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Estimation of State of Urban Soil Using Algal Bioassays

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ABSTRACT

This article describes application of algal bioassays for monitoring of urban soils in the city of Saransk. Depending on the pollution degree, the following algae were detected in soils : bluegreen (*Cyanophyta* L.), green (*Chlorophyta* L.) and diatomic (*Diatomophyceae* L.) algae. The highest number of algae was detected in environmentally clean soils. Terrestrial algae response to pollutions : their species variety decreased; the structure of leading families and genera changed.

Key words : Biological test, monitoring, soil microflora, blue green, green (*Chlorophyta* L.), diatomic algae

INTRODUCTION

Estimation of environmental quality is an urgent issue of nature protection. In recent decades, the methods of biological estimation are intensively studied and applied to obtain integrated property of environmental quality. Only biological tests can comprehensively characterize overall impact of pollutants and suitability of environment for wild life, estimate it in indices having biological sense. In addition to estimation of anthropogenic impact, it is important to apply biological tests for continuous monitoring of environment in order to understand general trends of its variations both locally and regionally. The most important in biological indication is not the estimation of occurrence of certain restricting parameters but the plant response, biological impact of this on environmental factor. Herewith, an important property of biological test is ability of early indication even upon minimum accumulation of pollutants. In accordance with various levels of biological systems, there exist various levels of biological indication : from physiological–biochemical and anatomic–morphological to biogeocoenotic and landscape, the first levels are generally used as the most sensitive (Nam *et al.*, 2021). Soil is the most polluted component of urban environment. Algae are very important for land reclamation. Algae participate directly in numerous biochemical processes, affect soil physical properties. Algae affect indirectly the soil life through various interactions with soil microorganisms and higher plants.

The main biochemical processes performed by algae in soils are as follows : accumulation of organic matters and nitrogen, destruction of minerals, redistribution and accumulation of elements. They are capable to interact with all components of communities and to play important role in their operation. In addition, algae release a range of biologically active substances, vitamins, various slimes into ambient environment, which promotes coagulation of single mineral particles of substrate and structure generation of future soil, and also acts as erosion preventive barrier. Blue-green algae capable to bind atmospheric nitrogen are an important source of addition of this biogenic element into soil.

Two trends are highlighted for application of algae to indicate variations occurring in soil under the impact anthropogenic factors : (1) The pattern and degree of technogenic impact are judged by the structure of community of terrestrial algae and (2) Certain types of algae are used as references under laboratory conditions.

Now-a-days estimation of state of soil-inhabiting organisms, their biological variety is highly important for solution to the problems of environmental protection : highlighting areas of environmental troubles, prediction of loss caused by human activity, determination

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of stability of ecosystem and impact of various anthropogenic factors (Dorokhova *et al.*, 2015; Gorchakova *et al.*, 2019). Microorganisms and their metabolites facilitate early diagnostics of any environmental variations, which is important for prediction of variations under the impact of natural and anthropogenic factors (Yu *et al.*, 2020; Maltsev *et al.*, 2021).

Peculiar feature of terrestrial algae is their phototrophicity, which stipulates characterization of algosinusia using the same criteria as for higher plants i. e. species composition is estimated, as well as existence of dominant species, occurrence of certain algae species and groups, distribution of algae in soil profile and quantitative properties of community. Peculiar attention is paid to selection of edificators, though formation of soil algosinusia depends on overall set of environmental factors (Sheard *et al.*, 2017; Foets *et al.*, 2020).

The following algae species are characteristic for soils : blue-green, yellow-green, green and diatomic (Chudaev *et al.*, 2015; Buevich *et al.*, 2018a, b; Bonfante, 2019). The main aim of our studies was estimation of environmental state of territory using algae, including analysis of species composition and taxonomic structure of algae; determination of peculiarities of phytocoenotic arrangement of groups of terrestrial algae in communities of natural colonization.

MATERIALS AND METHODS

The procedure of algal bioassay was adjusted in the premises of Evseviev Mordovian State Pedagogical Institute [laboratory building, building No. 2 (technological faculty) and main building]. Three 10 × 10 m sites were selected for diagnostics of environmental state of soil, which presented the main types of plant communities and were exposed to various extents of anthropogenic load.

Soil samples in amount of 1 cm^3 were taken at the depth up to 1 cm at each site, then all samples were mixed, and averaged sample with the weight of 1 g was taken from the mixed bulk. One gram of soil was mixed in 10 ml of Drew medium in Petri dishes. The Drew medium was 0.04 g/100 ml KH_2PO_4, 0.02 g/100 ml $MgSO_4$, 0.01 g/100 ml $CaCl_2$ and 0.01 g/100 ml $FeCl_3$. The petri dishes were closed and placed into diffused light (eastern side) at ambient temperature. The tests were repeated three times. Growth took place in 15 days. Algae were detected using a Biolam microscope at 300× magnification : algae were preliminary sketched, and were identified using International Journal of Algae in laboratory.

RESULTS AND DISCUSSION

Seven main species of terrestrial algae from three groups were detected in the considered soil sites. The algae were analyzed during two vegetation periods. The absence of yellow-green algae in samples immediately evidenced that the soils of the considered urban area were attributed to disturbed and polluted, since this group existed only in unpolluted soils. Blue-green algae were the most numerous, since they were the most resistant against violations. They occurred in all sites (Table 1).

Blue-green algae were the most numerous in

Table 1. Algae in the territory of Evseviev Mordovian State Pedagogical Institute (Saransk)

Date	Algae detected during analysis	Location		
		Main building	Building of technological faculty	Laboratory building
July 23, 2018-August 1, 2019	Blue–green	1. *Oscillatoria splendida*	1. *Oscillatoria splendida* 2. *Anabaena cyanophyta*	1. *Oscillatoria splendida* 2. *Anabaena cyanophyta*
	Green	1. *Clorochytrium inclusum* 2. *Entocladiaviridis* 3. *Bolbocoleon piliferum*	1. *Clorochytrium inclusum*	1. *Bolbocoleon piliferum*
September 9, 2018-September 20, 2019	Blue–green	1. *Oscillatoria splendida*	1. *Oscillatoria splendida* 2. *Anabaena cyanophyta*	1. *Oscillatoria splendida* 2. *Anabaena cyanophyta*
	Green	1. *Bolbocoleon piliferum*	1. *Entocladiaviridis*	1. *Entocladiaviridis* 2. *Bolbocoleon piliferum*
	Diatoms	-	1. *Suvirellasaxonica* 2. *Navicula lanceolata*	-

samples since they were tolerant to medium quality. In addition, in most locations of the sites, *Oscillatoria (Oscillatoria splendida* L.) and *Anabaena (Anabaena cyanophyta* L.*)* genera were detected, which were indicators of soil pollution by chemical reagents. This evidenced high content of chemical substances in soils. Their existence can also be related with the impact by automobiles. In green algae spices detected were : *Cloro chytriuminclusum* Reincke, *Entocladia viridis* Reincke and *Bolbocoleon piliferum* Pringsheim. In the territory of main building, the cleanest one in terms of environment, three species were detected; whereas near the building of technological faculty and the laboratory building only one species for each was detected : *Chloro chytriuminclusum* Reincke and *Bolbocoleon piliferum* Pringsheim, respectively.

In September 2019 in the territory adjacent to building No. 2, two more species of diatomic algae were detected in comparison with those in July : *Suvirella saxonica* Ehr. and *Navicula lanceolata* (*Agardh)* Ehrenb. This proved that vegetative period of diatomic algae took place in September; $CaCO_3$ crystals were deposited in valves of diatomic algae and they became visible in microscope.

CONCLUSION

Terrestrial algae were sensitive to anthropogenic pollution : species variety of terrestrial algae decreased, structure of leading families and genera changed. Qualitative and quantitative composition of algal flora in the considered territory made it possible to conclude that normal operation of soil microflora was violated.

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