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ECOLOGY OF THE HALOPHILIC VEGETATION OF THE PANNONICUM VII. ZONATION STUDY ALONG THE BEGA-BACKWATERS IN THE VOIVODINA (YUGOSLAVIA)

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In the cours of studying the halophilic vegetation of the Pannonicum, there was provided for us an opportunity, as well, to investigate the halophilic vegetation of the Bega-region in Bánát. In the progressively drying bed, resp. in the vicinity of backwater reaches detached in a natural way or cut off by regulation, there have been produced soils of alkali character in various degrees, resp. various biogeocoenoses. These plant communities of a soil becoming alkali in various degrees and reflecting different hydrographic conditions are forming a variegated zonation system.

The aim of these investigations is to clear up the connections between the vegetation cover of the single zones and their biotic and abiotic ecological factors.

For carrying out our aims, the Bega-backwater reaches in the vicinity of Zrenjanin have proved to be suitable.

The floristic-phytocoenologic elaboration of these areas with summarizing character had already taken place some decades ago in the same way as that of the halophilic plant cover of other areas in the Voivodina, Bácska, and Bánát (SLAVONIĆ, 1939; 1948). In our investigations we want to take part in carrying out the programme of the Hungarian—Yugoslav research co-operation by clearing up further synecological detail problems.

We have got a basis for the zonation conditions of halophilic communities in Yugoslavia by SLAVNIĆ's investigations (1939) who added also some short remarks to his observations for characterizing the soil.

Discussion of the results of investigations

I. Observations carried out in the area of Arda, West of Zrenjanin.

The Bega-backwater lying here is surrounded by a spacious solonetz heath pasture with artemisia. Following its vegetation of solonetz soil arranged mosaic-like, towards the backwater, certain zonality is to be noticed, as well, as a result of the relief-differences in a terrace-like pattern.

Zone 1 was missing here. Zone 2 stands out of the solonetz level, with a chernozem surface soil and in its lower layers with sodic solonetz. Its community is: *Achilleo-Festucetum pseudovinae limonietosum* (STAVNIĆ 48), BODROGK. 59. It is showing a transition towards the vegetation of a steppe with artemisia. On the basis of tabulated recordings it could be ascertained that the *Festuca pseudovina* of dominating role generally forms 40—50 per cent of the total cover of 75—80 percentage. The other species — prevailingly the glycophilic ones occurring in 5—10 per cent — take part in the community due to the upper 20 cm alkali-free ground level. Thus the *Achillea collina, Gypsophila muralis, Plantago lanceolata,* as well as the *Kochia prostrata* showing a great ecological adaptability and occurring habitually in the southern areas of the Pannonicum (SLAVNIĆ 1939).

The appearance of some ephemerous *Trifolium* species is similarly connected with the alkali-free upper ground level, like that of *T. striatum, T. retusum, T. campestre,* as well as *Scleranthus annuus.* They are showing the scanty in rainfall in the spring aspect of the year of investigation with the low individual growth and the conditions of dominance.

The appearance of *Limonium gmelini* — here in the same way as in other regions beyond the Tisza — is referring to the presence of deeper lying solonetz layers. The laboratory data of the soil profile unearthed in that zone give some proof here, too. According to them, below the calcium carbonate and alkali-free A-level there follow meadow solonetz layers of solonchak character with 0.25 per cent maximum salt content (Table 1).

Zone 3 is *Artemisio-Festucetum pseudovinae achilleetosum.* Its species combination is showing a transition towards the grass cover of the previous zone. Owing to the considerably more unfavourable habitat conditions, the vegetation cover is not more than 40 per cent. There prevailed here, too, the *Festuca pseudovina* with a dominance of 10—15 per cent. A considerable part is played by the character species: *Artemisia maritima* ssp. *monogyna,* etc. As a result of favourable heat, resp. light conditions, it can be found in state of flowering already at the end of May. The other is *Limonium gmelini* that sporadically achieved even the values of 10 per cent cover.

Its differential species is *Achillea collina;* its dominance values have anyway achieved but rarely the 5 per cent. On the other hand, the appearance of *Hordeum hystrix* in spots may be considered as a consequence of an increased grazing.

The qualitative and quantitative relations of the ephemerous species of the lower grass layer are showing some connection with several changes manifested mainly in the domain of hydrographic conditions. The small stalks of weed of *Sedum rubrum,* together with the remains of *Myosurus minimus,* lead us to conclude more humid habitat conditions than the average ones are. At present, however, they could be found only exceptionally. There is more important the rather significant expansion of *Matricaria chamomilla* var. *salina* and *Polygonum aviculare* that having germinated as a result of the plenty of rainfall in the latter weeks, have overgrown the barren spots.

The barren spots, seemingly missing any plant cover, have proved in this way not to be without any vegetation. In the aspect of early spring, *Poa bulbosa* had filled here a part. As a result of drought, however, its parts

being overground already in May have withered. Its quantitative conditions can be concluded from the amount of its bulbils piercing through the soil. The formation of the increasedly xerothermic conditions may be a concequence of the solonetz layers being near to the surface.

The relief of zone 3 was anyway lying 20—40 cm or so deeper, from which zone 1 stood out like an island or a kind of micro-terraces.

And it had also a corresponding soil structure. As — on the basis of data known by us so far — we can draw a consequence from the species components of the grass cover, we have got here a rough meadow solonetz soil with moderate steppes and a 5—8 cm thick alkalized A-level, and with a columned B_1-level without any major salt accumulation. That is the explanation of the formation of a sub-association of glycophilic character, the 0.10—0.12 per cent total salt content being endurable also for the glycophilic species of xerophilic character. A salt accumulation in the B_2-level could be demonstrated below 40 cm (Table 1).

Table 1. Results of the comparative laboratory investigations of the soil profiles of vegetation zones 2 and 3

Soil depth in cm	Arany's fixity	Humus	Calcium carbonate	Total salt	Sodic alkalinity
		per cent			
Achilleo-Festucetum pseudovinae limonietosum					
0— 5	62	4.82	0	0	0
5—10	54	3.33	0	0.05	0
10—20	49	2.24	0	0.09	0
20—40	61	2.05	4.36	0.22	0.09
40—60	72	1.97	5.64	0.27	0.11
60—80	81	1.61	9.14	0.25	0.11
Artemisio-Festucetum pseudovinae achilleetosum					
0— 5	67	2.95	0	0.10	0
5—10	60	2.80	0	0.12	0
10—20	79	2.14	0	0.15	0
20—40	73	2.02	0	0.40	0
40—60	78	1.02	4.44	1.00	0.04
60—80	77	1.49	8.98	1.00	0.04

We obtain a picture about the physical structure of soil by the percentage of fraction analysis of its unearthed profile (Fig. 1B). Here is the B_1-level of columnar structure the most fixed, the physical sand is 40 per cent or so, and both clay fractions have shown a value of 60 per cent.

Zone 4 is, as a matter of fact, an extrazonal appearance of the saline speargrass meadow. In the depressions of the artemisia steppe eroded by currents, owing to the favourable hydrographic conditions high above the meadow-zone, in a meadow soil that is saline in the depth, there was predominant the sub-association *Limonium gmelini* of *Agrosti-Alopecuretum*, indicating a deeper lying solonetz layer. The winding water courses and

their direction were delimited sharply from the adjacent grassy steppe not only by the different plant cover but also by the light green hue of *Agrostis alba*.

Its species combinations were forming a double grass layer, differing hardly from the species associations of the marshlands of the meadow solonetz fens.

In the same zone, in the enlarging stagnant-water sectors of the streamlets, the speargrass meadows are replaced by the spots of alkali silt associations. The ephemerous species components of this *Pholiuro-Plantaginetum tenuiflorae* were showing several transitions towards the marshy meadows, and *Ranunculus lateriflorus* presented itself to be facies-forming: with regard to the arid early summer conditions of the investigated year, in fragments — *Myosurus minimus* subass. (Slavnić 48) Bodrogk. 65.

Zone 5 is lying at the rim of the bed of the Bega-backwater and is a hygrophilic species combination of *Agrosti-Alopecuretum*. As a result of an unreasonable utilization in the course of pasturing some species tolerating the treading became predominant, thus the facies of association *Agrosti-Alopecuretum trifolietosum fragiferi* (Ubr. 48) Bodrogk. 65. *Medicago lupulina* that could form in that zone sporadically even a 15—20 per cent cover. This was supported by the considerably lower dominance value of *Lotus corniculatus, Trifolium repens, T. fragiferum*, as well.

On smaller mounds, from the growth of *Festuca pseudovina, Lolium perenne, Salvia nemorosa, Thlaspi arvense* we could conclude xero-mezophilic habitat conditions exposed to being stamped.

The *Limonium gmelini* occurring thread by thread has proved the presence of lower meadow solonetz layers.

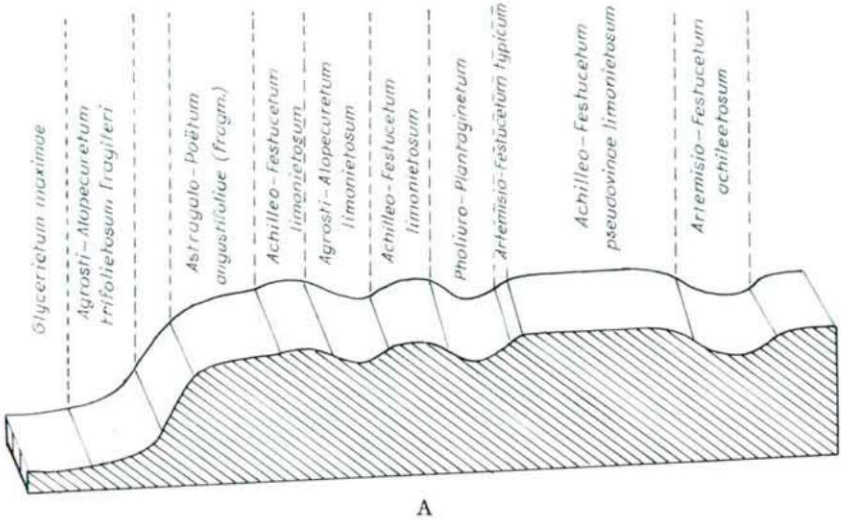
The region of zone lying in the vicinity of the backwater has shown already a transitory character. As a result of higher humidity, there occurred the *Bolboschoenus maritimus* as a differential species, forming a sub-association of *Agrosti-Alopecuretum bolboschoenetosum* that approaches the sub-association *Bolboschoenetum maritimi agrostetosum* Bodrogk. 62, of similarly transitory charcter.

Zone 6, that is simultaneously the zone of deepest relief of the area, the *Glycerietum maximae* Hueck 31, filled up the largest part of the Bega-backwater in the year of investigation, as well. The total cover of its stand did not exceed 40 per cent, here either, of which *Glyceria* was 10—15 per cent, *Typha angustifolia* 10 per cent. Owing to the water regularization, the species *Agrostion*, mainly *Symphytum officinale, Lythrum virgatum, Lycopus exaltatus*, etc. prevail more and more (Fig. 1A).

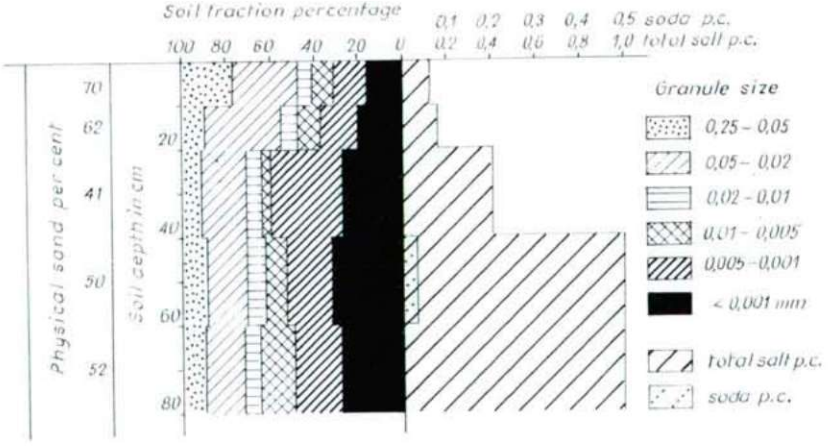
Formation of artificial micro-zonation systems

The micro-zones that have developed for twenty-four years on the crater-slopes of the shell-holes from World War II in the south-western area of the „alkali meadow of Aradác", have proved to be highly suitable for investigating the vegetation cover of the zone system produced as a result of the ground and relief differences. They were deep enough even after two and half decades for showing subsoil water on their bottoms.

The hole marked with 1 has taken place in the soil of a withering *Agrosti-Alopecuretum* meadow. Its siltation was rather slow and that crater is the deepest one even to-day. The soil that had been blown up resulted in a rising ground at the rim of bomb-crater. On that a secondary *Achilleo-Festucetum pseudovinae* typicum was produced.



A



B

Fig. 1. Zonationsystem in the area at Arda (A). Soil-physical and chemical conditions of the *Achilleetosum* profile of *Artemisio-Festucetum pseudovinae* (B).

80 cm deep from the rim of crater, on the hole-side, similarly to the bank-zone of the Bega-backwater, the *Carex vulpina* facies of *Agrosti-Alopecuretum* may be found, with *Eleocharis palustris*, showing that also the lower layers are salt-free.

On the crater-slope, in a depth of 2.5 m, a zone soaked by the subsoil water, the fragmentary species combinations of the *Polygono-Bolboschoenetum* described from the Tisza-basin can be recognized, with 60 per cent dominance; among them *Rorippa amphibia Glyceria fluitans.*

In the deepest zone of the crater whose diameter is 2 m or so (!), where the subsoil water could be estimated about 15—20 cm deep, *Scirpo-Phragmitetum typhetosum angustifoliae* became dominant; in its species combinations *Alisma plantago-aquatica* was of higher dominance percentage (Fig. 2A).

The hole-group marked with 2, on the other hand, took place in the meadow solonetz soil of *Artemisio-Festucetum pseudovinae.* As a result of the precipitation, resp. soil water that have exerted their effect for more than two decades, the bomb-craters became silted in a shorter time due to the soil liquefaction by the *Na* ions. These craters were therefore hardly 50—60 cm deep in the time of investigation.

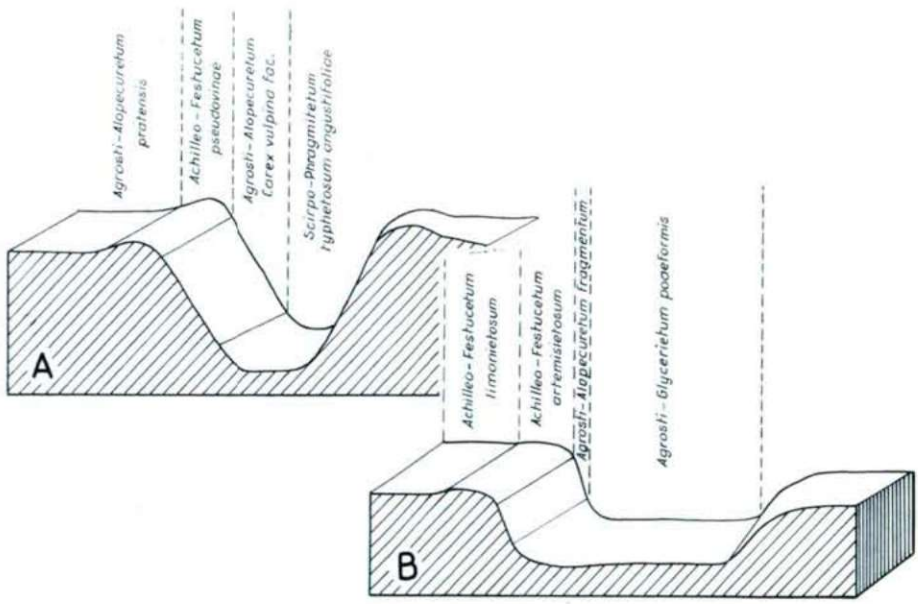


Fig. 2. Micro-zonation conditions of the bomb-craters in the meadow at Aradác, sunk in meadow (A) and solonetz soils (B).

Their zonation is the sub-ass. *Achilleo-Festucetum Limonium,* followed on the rim of the crater by the sub-ass. *Artemisia monogyna.* In the deeper-lying micro-zone *Agrosti-Alopecuretum,* on the bottom *Agrosti-Glycerietum, Bolboschoenetum,* and on the bottom of other craters *Glycerietum maximae* became dominant, with *Typha angustifolia* (Fig. 2B).

Zonation conditions of the fen at Baglyas

In this part of the Bega-backwater a deep-lying flat fen was formed in the course of the siltation. Its hydrographic conditions were much more favourable than those of the area investigated previously. For the vegetation cover, during the whole season of growth, a suitable water supply is available, in that way the plant associations of the single zones became considerably richer in species.

As the preconditions of salt accumulation are by no means assured in such a degree that a halophilous plant cover could have formed, the areas forming the higher zones have got under agricultural cultivation. Thus, in the original state, two zones could be separated.

1) *Agrosti-Alopecuretum gratioletosum (officinalis)* in the higher zone of the marshland. Its differential species are: *Gratiola officinalis, Oenanthe silaifolia, Rorippa austriaca.*

The association is of double level. In its lower level, *Trifolium repens, Lysimachia nummularia, Potentilla reptans* are of high dominance; its moss layer is formed by *Drepanocladus aduncus.*

The association, concerning its composition, is very similar to the vegetation in some inundation areas of the Tisza in Hungary (BODROGKÖZY, 1962). Thus some hybridization could be observed between the species combinations of the weakly alkali marshlands and the marshlands in the inundation areas.

2) *Agrosti-Beckmannietum gratioletosum (officinalis)* (nom. nov.). The fen at Baglyas is a zone of lower relief, inundated by soil water the most intensively. In its species combinations the glyco-hygrophilic species are dominant, first of all *Gratiola officinalis,* the name giver of the sub-association. *Oenanthe silaifolia, Euphorbia palustris, Juncus atratus,* that are forming a considerable part of cover, may be considered as differential species. They

Table 2. *Agrosti-Beckmannietum agrostetosum*

Soil depth in cm	Arany's fixity	Humus	Calcium carbonata	Total salt	Sodic alkalinity
		p e r c e n t			
0— 10	47	4.41	4.90	0.11	0.03
10— 20	38	1.92	7.36	0.11	0.06
20— 40	61	0.63	7.52	0.25	0.16
40— 60	80	0.33	4.80	0.60	0.07
60— 80	50	0.30	2.40	0.50	0.13
80—100	98	0.41	2.92	0.35	0.13
		Agrosti-Beckmannietum typicum			
0— 10	63	3.30	2.08	0.10	0
10— 20	72	2.82	1.88	0.10	0
20— 40	58	2.14	1.70	0.11	0
40— 60	68	2.10	4.52	0.14	0
60— 80	66	1.36	14.10	0.13	0

are usually missing from the solonetz fens, emphasizing here, too, the transitory character towards the phytocoenoses of the inundation areas and other marshlands. In its moss layer, similarly *Drepanocladus aduncus* was forming uninterrupted stands.

In regard of the dominance conditions, we may find sporadically even total covers of 60—70 per cent. There are dominant *Beckmannia eruciformis* forming the upper grass layer, and *Agrostis alba* forming the lower grass layer. *Gratiola* and *Oenanthe silaifolia* could, anyway, achieve a participation of 30—40 per cent of the total cover of 60—70 per cent. That can be connected mainly with the favourable nutrient and hydrographic conditions of the meadow soil that is saline in the depth (Table 2).

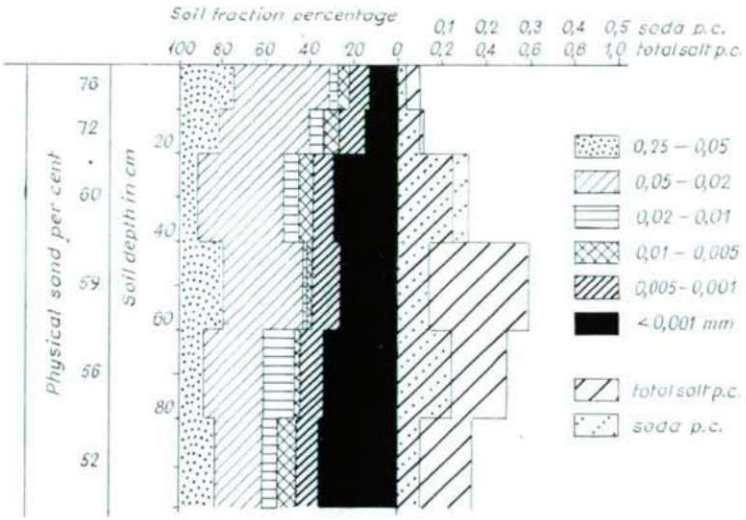


Fig. 3. Results of investigation of the soil profile of *Agrosti-Beckmannietum agrostetosum*.

Zonation conditions in the area of Muzslya

About 2 km south-west of the village, the parallel and later zigzagged courses of the Bega-backwaters lying in east-west direction cam be found. Starting from the villages, we have investigated the first and second backwaters and their vicinity.

Besides the ground and relief differences, there played a considerable part in respect of the formation of the plant cover of the single zones also the zoogene effect brought about by the vicinity of the settlement. There have sporadically appeared the signs of becoming barren as a result of the intensive pasturage and treading. Between the two backwaters, the area is not suitable for being cultivated agriculturally, in this

way, the grass associations of the single zones, the vegetation cover producted as a result of the complex effect of biotic and abiotic factors, have appeared as suitable for phytocoenological investigations.

Zone 1 was missing here, too. Zone 2 is the *Poa bulbosa* facies of *Achilleo-Festucetum artemisietosum* BODROGK. 65. On its strongly eroded berms the total cover of vegetation is 30—40 per cent. The participation of *Artemisia maritima* ssp. *monogyna* is sporadically the highest, in other places becoming more barren the participation of *Poa bulbosa* gets a leading part at the expense of *Festuca pseudovina*. In the latter case, some spots seemed to be fully barren because the *Poa bulbosa* withered except its underground organs. The berm-side and eroded depressions were, however, covered by *Camphorosmetum annuae* (RAPAICS 16) SOÓ 33.

Table 3. *Achilleo-Festucetum pseudovinae cynodontetosum*

Soil depth in cm	Arany's fixity	Humus	Calcium carbonate	Total salt	Sodic alkalinity
		per cent			
0— 5	66	3.85	0	0.09	0
5— 10	49	3.22	3.00	0.08	0
10— 20	34	1.13	4.88	0.09	0
20— 40	40	0.46	9.58	0.22	0
40— 60	50	0.35	18.38	0.40	0
60— 80	45	0.30	10.00	0.32	0
80—100	42	0.20	10.40	0.25	0
		Artemisio-Festucetum pseudovinae camphorosmetosum			
0— 5	48	1.66	0	0.07	0
5— 10	35	1.20	1.70	0.22	0.10
10— 20	49	1.14	3.42	1.50	0.23
20— 40	49	1.35	3.50	4.00	0.31
40— 60	46	0.39	4.96	2.50	0.42
60— 80	45	0.25	19.20	1.50	0.40
80—100	47	0.20	20.76	0.38	0.32
		Camphorosmetum annuae Puccinellia facies			
0— 5	46	2.02	3.94	0.22	0.07
5— 10	36	1.06	6.58	0.30	0.24
10— 20	36	0.36	6.84	0.70	0.27
20— 40	40	0.32	5.40	0.90	0.30
40— 60	50	0	16.22	0.40	0.14
60— 80	48	0	16.68	0.20	0.06
80—100	49	0	11.28	0.16	0.06

The low number of species is not only a result of the exaggerated biogenic effect but also the consequence of the chemical composition of soil. The 20 cm thick A-layer was in regard of the total salt content near to have an alkali character, below it being a solonetz B-layer. The presence of soda could not be demonstrated (Table 3).

In some regions of this zone, on island-like arising reliefs, in areas less touched by an arosion, the coenoses of a grass comparatively rich in species, subass *Cynodonti-Poëtum* (RAPAICS 26) Soó 57 *Festuca rupicola* fac. resp. *Achilleo-Festucetum cynodontetosum* developed, producing the properly first zone. Their total cover achieved 80 per cent, in 60 per cent of which *Festuca rupicola* took part. From their species combinations, the deep rooting halophytons were entirely missing. In that way, their meadow chernozem soil is free from getting a solonetz character (Table 3).

3) This zone, formed terrace-like and lying 30—40 cm lower than the former one, gave the area already a solonetz character. The A-layer of its soil profile is hardly 5 cm, in its modestely steppe-like, rough meadow soil, as a result of its calcium carbonate and soda content near the surface, an artemisi-steppe variety, approaching the barren ground, of *Artemisio-Festucetum pseudovinae camphorosmetosum* (RAPAICS 27) SLAVNIĆ 48 developed. From among the zones investigated here this was the most extensive.

Owing to the damaging influence of the considerable total salt, resp. alkali values near to the soil surface, supported by the increased biogenic effect, a closed grass cover of the *Festuca* stand could not develop, and at the end of May it got already an open character. In the 45 per cent total cover *Festuca pseudovina* participated only with 5, *Poa bulbosa*, on the other hand, however in a state of rest, participated with 20 per cent. From among the halophilic species, apart from *Camphorosma annua*, threads of *Kochia prostrata*, *Plantago maritima* have shown soil-ecological conditions of solonchak character. *Lepidium ruderale*, *Matricaria chamomilla* var. *salina* of broad ecological adaptability can similarly be observed. At the same time, two characteristic representatives of the artimisia steppes, *Artemisia monogyna* and *Limonium gmelini* could be found only by threads in some parts of this zone.

Zone 4 could be found by approaching the Bega-backwater marked by us with number 1. The solonetz layer, resp. that containing the salt accumulation can already be found on the surface of the eroded relief or in its vicinity. But here are the hydrographic conditions already more favourable and the zone is, therefore, occupied by the *Puccinellia limosa* facies of *Camphorosmetum annuae*. Total cover is between 35—50 p. c., the dominant species being *Puccinellia limosa*. Its dominance conditions, resp. its participation in the total cover are depending upon the degree of pasturage. Its existence is assured salt content did not rise, even in the accumulation layer of the relief unearthed at the end of May, above one per cent. Also the 2 per cent organic material content near the surface is exerting a compensating effect on the soil-ecological conditions of the root zone. There occurs in some loftier regions of this zone, having therefore a leached A-layer, that owing to the increased biogenic effect a degraded steppe was formed, the dominant species of which are: *Hordeum hystrix Carex stenophylla, Cynodon dactylon.*

Zone 5 was occupied, as a consequence of a further lowering of the level by alkali meadows. *Puccinellietum limosae polygonetosum avicularis* was dominant. The *Puccinellia*, for some cause, could not be closed, the barren

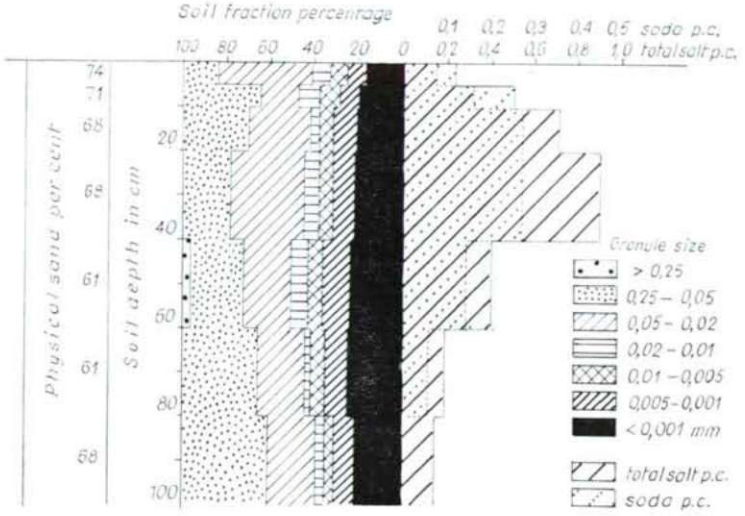


Fig. 4. Results of investigation of the soil profile of *Puccinellietum limosae camphorosmetosum.*

soil spots were therefore occupied by *Polygonum aviculare.* The pushing forward of the ephemerous *Polygonum* may supposedly be explained by the periodic state of being covered by water that is unfavourable for *Puccinellia.* The place of the withdrawing honey grass is occupied, similarly to those observed in other regions of the Pannonicum, in water-free periods.

Zone 6 has formed a narrow strip at the rim of bed of the backwater marked with No. 1. It is a typical alkali silt-association, its ephemerous species combination developed, therefore, in the bank region that became dry after sinking of the surface of water.

On the same tarrace-height, owing to the shorter lasting water-coverage of the bank-line of backwater 2, the coenosis is formed by perennial hygrophilic species. The soil of this zone is less alkalized, thus the *Agrostis alba* sub-association of *Agrosti-Alopecuretum* could develop.

Pholiuro-Plantaginetum tenuiflorae (RAPAICS 27) WENDELBG. 43 *eleocharetosum (uniglumis)* has shown — mainly because of the soil of zone becoming strongly saline — a transition towards the zone above it with *Puccinellia.*

Its soil is meadow solonetz of solonchak charakter in the profile of which calcium carbonate and sodic alkalinity can be demonstrated from the surface. The upper five cm of the A-layer is, anyway, so much eluviated that the total salt content did not rise above the limit of alkalinity (0.11 per cent), in this way also the weakly salt-tolerant hygro-halophilic species could find suitable essential conditions (Table 4).

Zone 7 is in the bed of backwater 1 where water has but a periodical character. After desiccation, the formation of a characteristic silt-plant community became possible. That zone is below the solonetz layer, therefore but a weakly solonchak poured soil is formed in the whole bottom-breadth of the water-bed. Its association is *Heliotropio-Verbenetum supinae* SLAVONIĆ 51,

Table 4. Zone 6. *Pholiuro-Plantaginetum tenuiflorae eleocharetosum (uniglumis)*

Soil depth in cm	Arany's fixity	Humus	Calcium carbonate	Total salt	Sodic alkalinity
		p e r c e n t			
0— 5	42	2.41	3.60	0.11	0.02
5— 10	37	0.99	4.68	0.14	0.11
10— 20	56	1.02	5.09	0.30	0.24
20— 40	59	0.36	5.90	0.50	0.31
40— 60	66	0.26	4.80	0.60	0.21
60— 80	68	0	8.60	0.35	0.19
80—100	58	0	20.08	0.30	0.10

Zone 7. *Bolboschoenetum maritimi agrostetosum*

Soil profile in cm	Arany's fixity	Humus	Calcium carbonate	Total salt	Sodic alkalinity
		p e r c e n t			
0—10	58	4.60	4.80	0.09	0.05
10—20	49	1.76	4.68	0.11	0.15
20—40	86	1.01	3.68	0.38	0.14
40—60	96	0.51	3.76	0.40	0.24
60—80	96	0.28	2.48	0.80	0.24

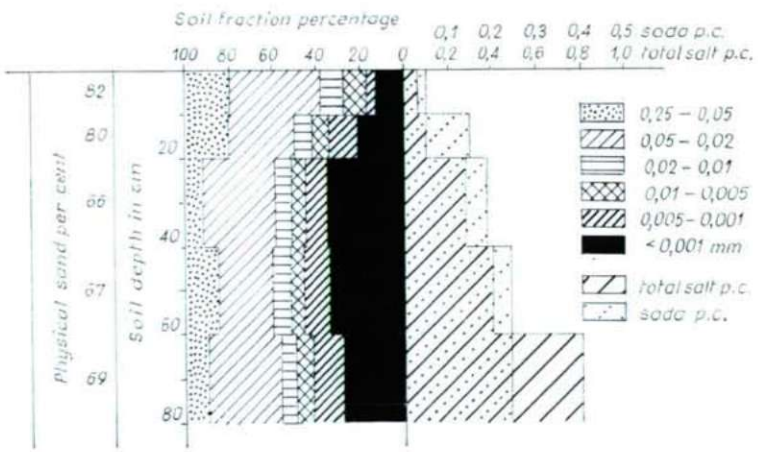


Fig. 5. Soil profile of *Bolboschoenetum maritimi.*

described by SLAVONIĆ from several regions of Voivodina. From among its character species, the *Verbena supina* of Pontic-Mediterranean origin presented itself in large numbers. Apart from it *Chenopodium chenopodioides (= Ch. botryoides)* occurred as a differential species. Presenting itself en

masse, it is in fact predominant in the area. In other regions of the Pannonicum, under similar habitat conditions, it forms sub-associations in other halophilous communities.

In the zone of similar level of Bega-backwater 2, the sporadically appearing stands of *Bolboschoenetum maritimi,* resp. *Scirpo-Phragmitetum* could be observed.

Z o n e 8. The bed-reaches of Bega, lying deeper than the former level, are therefore a water-covered zone in a great part of the vegetation season. Its vegetation is *Batrachio-Ranunculetum polyphylli* Soó 61, one of the associations of *Ruppion maritimae* Br–Bl. 31, characteristic of the alkali waters. We are knowing rather little about its association conditions in connection with the Pannonicum. From the Voivodina it is mantioned by Slavnić (1956).

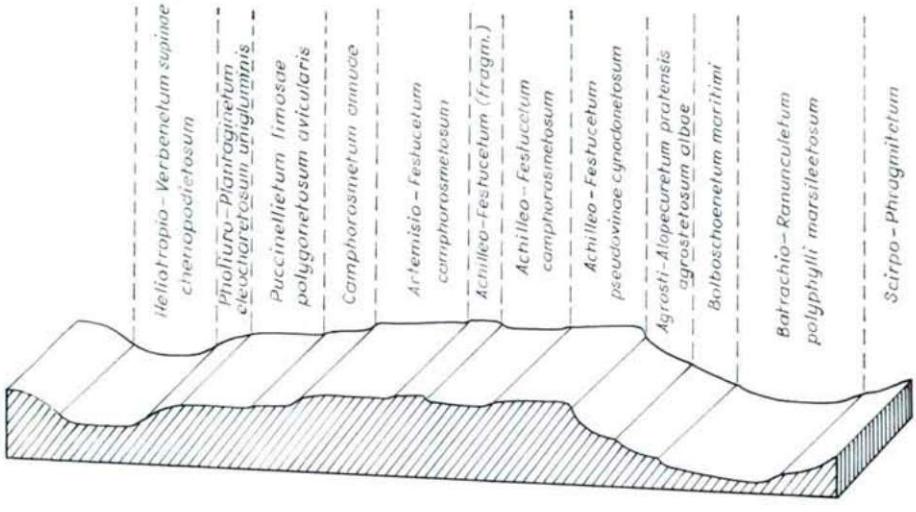


Fig. 6. Result of the increased anthropogenic effect upon the plant communities forming the zonation-system of Bega-backwaters 1 and 2.

In the Bega-backwater marked with 2, there developed a peculiar species combination of its, presenting itself as a differential species of *Marsilea quadrifolia.* Its appearance en masse in some places was an evidence of its favourable life conditions in weakly alkali lakes. It is, as a matter of fact, a plant species of the marshy silt soils but — in case of similarly inundated rice cultures — it endured even a higher water coverage without being damaged.

Elsewhere we could observe the appearance of complex character of its reed-grass vegetations. In this way, *Nymphoidetum pleltatae* (Allorge 22) Oberd. et Müller 60., *Potametum lucentis* Hueck 31, *Oenanthetum aquaticae* Soó 27 can also ba considered as fragments of the reed-grass vegetation sur-

vived from the period of the old high-level backwaters, and they can be found even to-day in the deeper sectors of the backwater in their original association.

About 5 km West of Muzslya, in the area of the backwaters marked with Nos. 5 and 6, we have repeated our zonation investigations for controlling the above ones. Between the two meanders, similarly to the previous ones, an untouched, original grass cover was at our disposal.

The single zones and their vegetations have shown approximately identical connections. The more variegated relief conditions led to a repetition of zones many times.

The highest zone (1) of the ridge between the backwaters was here covered by a rich species association of grass with chernozem soil .It was saved from the danger of being devastated only by its complicated approachability. Its species combinations are entirely missing the halophytic representatives. We cannot speak, therefore, about the lower soil layers becoming more and more solonetz in character.

Its plant stands are in two layers. The upper one was formed by *Poa angustifolia, Agropyron repens,* the lower one by *Astragalus austriacus, Trifolium campestre, T. retusum, Cynodon dactylon* with *Festuca pseudovina.*

Zone 2, the *Achilleo-Festucetum pseudovinae cynodontetosum* has had similarly a species combination without species of halphilic character.

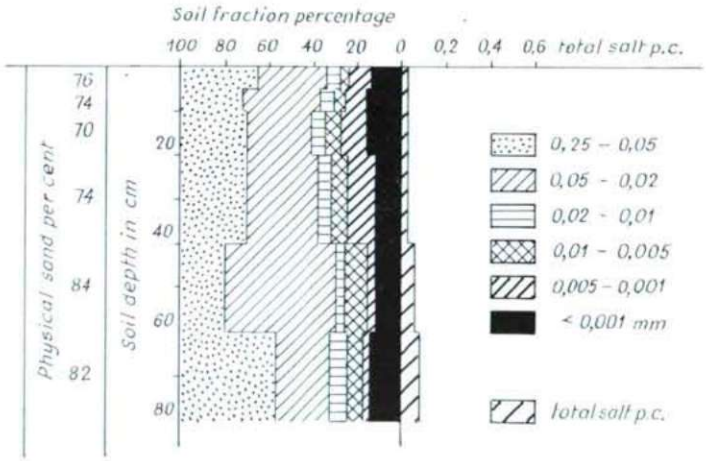


Fig. 7. Soil profile of *Achilleo-Festucetum pseudovinae cynodontetosum.*

Its unearthed soil profile is fully soda-free, and a major salt content could not be demonstrated in layer B_2, either.

Its species association is, anyway, as shown by the namegiving species of the sub-association, as well, a strongly pastured and trodden area.

Zone 3 can be characterized, here too, by the appearance of the solonetz layers.

In the direction of the meander No. 6, the accumulation level of solonetz is immediately on the surface, and the terrace-layer was dominated in the rough solonchak meadow solonetz by *Camphorosmetum annuae*, while on the opposite side by *Artemisio-Festucetum pseudovinae camphorosmetosum* that is characteristic of the meadow rough solonetz becoming moderately steppe like.

Approaching backwater 5, there followed a sector eroded by soil water, in whose zone forming the deepest relief the meadow soil of *Agrosti-Alopecuretum limonietosum*, getting more and more a solonetz character, can be found, marking similarly this zone, resp. the level of its terrace at the rims of the two meanders. That, however, resulted, owing to the gradual eluviation, in the typical appearance of the association. The vegetation cover developed in the higher layer round this zone is characterized partly by the solonetz layer got to the surface partly by the alkali silt.

Table 5. *Achilleo-Festucetum pseudovinae cynodontetosum*

Soil depth in cm	Arany's fixity	Humus	Calcium carbonate	Total salt	Sodic alkalinity
		per cent			
0— 5	67	4.82	0	0.02	0
5—10	60	4.20	0	0.02	0
10—20	46	2.92	0	0.02	0
20—40	46	2.06	0	0.02	0
40—60	48	1.22	0	0.05	0
60—80	49	0.43	15.04	0.07	0
Achilleo-Festucetum pseudovinae alopecuretosum					
0—10	55	3.87	0	0.02	0
10—20	48	2.86	0	0.06	0
20—40	67	1.72	0	0.10	0
40—60	68	1.08	2.08	0.15	0.02
60—80	79	0.93	7.52	0.15	0.09
Agrosti-Alopecuretum pratensis limonietosum					
0—10	51	3.23	0	0.03	0
10—20	52	2.54	0	0.08	0
20—40	59	1.74	0	0.14	0
40—60	67	1.80	2.14	0.25	0.04
60—80	72	1.44	5.12	0.60	0.06

Backwaters 5 and 6 have deeper and constant water, therefore in the bed of meanders partly the associations of Glycerietum maximae, partly those of *Scirpo-Phragmitetum typhetosum* became dominant, as seen in case of the Bega-backwater lying West of Zrenjanin.

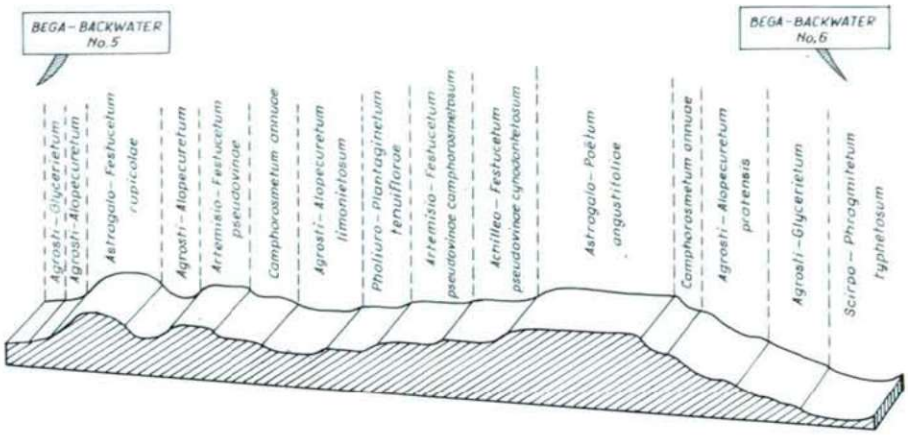


Fig. 8. Zonation conditions of the vegetation cover between Bega-backwaters 5 and 6.

Summary

In the course of the synecological investigation of the halophilic vegetation of the Pannonicum, the area of the Bega-backwaters in the Voivodina in Yugoslavia was elaborated. The task was to clarify the zonation conditions of the halophilic and glycophilic grass cover along some meander reaches chosen in the region of Zrenjanin.

During the investigations it was proved again that between the characteristic features of the zones of zigzagged limits lying terrace-like and the vegetation cover a close connection can be demonstrated here, too. After comparing the results of elaboration of three areas lying between backwaters rather far from one another, the following facts could be ascertained.

1) The outstanding ridges of the relief between the backwaters may be regarded as zone 1. In its meadow chernozem soil that does not get alkali, *Astragalo-Poëtum angustifoliae,* resp. *Achilleo-Festucetum pseudovinae* typicum can be found. This zone may sporadically missing or can appear island-like.

2) The zones lying below it have in the depth saline, resp. meadow solonetz soils becoming more and more steppe-like. Its vegetation cover developed partly of glycophilic species rooted in the surface soil of the eluviated A-layer, partly of deeply rooted halophilic species reaching the solonetz layer. Their phytocoenoses can be placed among *Achilleo-Fectucetum pseudovinae artemisietosum,* resp. *limonietosum,* and *Artemisio-Festucetum.*

3) In the meadow solonetz of zone 3 becoming roughly solonchak steppe-like, *Artemisio-Festucetum pseudovinae camphorosmetosum, Camphorosmetum annuae,* resp. its *Puccinellia limosa* sub-association could be observed.

4) In zone-groups of salt subsoil under hydrographically favourable conditions *Agrosti-Alopecuretum limonietosum,* in weakly saline soils *Agrosti-*

Alopecuretum typicum, *Agrosti-Glycerietum*, and *Agrosti-Beckmannietum* were to be found.

5) In the alkali silt of meander reaches in state of drying out, *Pholiuro-Plantaginetum tenuiflorae*, resp. *Heliotropio-Verbenetum supinae chenopodietosum* could be found.

The single zones can be formed under artificial conditions, as well. The craters of the bombs of air-raids fallen two decades ago on various alkali soils proved to be very suitable for investigating these.

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