



J. Vrba/E. Romijn

Impact of Agricultural Activities on Ground Water

Volume 5
1986

Volume 5
1986

International Contributions to Hydrogeology

Edited by

G. Castany, E. Groba, E. Romijn



CONTENTS

PREFACE

INTRODUCTION

CHAPTER

1.	The atmosphere-soil-plant system and the water cycle (E. Romijn)	1
1.1.	Introduction	1
1.2.	The abiotic subsystem	3
1.2.1.	Evaporation and evapotranspiration	3
1.2.2.	The climate and the water balance	10
1.2.3.	The soil	13
1.3.	The biotic subsystem	17
1.3.1.	The trophic system	17
1.3.2.	Limiting factors	19
	List of symbols	26
	References	28
CHAPTER	2.	Movement of agrochemicals in the unsaturated and saturated zones (V. Beneš)
2.1.	Movement of agrochemicals in the unsaturated zone	29
2.1.1.	Water in the unsaturated zone	31
2.1.2.	Water flow in the unsaturated zone	32
2.1.3.	Soil water potential	34
2.1.4.	Hydraulic conductivity	40
2.1.5.	Water uptake by the root system	43
2.1.6.	Calculation of the water flow	45
2.1.7.	Movement of solute in the unsaturated zone	46
2.1.8.	Calculation of solute movement	48
2.1.9.	Schematic diagram of nitrogen movement	50
2.2.	Movement of agrochemicals in the saturated zone	52
2.2.1.	Water flow in the saturated zone	52
2.2.2.	Types of aquifers	54
2.2.3.	Flow in phreatic aquifer	56
2.2.4.	Flow in confined aquifer	56
2.2.5.	Radial flow	56
2.2.6.	Coefficients of specific storage	57
2.2.7.	Coefficients of hydraulic conductivity	59
2.2.8.	Coefficients of transmissivity	60
2.2.9.	Movement of solutes in the saturated zone	61
2.2.10.	Coefficient of hydrodynamic dispersion	63
2.2.11.	Mathematical solution of the flow and transport equation	68
	List of symbols	76
	References	79

CHAPTER	3.	Impact of fertilizers and pesticides on groundwater quality (V. Houzim, J. Vávra, J. Fuksa, V. Pěkný, J. Vrba and J. Stibral)	82
	3.1. Introduction	89	
	3.2. Organic fertilizers	91	
	3.2.1. Types of organic fertilizers	91	
	3.2.2. Biochemical degradation of organic fertilizers in soil	96	
	3.3. Inorganic fertilizers	98	
	3.3.1. Chemical decomposition of fertilizers	101	
	3.3.2. Impact of physical and chemical properties of inorganic fertilizers on groundwater quality	104	
	3.3.3. Biological adsorption of fertilizers and its impact on groundwater quality	108	
	3.3.4. Circulation of other nutrients	110	
	3.4. Pesticides	112	
	3.4.1. Chemical decomposition of pesticides	121	
	3.4.2. Biological degradation of pesticides in soil	124	
	References	129	
CHAPTER	4.	Influence of irrigation and drainage (E. Romijn)	132
	4.1. Introduction	133	
	4.2. Objectives of irrigation and drainage	133	
	4.2.1. Objectives	133	
	4.2.2. Soil water conditions	134	
	4.2.3. Importance of irrigation and drainage	135	
	4.3. Criteria for development of irrigation and drainage systems	136	
	4.3.1. Irrigation	136	
	4.3.2. Drainage	140	
	4.4. Side effects of irrigation and drainage with special reference to groundwater quantity and quality	142	
	4.4.1. Side effects of irrigation	142	
	4.4.2. Side effects of drainage	144	
	List of symbols	147	
	References	148	
CHAPTER	5.	Mathematical models (J. Balek)	149
	5.1. System approach	149	
	5.1.1. Identification of the problem	150	
	5.1.2. Identification of available data	151	
	5.1.3. Identification of simulated system	151	
	5.1.4. Identification of constraints	153	
	5.1.5. Selection of the model	153	
	5.1.6. Testing of the model	154	
	5.1.7. Adaption of the model	154	
	5.2. Classification of the models	155	

5.2.1.	Classification considering the process modelled	155
5.2.2.	Classification considering mathematical approach	158
5.2.3.	Classification considering the purpose of the models	164
5.3.	Conclusion	169
	References	170
CHAPTER 6.	Groundwater quality monitoring under different agricultural conditions (J. Vrba)	
6.1.	Introduction	173
6.2.	Sources of pollution produced by agricultural activities	175
6.2.1.	Animal wastes	175
6.2.2.	Inorganic fertilizers and soil additives	176
6.2.3.	Pesticides	176
6.2.4.	Irrigation return flow	177
6.3.	Monitoring system	178
6.3.1.	Delimitation of the monitored area and design of the monitoring system	178
6.3.2.	Data acquisition	180
6.3.3.	Data transmission, storage and processing	190
6.3.4.	Data retrieval and analysis	191
6.3.5.	Data utilization for decision making	193
6.3.6.	Legislative, administrative and technical implementation of protective measures	194
	References	196
CHAPTER 7.	Control and management of agricultural impact on groundwater (V. Kolaja, J. Vrba, K.H. Zwirnmann)	
7.1.	Introduction	197
7.2.	Nitrogen and water resources - outline of a management and control system	197
7.3.	Control of groundwater pollution	203
7.3.1.	Preventive groundwater system protection	204
7.3.2.	Control of pollution sources	210
7.4.	Pesticides - outline of a management policy	218
7.5.	Impact of groundwater contaminated with pesticides and fertilizers on human health	221
7.6.	Conclusions	225
7.6.1.	Agricultural sector	226
7.6.2.	Water supply and management	227
7.6.3.	Impact on human health	228
	References	229

CASE HISTORIES

- Consequences of irrigated agriculture in arid and semi-arid areas on groundwater
(M.C. Agarwal, A.C. Goel, R.K. Malik) 233
- Impact of agriculture on groundwater in Ireland
(C.R. Aldwell, D.J. Burdon, M. Sherwood) 243
- Elevated levels of nitrate in groundwater beneath intensively grazed pastureland in New Zealand
(R.J. Burden) 263
- The distribution of agricultural soil leachates in the unsaturated zone of the British chalk
(S.S.D. Foster, A.H. Bath) 271
- Prediction of variations in groundwater quality under the influence of pen sewage irrigation
(V.M. Goldberg) 285
- Numerical simulation of the effect of soil nitrogen transport and transformations on groundwater contamination
(M. Mehran, J. Noorishad, K.K. Tanji) 297
- Factors of bacteria and virus transport in groundwater
(A. Pekdeger, G. Mattheiss) 313
- Modeling nitrogen behavior in the soil profile
(H.M. Selim) 323