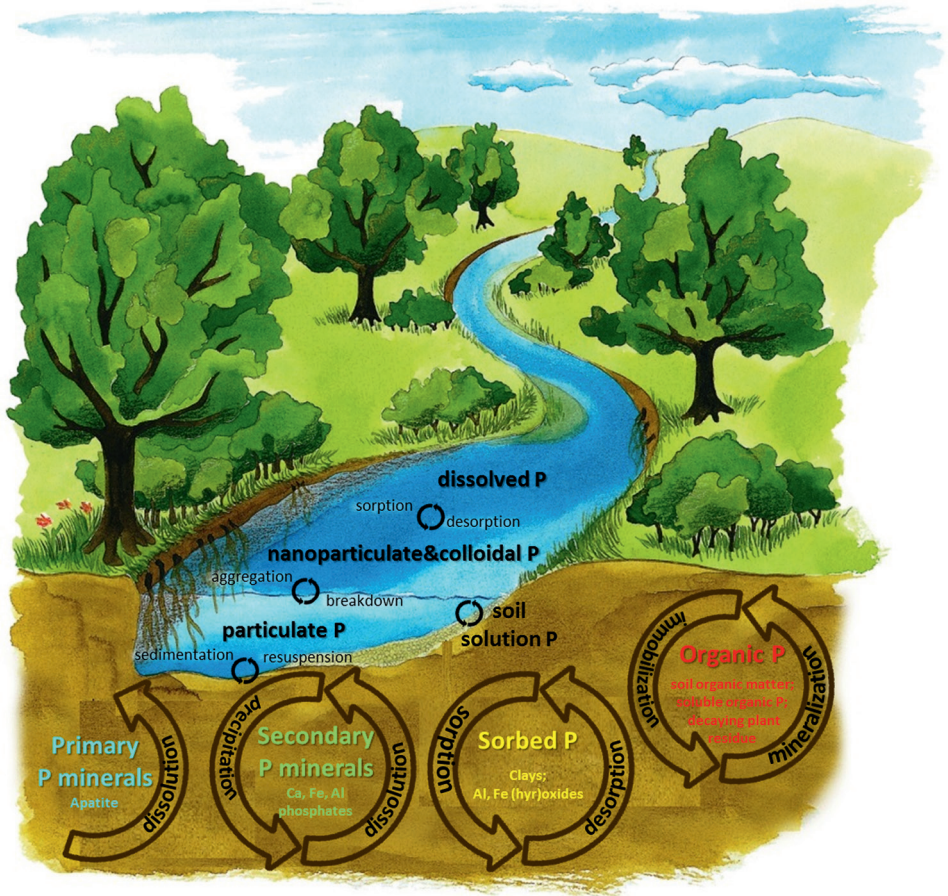


The Role of Natural Nanoparticles and Colloids for Phosphorus Binding in Forested Headwater Catchments

Nina Gottselig



Forschungszentrum Jülich GmbH
Institute of Bio- and Geosciences
Agrosphere (IBG-3)

The Role of Natural Nanoparticles and Colloids for Phosphorus Binding in Forested Headwater Catchments

Nina Gottselig

Schriften des Forschungszentrums Jülich
Reihe Energie & Umwelt / Energy & Environment

Band / Volume 330

ISSN 1866-1793

ISBN 978-3-95806-160-6

Table of Contents

ABSTRACT	II
KURZFASSUNG	IV
1 INTRODUCTION	1
1.1 PHOSPHORUS IN TERRESTRIAL FORESTED ECOSYSTEMS	1
1.2 NATURAL NANOPARTICLES AND COLLOIDS	3
1.3 PHOSPHORUS BOUND TO NATURAL NANOPARTICLES AND COLLOIDS	4
1.4 THE ADVANTAGEOUS TECHNIQUE OF FIELD FLOW FRACTIONATION (FFF) FOR PARTICLE ANALYSIS	6
1.5 AIM AND SCOPE OF THE THESIS	8
2 THEORETICAL BACKGROUND: FIELD FLOW FRACTIONATION (FFF)	11
2.1 PRINCIPLE OF ASYMMETRIC FLOW FIELD FLOW FRACTIONATION (AF ⁴)	11
2.2 AF ⁴ HYPHENATION	14
2.2.1 ICP-MS FOR SENSITIVE ELEMENTAL DETECTION IN THE FRACTIONS	15
2.2.2 ORGANIC CARBON DETECTOR (OCD) FOR PRECISE ORGANIC C DETECTION	17
3 MATERIALS AND METHODS	19
3.1 FORESTED HEADWATER CATCHMENTS FOR STREAM WATER SAMPLING	19
3.1.1 REGIONAL SCALE AND COMMON DENOMINATOR SITE: WÜSTEBACH	19
3.1.2 ADDITIONAL SITES ON NATIONAL SCALE: CONVENTWALD, MITTERFELS, VESSERTAL, LEIRELVA	21
3.1.3 EUROPEAN SITES	21
3.2 SAMPLING AND PREPARATION	23
3.3 ANALYTICAL APPROACH FOR THE ANALYSIS OF NATURAL NANOPARTICLES AND COLLOIDS IN FOREST STREAM WATERS	27
3.4 ANALYSIS OF FRACTION SPECIFIC ELEMENTAL DATA	29
4 RESULTS AND DISCUSSION	31
4.1 METHOD DEVELOPMENT FOR PRECISE FRACTIONATION OF NATURAL NANOPARTICLES AND COLLOIDS AND ELEMENTAL DETECTION IN THE FRACTIONS	31
4.1.1 PARAMETER OPTIMIZATION FOR ASYMMETRIC FLOW FIELD FLOW FRACTIONATION	31
4.1.2 FACILITATING ONLINE ELEMENTAL DETECTION OF ENVIRONMENTAL SAMPLES	34
4.1.3 METHODOLOGICAL CONSIDERATIONS OF ORGANIC CARBON DETECTION AND FOR ASSESSING THE BIOAVAILABILITY OF NATURAL NANOPARTICLES AND COLLOIDS	35
4.1.3.1 OXIDATION EFFICIENCY OF THE ORGANIC CARBON DETECTOR	35
4.1.3.2 ORGANIC CARBON DETECTION THROUGH ICP-MS	37

4.1.3.3	POTENTIAL BIOAVAILABILITY OF NATURAL NANOPARTICLE AND COLLOID BOUND P	40
4.2	CHARACTERIZATION OF P-CARRYING NATURAL NANOPARTICLES AND COLLOIDS IN TRIBUTARIES AND MAIN STREAM FLOW WITHIN ONE FOREST CATCHMENT	41
4.2.1	NATURAL NANOPARTICULATE AND COLLOIDAL P, Fe AND Al ALONG THE STREAM FLOW	41
4.2.2	PROPORTION OF PARTICLE-BOUND RELATIVE TO TOTAL ELEMENTAL CONTENTS	44
4.2.3	POTENTIAL ROLE OF ORGANIC MATTER FOR P-BINDING	47
4.2.4	PRELIMINARY EFFECT OF DEFORESTATION	48
4.2.5	IRON ISOTOPE SIGNALS IN DIFFERENT RESERVOIRS OF A FORESTED CATCHMENT	49
4.3	IDENTIFICATION OF P BINDING PATTERNS TO NATURAL NANOPARTICLES AND COLLOIDS OF FORESTED HEADWATER CATCHMENTS ACROSS GERMANY	51
4.3.1	NATURAL NANOPARTICLE AND COLLOID FRACTIONS IDENTIFIED WITH AF ⁴	51
4.3.2	ASSOCIATION OF P WITH NATURAL NANOPARTICLES AND COLLOIDS ACROSS 5 FOREST STREAMS	54
4.3.3	POTENTIAL ECOLOGICAL RELEVANCE OF NATURAL NANOPARTICLES AND COLLOIDS FOR P IN FOREST STREAM WATERS	55
4.3.4	THE FIRST FLUSH EFFECT OF STREAM WATER NATURAL NANOPARTICLES AND COLLOIDS	59
4.3.5	INFERENCES FOR STREAM WATER NATURAL NANOPARTICLE AND COLLOID RELEASE FROM SURROUNDING SOILS	60
4.3.6	A FIRST APPROACH ON THE NATURAL NANOPARTICLE AND COLLOID COMPOSITION OF AQUATIC ECOSYSTEM SAMPLES	61
4.4	DISTRIBUTION AND COMPOSITION OF P CARRYING NANOPARTICLES AND COLLOIDS ACROSS EUROPEAN STREAM WATERS	61
4.4.1	FRACTIONATION OF NATURAL NANOPARTICLES AND COLLOIDS ON EUROPEAN SCALE	61
4.4.2	COLLOIDAL SIGNIFICANCE FOR ELEMENT PARTITIONING IN WATER SAMPLES	63
4.4.3	ELEMENTAL COMPOSITION PATTERNS OF NATURAL NANOPARTICLES AND COLLOIDS ON THE EUROPEAN SCALE	64
4.4.4	APPROACH FOR THE pH DEPENDENT PREDICTION OF PARTICULATE ELEMENTAL CONCENTRATIONS	66
4.4.5	FOREST STREAM WATER pH AS DETERMINING VARIABLE FOR THE ELEMENTAL COMPOSITION OF NATURAL NANOPARTICLES AND COLLOIDS	68
4.4.6	PREFERENTIAL P BINDING OF THE DIFFERENT GEOGRAPHIC REGIONS IN EUROPE	70
4.4.7	THE INFLUENCE OF SITE SPECIFIC PARAMETERS ON ELEMENT CONCENTRATIONS OF NATURAL NANOPARTICLES AND COLLOIDS	71
4.4.8	CENTRAL ENVIRONMENTAL FACTORS DRIVING NATURAL NANOPARTICLE AND COLLOID FRACTION CONCENTRATIONS	72
4.4.9	INDIRECT EFFECTS OF ENVIRONMENTAL FACTORS ON NATURAL NANOPARTICLE AND COLLOID FRACTION CONCENTRATIONS	75

5	SUMMARY, CONCLUSIONS AND OUTLOOK	77
	<hr/>	
REFERENCES		81
LIST OF FIGURES		92
LIST OF TABLES		97
LIST OF ABBREVIATIONS		99
LIST OF SYMBOLS		101
SCIENTIFIC CONTRIBUTIONS		102
CURRICULUM VITAE		105
ACKNOWLEDGEMENTS		107
ANNEX		109

**Energie & Umwelt /
Energy & Environment
Band / Volume 330
ISBN 978-3-95806-160-6**

