

**DYNAMIC ROWS OF GRASS VEGETATION ASSOCIATIONS OF REGROWTH
SUCCESSIONS AND ACCUMULATION OF HEAVY METALS
ON THE TERRITORIES OF THE FORMER RURAL SETTLEMENTS**

L. N. Anishchenko¹, S.N. Potsepai², Yu.G. Semenova², S.A. Bel'chenko²

¹*Bryansk State University, Bryansk, Russian Federation*

²*Bryansk State Agrarian University, Bryansk, Russian Federation*

e-mail: eco_egf@mail.ru

For the conditions of the Bryansk region (Non-Black Soil Zone of the Russian Federation) the succession of ruderal vegetation has been described. Researches were conducted in the conditions of a buffer zone in the national park and selitebny habitats and the known terms of education and encrustation deposits. 11 successions ranks have been described, the derivative communities, consecutive change of phytocenoses of various associations have been identified. The results of chemical analysis researches of dominant species of the studied phytocenoses on the maintenance of elements of group of heavy metals, have allowed establishing plants absorbers and neutral species to pollutants, on the calculated accumulation coefficients. These species such as *Galinsoga parvifolia*, *Urtica dioica* (contents indicators Cu), *Thladiantha dubia* (Fe), *Potentilla anserina* (Cr). Species, forming ruderal communities and accumulating heavy metals, may serve not only as indicators of their presence in the soil, but also used in phytoremediation of anthropogenic transformed territories.

Keywords: vegetation, synanthropic and ruderal vegetation, successions, heavy metals

This article deals with the investigation of succession change stages occurring during vegetation regrowth period in uninhabited settlements as this problem has been studied insufficiently. Floristic and geobotanical investigation of vegetation cover on the territories of rural settlements in the south-west of the southern Non-Black Earth Zone of Russia have been carried out in the course of the last years [4, 7]. It scientifically justifies diagnostics of dynamic vegetation processes aimed at monitoring.

This paper is aimed at reflection of different succession processes stages on the territories of the former rural settlements in the southern Non-Black Earth Zone of Russia.

Ruderal vegetation, as a synanthropic element, carries out a role of protector from intensive habitats transformation. Also ruderal cenoses prevent soil erosion, can be used in biological remediation processes.

The climate of the territory which is being investigated is temperate and continental. Average yearly temperature is 4,7 °C. The period of active vegetation lasts 185 days. Mean annual precipitation is 680 mm. Frost-free period lasts 135-140 days [6]. According to the geobotany division into districts the most part of the territory belongs to the Bryansk area with its coniferous and broad-leaved forests of Severodvinsk and Verhnednepronsk sub province of the North-European taiga province, in botanical and broad-leaved province with its two Poleskaya and Srednerusskaya province.

When describing vegetation we used the detailed and route method on the territory of the villages of Krasnaya Sloboda, Smelizh, the village of Chukhrai (a protected area, the reserve «Bryansky Les»), the villages which were moved further out in 1987 (the principal part of reserve «Bryansky Les») named Proletarsky, Vily, Scuty, St. Yamnoye (Suzemka district). About 200 geobotanical descriptions have been performed with the help of the ekologo-floristic classification method [1]. The names of associations are match «International Code of Phytosociological nomenclature» [10]. When classifying associations on the territories of the former rural settlements we used the method of Zh. Braun-Blanke [1] and the deductive method of the K. Kopečky-S.Hejny [3]. When analyzing the material and interpreting the data we took into account the stage of succession (the association age up to 5 years, up to 5-15 years, more than 15 years) and the pattern of associations use in places of abandoned settlements (fallow and pasture lands). Species names are given according to S.K. Cherepanov [2].

In each of communities the grass cover on the test site area of 0, 25 sq.m was mown, the selected hay crops left as tests for their further laboratory research on the content in biomass of elements of group of the heavy metals (HM). Soil samples, at the time of collection of plant material, at a depth of 0-20 cm from the diagonal arrangement of the zone of the root system on the test site area in 5 points with the subsequent consolidation in the mixed sample according to the requirements stated in GOST 28168-89 have been selected. Preparation of tests for the analysis of gross maintenance of TM was carried in accordance with OST 10259-2000, determination of gross content of TM in samples was performed using the device of the «Spektroskan Maks» company Spectron [5]. With use of the obtained data coefficients of accumulation (KN) as the relation of concentration of an element in plants to concentration of an element in the soil have been calculated.

The most part of the investigated communities of associations in the succession orders belongs to the *Artemisieta* Lohmeyer et al. in R. Tx. 1950, , *Agropyreteea repentis* Oberd., Th. Müller et Görs in Oberd. Et al. 1967, *Chenopodieta* Br.-Bl. 1952 em. Lohmeyer, J. Tx. Et R. Tx. 1961 ex Matuszkiewicz 1962 classes.

Initial stages of successions in places where arable lands had earlier been heavily fertilized are communities of the *Chenopodietea* class subsequently they are replaced by derivative communities *Cyclachaena xanthiifolia*. Communities of the *Cyclachaena xanthiifolia* which have been present on the territory for a long time (for more than 5 years). The succession order with the fallow regime is represented by monodominant plant communities with the species particular about nitrogen content in the soil:

(1) B.c. *Amaranthus retroflexus* (B.c. *Chenopodium album*) → D.c. *Cyclachaena xanthiifolia* → D.c. *Thladiantha dubia*

On the noneutrophicated lands which were plowed earlier and mostly after tilled and industrial crops succession is represented by monodominant **cenoses** ass. *Berteroetum incanae* Siss.et Tidem.ex Siss., basal *Heracleum Sosnowskyi* plant communities.

(2) Ass. *Berteroetum incanae* → B.c. *Heracleum Sosnowskyi* → ass. *Convovulo-Brometum inermis* (B.c. *Elytrigia repens*) → D.c. *Bromopsis inermis*

For *Heracleum Sosnowskyi* to appear substrates surface (arable layer) must be loose weed plant projective cover must be small at the initial stage, it will have an optimum effect. *Heracleum Sosnowskyi* communities is replaced either by basal communities *Elytrigia repens* (in 12-17 years), or by communities *Bromopsis inermis*, communities of associations *Convovulo-Brometum inermis* (in 15 years and in more than 15 years). These are **xerosere** in the succession fallow orders.

Regrowth stages of succession under industrial crops depending on soil saturation with plant food elements are represented at the first stages by monocenoses of the annuals:

(3) *Galinsoga parvifolia* → ass. *Poetun annuae* → *Solidago canadensis* → ass. *Calamagrostio epigeiis-Tanacetum vulgare*

(4) *Matricaretum perforatae* → ass. *Poetun annuae* → ass. *Matricario perforatae-Polygonetum avicularis* → *Carduetum acantoides* → ass. *Calamagrostio epigeiis-Tanacetum vulgare*

(5) B.c. *Cannabis sativa* → ass. *Cichrio-Artemisietum absintii* → B.c. *Onopordium acanthium*

At the final stages multispecies cenoses of synanthropic and typically meadow vegetation classes form (*Artemisietea vulgaris* Lohmeyer et al. in R. Tx. 1950 and *Molinio-Arrhenatheretea* R. Tx. 1937 em R. Tx. 1970). On the whole we can observe segetal communities replaced by ruderal meadow vegetation associations (more than 15 years). These are old field xerosere successions.

All above mentioned succession orders have been diagnosed on abandoned farmsteads and collective farm arable lands in rural settlements with low density of population. It is possible that these places were used for haymaking and pasturing.

The following succession orders could be observed on the territories of the former rural settlements of old field regime (if the territory is fully preserved):

(6) B.c. *Urtica dioica* → ass. *Urtico-Aegopodietum* (ass. *Cichorio-Artemisietum absintii*) → ass. *Calamagrostio epigeiis-Tanacetum vulgare*

The xeroseres take place with rather rapid succession (after 8-9 years of old field regime), which result in plant cover regrowth (ass. *Urtico-Aegopodietum* (Tx. 1963) Oberd. 1969).

However on the territories where people have moved in and are living at present associations of succession series are partly repeating the series:

(7) B.c. *Urtica dioica* → ass. Leonuro- *Urticetum dioicae* → *Artemisia vulgaris* ass. *Cichorio-Artemisietum absintii* → ass. *Calamagrostio epigeiis-Tanacetum vulgare*

(8) B.c. *Urtica dioica* → ass. *Cichorio-Artemisietum absintii* и D.c. *Thladiantha dubia*, *Melilotus alba*

Sometimes associations of succession orders stay within the class of *Artemisietea vulgaris* Lohmeyer et al. in R. Tx. 1950.

When vegetation on former agricultural lands which were used as pasture has regrown succession orders are represented by typical plant communities of trampled down pastures:

(9) B.c. *Trifolium repens* → ass. *Polygonetum avicularis* → ass. *Poo pratensis - Plantaginetum majois* → B.c. *Deschampsia cespitosa*

(10) B.c. *Trifolium repens* → ass. *Polygonetum avicularis* → ass. *Potentillietum anserinae*

(11) B.c. *Trifolium repens* → ass. *Polygonetum avicularis* → ass. *Plantadini-Polygonetum avicularis*

Plant communities of the *Poo pratensis-Plantaginetum majois*, *Potentillietum anserinae*, *Plantadini-Polygonetum avicularis* associations form in 4-5 years after the beginning of pasturing they exist long enough and represent disclimax associations. They are the pasture succession order xeroseres. These orders are associations whose specific diversity with the progress of succession is practically constant, but sometimes it falls (regressive successions).

Thus general systems of succession changes on the whole are represented by 8 types of succession replacements. In the main they are old field order xeroseres of regrowth successions. The greatest speed of succession replacements have been registered in the pasture order of dynamic replacements. With the progress of successions association alpha diversity of serial orders is increasing. Various stages of successions are represented by the most diverse floristic composition. In the replacement types 1-6 initial stages are represented by young association with unstable floristic composition.

In the middle stages of serial orders species of ruderal and meadow inhabited places mix up. Certain elicited appropriateness coincides with the data on the republic of Bushkortostan [9].

We have also registered the convergence phenomenon. Here we can observe similarity between syntaxons of ecological and floristic classification at the last stages of succession replacements. It can't be full similarity.

Also, knowledge of the time of forming of these or those vegetable communities on deposits, it will be possible to establish the age of not used habitats in agricultural production.

Coefficients of accumulation are shown in Table.

Table – Coefficients of accumulation of heavy metals in the biomass of plant communities

Element	*Species of the plants forming communities								
	1	2	3	4	5	6	7	8	9
Sr	1,14	1,38	0,80	1,09	0,33	1,82	1,59	0,69	0,75
Pb	1,22	0,72	0,53	0,63	0,79	1,57	0,64	0,69	0,93
As	2,52	2,14	1,27	0,75	1,75	0,71	0,89	1,15	1,69
Zn	0,38	0,83	0,49	0,69	0,73	0,84	0,77	0,89	0,86
Cu	1,55	0,81	1,05	1,16	0,88	0,99	0,89	1,47	0,91
Ni	0,61	1,21	1,29	0,79	1,12	2,69	1,36	0,89	1,71
Co	0	1,55	0,11	0	0	0	0	0	0
Fe	0,96	0,60	0,63	0,44	0,38	1,12	1,08	1,69	1,45
Mn	1,87	4,41	2,41	2,36	1,92	1,63	0,55	0,65	1,83
Cr	1,11	0,81	1,21	0,87	1,11	4,28	0,89	1,11	1,59
V	0	0	0	0	0	0	0	0	0
Ti	0	0	0	0	0	0	0	0	0

*Plant species: 1. *Heracleum sosnowskyi*. 2. *Galinsoga parvifolia*. 3. *Solidago canadensis*. 4. *Urtica dioica*. 5. *Melilotus alba*. 6. *Deschampsia cespitosa*. 7. *Cyclachaena xanthiifolia* 8. *Potentilla anserina*. 9. *Thladiantha dubia*.

The most expressed accumulation by elevated biomass estimated on the basis of the calculated coefficients of accumulation is registered for fitocenoses *Heracleum sosnowskyi* formed by a plant which is gaining a good green mass. *Heracleum sosnowskyi* accumulates Sr, Pb, As, Cu, Mn, Cr; The species of an adventitious plant of *Galinsoga parvifolia* absorbs and accumulates Sr, As, Ni, Co, Mn, Zn, *Solidago canadensis* – As, Ni, Co, Mn; *Urtica dioica* – Sr, Cu, Mn, *Phytolacca americana* – As, Ni, Cr, Mn, *Deschampsia cespitosa* – Sr, Pb, Ni, Fe, Mn, Cr, *Cyclachaena xanthiifolia* – Sr, Ni, Fe, *Potentilla anserina* – As, Cu, Fe, Cr, *Thladiantha dubia* – As, Ni, Fe, Mn, Cr. Ions of Sr, Ni, Mn, As easily migrate in a soil profile, and then in underground organs and in shoots (green mass) of plants where accumulated which generally reflects the data given in the literature [8]. The bioorganic element Fe – an indispensable component of the plant cell which mainly accumulates in underground organs of plants – the roots, a modified underground shoots.

Due to the above, Fe mainly accumulated at insignificant number of investigated species. Mn is also the major biogenic element which actively migrates in the sprout parts of plants, therefore the highest gross concentrations are registered in sheet plates of plants. The highest total content of Mn are observed in plants all cenoses except *Cyclachaena xanthiifolia* and *Potentilla anserina*.

The plant fitocenoses *Heracleum sosnowskyi*, possessing the greatest biomass and dominant the long period of time in considerable territories accumulate the greatest number of heavy metals, and in the cenoses with *Cyclachaena xanthiifolia* – the smallest.

Plants in synanthropic communities growing in the conditions of excess lead and zinc don't accumulate these elements ($K_n < 1$), due to low mobility of Pb and Zn compounds in the soil, and biological characteristics of plants: species, genotype, stage of plant development.

In relation to the increased concentration of Pb and Zn of investigated plants communities belong to the group of communities «exceptionals».

The plants of communities *Galinsoga parvifolia*, *Urtica dioica*, growing in the conditions of gross excess Cu concentrations have been attributed to the group of «indicators» ($K_n > 1$).

Also, the «indicators» – plants *Thladiantha dubia* community in relation to Fe, *Potentilla anserina* – in relation to Cr.

Thus, some plants accumulating heavy metals, may serve not only as indicators of their presence in the soil, but also used in phytoremediation of anthropogenic transformed territories.

So, all «non-aggressive plants», i.e. not relating to biologically active on reproduction speed – *Galinsoga parvifolia*, *Urtica dioica* and others, in process of development of biomass will be mown and utilized. *Potentilla anserina* – a plant, quickly occupying disturbed habitats, for the creation of universal protection of the buffer from heavy metals.

References

- 1 Braun-Blanquet J. Pflanzensoziologie. Grundzuge der Vegetationskunde. 3Aufl.-Wien- New York: Springer-Verlag. – 1964. – 865 s.
- 2 Cherepenov S.K. Vascular plants of Russia and neighboring countries. – SPb.: Peace and family-95. – 1995. – 992 p.
- 3 Kopečky K., Hejný S. Die Anwendung einer deduktiven Methode syntaxonomischer Klassifikation bei der Bearbeitung der straßenbegleitenden Pflanzengesellschaften Nordostböhmens // Vegetatio. 1978. – V. 36. – № 1. – S. 43-51.
- 4 Kharin A.V. Sintaksonomiya and organization of biomonitoring vegetation of Bryansk: Author. ... Diss. cand. biol. Sciences. – Bryansk, 2006. – 24 p.
- 5 Methods of measurement of the mass fraction of metals and metal oxides in powdered soil samples by X-ray fluorescence analysis. M 049-P / 04-S-Pb .: NPO "Spectron", 2004. – 20 p.

- 6 Natural resources and environment Bryansk region (edited by N.G. Rubalsky and others). – M: Research institute. – Nature, 2007. – 1147 P.
- 7 Potsepai Y.G. Synanthropic vegetation and its use for phytomelioration selitebny areas (for example, the Bryansk region): Abstract. ... Diss.kand.biol.nauk. – Bryansk, 2008. – 24 p.
- 8 Potsepai YG, Anischenko LN Accumulation of heavy metals adventitious plants of synanthropic communities // Problems of Agricultural Chemistry and Ecology, 2013. – P. 35-40.
- 9 Yamalov S.M., Saifullina N.M. Syntaxonomy of Grass vegetation of Abandoned settlements in the Mountain and forest zone of the republic of Bushkortostan // Pressing Problems of geobotany. Part 2. Petrozavodsk. Karel' sky scientific centre of the Russian Academy of Sciences, 2007. – P.318-321.
- 10 Weber H.E., Moravec J. International Code of Phytosociological nomenclature. 3rd additional //Journal of Vegetation Science. – Vol. 11. – №5. – 2000. – P. 739-768.