analytical solutions of the heat transport equation with	
constant α_T	24
2.5.1 The stationary case	24
2.5.2 Sudden change in temperature as boundary condition	24
2.5.3 Oscillating temperature as boundary condition	25
2.6 Numerical solution of the heat transport equation with	25
constant α_T	26
2.7 Heat balance of the soil and heat conversion	29
2.7.1 Estimating the soil-absorbed energy	29
2.7.2 Heat to evaporate 1 mm water	30
2.8 Literature	31
2.0 Literature	<i>J</i> 1



3 Gas regime of soils	32
3.1 The significance of the gas regime in the soil	32
3.2 Phenomena in soil gas regime	33
3.2.1 Profiles of CO ₂ and O ₂ concentrations in the soil	34
3.2.2 Cycles and depth profiles of CO ₂ production	36
3.3 Parameters of the gas regime in soils	39
3.3.1 The apparent diffusion coefficient D _s	39
3.3.2 The storage of gases in the soil	41
3.4 Quantitative description of the gas regime in soils	42
3.4.1 Extending the transport equation	42 44
3.4.2 Partial pressure and diffusive gas transport	47
3.5.1 An analytical solution for the stationary case	47
3.5.2 Numerical solution for a stationary example	49
3.6 Applications of the gas transport and gas regime equation	50
3.6.1 The measurement of the diffusion coefficient $\mathbf{\hat{D}_{s}}$	50
3.6.2 The "tortuous" macropore as a structure model	52
3.6.3 Vapour flow in the soil	55
3.6.4 Micro-anoxia as a problem of aeration, and the redox	
potential ΔE_{H}	56
3.7 Literature	59
4 Soil water regime	61
4.1 The significance of soil water; annual balances	61
4.2 Phenomena of soil water flow	63
4.2.1 Water tension and water content profiles in the soil	63
4.2.2 Flows at the boundary area and in the soil	66
4.3 Hydraulic conductivity and the moisture retention curve	68
4.3.1 The hydraulic conductivity $K(\psi_m)$	68
4.3.2 The moisture retention curve $\psi_m(\theta)$	70
4.4 The water regime equation	73
4.4.1 The local water balance	74
4.4.2 The equation for the water flow q_w	74
4.4.3 The hydraulic potential ψ_h	74
4.4.4 Different formulations of the water transport equation	76
4.5 Characteristic flow conditions of water in the bare soil	77 78
4.5.1 Equilibrium and quasi-equilibrium	79
4.5.2 Stationary and quasi-stationary conditions	80
4.6 Applications and numerical solutions for the water regime	
equation	80
4.6.1 Moisture equilibrium in the soil	80
4.6.2 Stationary flow in the soil during drying in summer	81

4.6.3 Solution methods for non-stationary flow	84
4.6.4 Simple water regime models for the flat, homogeneous	
cropped soil; the root uptake function P(z,t)	89
4.6.5 Calculating the evapotranspiration E	90
4.6.6 The water regime of a wheat field on a loess-Parabraunerde	
4.7 Literature	97
4.7 Literature	71
5 Regime of matter in soils	99
5.1 Introduction	99
5.1.1 Significance of "matter" in the soil	99
5.1.2 Extension of the transport models	99
5.2 Phenomena of ion flows	99
5.2.1 Movement of non-interacting ions during winter	
5.2.2 Movement of interacting ions during winter	
5.3 Parameters of solute transport	
5.3.1 Transport parameter: effective dispersion coefficient D _B	102
5.3.2 Quantity/intensity relation for components that do inter-	
act with the soil matrix; the specific storage capacity B	103
5.3.3 Specific storage capacity C (and the diffusion coefficient D)	108
5.4 Coupled transport flows of components that do not interact	~
with the soil matrix	109
5.4.1 General description of coupled transport	
5.4.2 Transport of dissolved non-interacting components in the soil.	111
5.4.3 Particle charge	
5.5 Introduction to reaction dynamics	
5.5.1 Fundamentals of the course of reactions	
5.5.2 Order of elementary reactions in homogeneous systems	
5.5.3 A special case: second-order reactions of sigmoidal shape	
5.5.4 Complex reactions in homogeneous systems	121
5.5.5 Heterogeneous reactions (interactions with the surfaces of	121
solids)	. 124
5.6 Models for reactive components and ions in the soil	128
5.6.1 Dynamic description of interactions of substances with	
the solid phase	129
5.6.2 Description of interactions of ions with charged surfaces	/
of the solid phase (ion-exchange)	131
5.7 Simple regime models of substances in the soil	
5.7.1 Models for nitrification and simultaneous movement of	15.
nitrogen	. 135
5.7.2 Simulating the nitrogen regime of loess field soils during	. 138
winter	, 136
ions for the example potassium	140
	140
	142
	. 143
5.7.6 "Complete" models of material components regime	146 149
10 LUEIXUIE '	149

6 Looking ahead	152
6.1 Beyond the assumptions	152
6.2 The soil as a non-rigid solid	153
6.2.1 Mechanical deformations and changes of the state of stress	154
6.2.2 Mechanical cause-and-effect relations	157
6.2.3 Changes of the parameters with mechanical deformations	162
6.3 The explicit modelling of nutrient uptake by plants	163
6.4 Field and regional models	167
6.4.1 Simulating solute transport in heterogeneous pore systems	167
6.4.2 Geostatistical formulation of spatial variability	168
6.4.3 Combining deterministic and stochastic approaches:	
Monte-Carlo simulation of salt transport	169
6.4.4 Alternative approaches: plate and compartment models	171
6.5 Modelling soil development	177
6.6 Literature	177
7 Appendix	180
7.1 Numerical solutions for non-stationary water transport and for	
solute transport under stationary flow conditions	180
7.1.1 Vertical solute movement under stationary flow conditions	180
7.1.2 Vertical water transport	184
7.1.3 Difference formulation with the help of the Taylor equation	185
7.1.4 Literature	185
7.2 Gas solubilities in water	186
7.3 Conversion of units	187
7.4 List of symbols and indices	189
•	
Register	190