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Letter to Editor

Influence of Mid-Field Afforestation on the Changes of Organic Nitrogen Compounds in Ground Water and Soil

L. Szajdak, I. Życzyńska-Bałoniak

Research Center for Agricultural and Forest Environment, Polish Academy of Sciences, Bukowska Street 19, 60-809 Poznań, Poland

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Abstract

Different forms of nitrogen (total, organic, amino acids in dry mass and in humic acids) as well as humus substances, dry mass, activity of urease in ground water and in soils under mild-field deciduous afforestation were measured. Experiments were carried out during an entire year. Afforestation decreased total organic substances in ground waters, as well as total nitrogen and free and bound amino acids to humic acids. In soil under afforestation the decrease of pH, activity of urease, and the content of amino acids in humic acids was observed.

Keywords: mid-field afforestation, biogeochemical barrier, humic acids and amino acids, forms of nitrogen in ground water and soils.

Introduction

All plants with the exception of water plants, epiphytes and parasites uptake nutrients from the soil. Considerable amounts of organic substances supply the soil with root exudates [3, 15, 16] among which amino acids prevail [2, 13, 22]. Because of biochemical adaptation and the mechanism of detoxication, the synthesis of peptides, the change in hormone concentrations, the accumulation of low weight metabolites created from the pool of the conversion of carbohydrates and nitrates, they have the ability to fit the changes of environmental conditions such as increases of toxicity developed by high content of macro and microelements [9, 10].

Micro and macro elements are presented in the form of metal-organic complexes, in which humus substances (particularly amino acids) are strong organic chelate ligands [4, 14]. For this reason the dissolved organic compounds participate in the cycle of organic matter and transport inorganic substances by ground water. Our earlier investigations showed that ground water of agricultural landscape where light soils dominate characterize high content of dissolved chemical substances [19], especially organic substances, whose main fraction represent humic substances [24, 27].

One of the basic mediums limiting the migration of chemical substances in ground water is the biogeochemical barrier: mid-field afforestations, meadows, and shelterbelts, which separate agricultural fields from watercourses [20, 25, 26].

Limited information is available concerning the influence of biogeochemical barriers on the limitation of the migration of amino acids from ground water in the agricultural landscape. Earlier we dealt with the problem of occurrences of amino acids in the small ponds and in the sediments of these small ponds. This investigation shows that much more of amino acids in small ponds is included

Correspondence to: Dr. L. Szajdak

in sediments. It was also observed that among all dissolved amino acids in the water neutral amino acids predominated (from 44 to 61%). In sediments basic amino acids were shown to have the highest content (from 60 to 76 %) [26].

The aim of this study was to show the control of amino acids wash away from the fields and migrate with ground water, and the estimation of the limitation degree by the biogeochemical barrier like mild-field afforestation and the spread of pollution such as free and bound amino acids dissolved in the ground water and present in the soil.

Materials and Methods

Research was carried out in afforestation located in the Kościan Plain, which is a part of West Poland Lowland. The object of this study was ground water and soil under deciduous afforestation. This afforestation includes different species of trees with the domination of the maple, ash, beech and hawthorn, but in the underground dominates elder lilac, companion crop of maple, ash and hawthorn. The afforestation is located on podsolic soils. Samples were collected each month in 1997. Mean rainfall was 790 nm, and average yearly temperature is 9.5°C. The ground water flowing across the afforestation of 16.5 m wide was uptaken from the piezometers. The water was filtered by Whatman GT/C filter paper and next determined pH, dry mass, organic and mineral carbon, the forms of nitrogen and dissolved humus substances. Soil samples were taken near the piezometers from the layer at 0-20 cm depth. Soils were air dried and sieved using a 1 mn sieve. Organic carbon was measured using TOC 5050 analyzer (Shimadzu, Japan). The content of organic matter was calculated by multiplication of the concentration of organic carbon by a factor of 1.724 [8].

Dry mass was obtained by the evaporation of the water and drying it at 105°C to constant weight. The following forms of nitrogen were analyzed: total, organic, ammonium and nitrate according to Hermanowicz, et al. [6]. Humic substances were isolated from the water before acidification by hydrochloric acid to pH=2 and next by the passing through the column with nonionic resin Amberlit XAD-2 [23]. Total nitrogen in soils was determined by sulphuric acid mineralization. Amino acid concentrations in dry mass of ground water, in humus substances dissolved in water and in humic acids extracted from soils were determined using an amino acids analyzer AAA T 339 (Mikrotechna, Prague) [17, 26]. Activity of urease in soils was determined according to Hoffmann and Teicher [18].

Results and Discussion

The content of dissolved substances in ground water carried away from agriculture field to the deciduous afforestation in dry mass was 2878 mg/l and the mean of year content was equal to 2074.0 mg/l. Also observed were high concentrations of organic substances up to 61.03 mg/l but mean year was 43.34 mg/l. Among all organic compounds, humus substances predominated and represented 88% of organic compounds (Table 1). Mean of total nitrogen in ground water carried away to the afforestation was 15.0 mg/l, but in this value 7.03 mg/l was included in organic forms.

Table 1. Means and intervals (italic) of physic-chemical parameters in mg/l for ground water flowing to the afforestation and flowing away of 16.5 m wide of the edge in 1997.

Physic-chemical parameters of ground water	Ground water flowing to afforestation	Ground water in 16.5 m of the edge of afforestation
pH	*7.29-7.79*	*7.03-7.61*
Dry mass	2074.00 *911.2-2878.40*	729.40 *528.4-1048.8*
Organic compounds	43.34 *31.20-61.03*	19.45 *6.98-45.19*
Humus substances	38.24 *28.03-50.22*	11.64 *3.42-23.94*
$N\text{-}NO_3^-$	5.34 *2.56-9.91*	6.36 *1.03-8.15*
$N\text{-}NH_4^+$	3.14 *1.96-4.48*	3.08 *1.96-4.20*
Organic nitrogen	7.03 *0.00-13.83*	5.43 *0.00-10.08*
Total nitrogen	15.51 *2.99-28.22*	14.87 *3.19-22.43*

It was observed that during flow of ground water across the afforestation, significant decreases of the content of the all chemical compound to 65%, at the same time the decrease of dissolved of organic compounds was 55%, humic substances 80%, but organic nitrogen compounds 23% (Table 1). The decrease of the concentration of main dissolved organic compounds in ground water may indicate the strong process of mineralization in these waters, and the significant sorption capacity of this soil. At the same time the soils near piezometers were investigated from which the groundwater was taken to analysis. pH values of the soils from boundary between the field and the afforestation ranged from 5.64 to 6.12. The mean content of total nitrogen in this soil was 169.19 mg/100 g of soil. But pH in the soil under the

Table 2. pH and means of the year and intervals (italic) of the urease activity and the total content of nitrogen in soil.

Physic-chemical properties of soil	Soil of the border between the field and the afforestation	Soil under afforestation 16.5 m from the edge
pH	*5.64-6.12*	*4.11-4.94*
Urease activity mg urea hydrolysed $g^{-1} soil \cdot h^{-1}$	6.365 *2.201-10.552*	2.471 *0.612-6.272*
Total nitrogen in mg/100 g of soil	169.19 *121.00-201.05*	170.36 *153.45-189.30*

Table 3. Content of amino acids in dry mass of the ground water flowing to the afforestation and in humic substances isolated from the ground water and in humic acids from soil.

Amino acids	Total amino acids flowing to the afforestation in the ground water in µg/l	Bound amino acids to humic substances in the ground water in µg/l		Amino acids in HA in mg/kg of HA	
		The ground water flowing to the afforestation	The ground water 16.5 m of the edge of the afforestation	In the border between the field and the afforestation	In soil 16.5 m of the edge of the afforestation
ACIDIC					
Cysteic acid	8.2911	2.4332	1.1154	0.0827	0.0640
Taurine	1.7124	0.2521	0.1936	0.0028	0.0151
Phosphoethanolamine	0.0226	0.2615	–	0.0250	0.0052
Aspartic acid	0.0158	0.0321	0.0337	0.0350	0.0938
Hydroxyproline	0.0445	1.4328	0.2132	0.3769	0.2877
Threonine	0.0321	0.5937	0.5329	0.1374	0.0888
Serine	0.0145	0.3654	0.4865	0.1542	0.1100
Glutamic acid	0.0201	0.5132	0.4347	0.0778	0.1709
α-aminoadipic acid	5.5143	–	–	0.0143	0.0128
Sum	15.6674	5.8840	3.0100	0.7061	1.0484
NEUTRAL					
Proline	0.2019	0.3943	0.5937	0.1165	0.1490
Glycine	0.8356	3.4827	2.2127	0.3959	0.3092
Alanine	8.6843	1.3286	0.9142	0.2379	0.1764
Citrulline	14.8721	–	–	–	–
α-aminobutyric acid	–	0.1475	–	–	0.0660
Valine	11.9946	0.3537	0.8165	0.2927	0.2259
Cysteine	0.3454	0.6677	0.0855	0.0559	0.0235
Methionine	0.4173	0.1785	0.0937	0.0525	0.0209
Cystathionine	16.3264	0.5577	0.5722	0.1719	0.1358
Isoleucine	3.9674	0.2545	0.2611	0.2234	0.2118
Leucine	0.8793	0.1329	0.1213	0.0285	0.0504
Tyrosine	5.9552	0.3854	0.3921	0.1727	0.1513
Phenylalanine	0.2745	0.2317	0.0072	0.0342	0.0025
β-alanine	1.6437	0.3648	0.3022	0.0066	–
β-aminobutyric acid	0.7848	0.2227	0.0510	0.0029	–
γ-aminobutyric acid	0.8783	0.0637	0.0425	0.0052	0.0044
Sum	68.0608	8.7664	6.4659	1.7968	1.5271
BASIC					
Ornithine	2.4173	0.4355	0.3433	0.0133	0.0470
Lysine	5.5457	0.2441	0.3429	0.1764	0.1391
Histidine	14.2984	0.6738	0.1307	0.0742	0.0685
1-methylhistidine	12.0925	0.1377	0.0648	–	–
3-methylhistidine	2.9721	0.6164	0.0601	–	–
Arginine	12.4315	2.3961	1.2923	0.3526	0.4287
Sum	49.7575	4.5039	2.2377	0.6165	0.6883
TOTAL AMOUNT	133.4857	19.1543	11.7136	3.1194	3.2588

afforestation at 16.5 m distance from the edge of the afforestation was smaller and ranged from 4.11 to 4.97, and mean content of nitrogen was similar to that determined on the boundary between field and afforestation and was 170.36 mg/100 g of soils (Table 2).

In both research soils activity of urease were measured. This enzyme participates in the hydrolytic decomposition of urea, which is one of the final products created during the degradation of organic nitrogen substances in soil. It was observed that the decrease of the activity of this enzyme with the distance of the edge of the afforestation. At the same time the increase of the content of N-NO_3 in ground water of the afforestation was observed. Research year belonged to wet and warm. This phenomenon accompanied strong process of the degradation of the litter, which caused the liberation of higher input of nitrogen to the ground water [11].

Humus is composed of 20 to 60% humic acids (HA). From twenty to forty five percent of the nitrogen associated with HA may consist of amino acids or peptides connected to the central core by hydrogen bounds [5]. Considerable quantities of amino acids occur in soil in the protein fraction bound to humus, mostly to humic acids [17]. Humus has a protective effect on the protein complex, preventing its further decomposition [21]. The protein fraction of humus is included in the organic colloid component of soils. The colloidal character of peat soils is stronger than in most mineral soils and the specific surface area of organic colloids is from 2 to 4 times greater than that of montmorillonite minerals [1, 7]. A characteristic feature of protein is the high content of various functional groups (-NH_2, =NH, -SH, -COOH) as a result of which they possess ion exchange and complexing properties [4]. They can transport complexes of heavy metals and biologically active substances for plants and soil organisms [12].

The ground water carried away from the field to afforestation contains 133.49 μg/l of the total amino acids (free and bound). The highest concentration represented the following amino acids: cystationine (16.33 μg/l), cytrulline (14.87 μg/l), histidine (14.30 μg/l), arginine (12.43 μg/l), 1-methylhistidine (12.09 μg/l), and valine 11.99 (μg/l). An average 15% of amino acids carried away from fields is bounded to humus substances. The highest content of these compounds represented glicyne (3.48 μg/l), arginine (2.39 μg/l) and cysteic acids (2.33 μg/l). Among amino acids bound to humic substances the following substances were absent: α-aminoadipic acid and citrulline. During flows away of the ground water across the afforestation 16.5 m wide the content of bound amino acids to humic substances decreased to 39%. It was observed the decrease of the concentrations of amino acid groups such as: acidic, neutral and basic carried away the afforestation. The highest decrease of the content of bound amino acids to humic substances was observed in basic amino acids (50%) and acidic amino acids 44%. During flows of the water across the afforestation the concentration of neutral amino acids decrease in the smallest degree (26%). This might indicate simultaneously the decrease of the content of amino acids by the afforestation and the effect of root exudates, which supply amino acids to the soil [13, 21, 22].

Conclusions

1. The ground water carried away from the fields to the afforestation contains high contents of organic chemical compounds.

2. The deciduous afforestation of 16.5 m wide decreases in the ground water the concentration of organic substances, total nitrogen and to humic substances free and bound amino acids.

3. The ground water flowing away from afforestation shows lower pH, activity of urease and the content of amino acids in humic acids.

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