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Bacterial composition of different types of soils of Georgia

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ABSTRACT

Soil is a dynamic system in which relationship among soil minerals, organic substances and living organisms constantly exists. Microflora is an integral part of complex system of soil in which bacteria are the largest group of soil microbes, both by total number and diversity. The study of bacterial composition of 18 types of soils from Western, Eastern and Southern Georgia has shown that soils are distinguished both by total number of bacteria and by frequency of occurrence for certain investigated bacterial genera (*Bacillus*, *Pseudomonas*, *Rhodococcus*). Bog (7.87 Log10 CFU/g) and brown forest (7.22 Log10 CFU/g) soils of Western Georgia, black (8.80 Log10 CFU/g) and grey cinnamonic (7.91Log10 CFU/g) soils of Eastern Georgia and Chernozem (10.92 Log10 CFU/g) of Souther Georgia are the richest by total number of bacteria. Bacteria of the genus *Bacillus* prevailed in most of studied soils (yellow, bog, yellow podzols, mountain meadow, saline, meadow cinnamonic, cinnamonic, mountain forest meadow, mountain meadow, meadow grey cinnamonic, grey cinnamonic, chernozem, brown forest black, raw carbonate soil in Western Georgia and brown forest in soil of Southern Georgia); bacteria of the genus *Pseudomonas* – in alluvial and brown forest soils both of Western and Eastern Georgia, and bacteria of the genus *Rhodococcus* – in yellow brown forest, red and Raw carbonate soil of Eastern Georgia. All three groups of bacteria occur at the same frequency only in black soil.

Introduction

Soil is the most important natural ambient for microorganisms. Type of soil being very heterogenic in structure is very significant since total number of microorganisms, composition and the amount of certain systematic groups depend on it. Soils, which differ by their physical and chemical properties, are very important environment for vital activity of microorganisms [1,2].

Microorganisms as essential components of circulation of all biogenic elements are involved in substance and energy exchange, in conversion of plant and animal wastes into various organic and mineral compounds. Composition of soil microbiota depends on soil type, which significantly differs in Eastern and Western Georgia [3].

According to the data of recent years, 1 cm^3 of medium productivity soil contains 20 billion microbial cells. This amount makes up approximately 1% of soil weight. 1 ha of 30 cm layer of different soil types contains from 1.5–2 to 15–40 tons of bacterial biomass. This number equals to biomass of completely living system; it also shows the importance of microorganisms in formation and development of upper layers of the earth. Community of microorganisms is not random associations but organized populations characterized by collective functioning and interaction. Such communities are distinguished by high stability and are not easily destroyed under the influence of environmental factors. Soils have some properties characteristic for microbial populations and communities: density (number per unit of area), adaptation (the ability to utilize a new substrate), age, etc. [4].

The goal of the work was to study bacterial component in different types of soils of Georgia and determine the ratio among its certain genera (*Bacillus, Pseudomonas*, *Rhodococcus*).

Materials and methods

Soil samples were collected in different regions of Western,

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Eastern and Southern Georgia: Imereti, Guria, Mengrelia, Shida Qartli, Qvemo Qartli, Kakheti, Mtskheta-Mtianeti and Samtskhe-Javakheti. For analyzing were taken 18 different types of soil: alluvial, black, bog, brown forest, cinnamonic, grey cinnamonic, meadow cinnamonic, meadow grey cinnamonic, mountain forest meadow, mountain meadow, raw carbonate, red, saline, yellow, yellow brown forest, yellow podzols, chernozem and brown forest black.

Viable bacterial cultures were isolated by the method described in our previous work [5].

The following groups of soil bacteria of the genera: *Bacillus*, *Pseudomonas* and out of actinobacteria – the genus *Rhodococcus* were chosen for observation.

To enumerate bacteria the following media were used: for *Bacillus* strains – nutrient agar (Biolife, Italy), for *Pseudomonas* strains – pseudomonas selective agar (Biolife, Italy) and for *Rhodococcus* strains – Czapek's medium (Biolife, Italy) and synthetic medium for nocardia-like bacteria (g/L: urea – 1.5, Na_2HPO_4 – 4, KH_2PO_4 – 3, $MgSO_4$ – 1, glucose – 30, sucrose – 10, $FeCl_3$ – 8 mg/L, B1 – 1 mg/L) [6].

Petri dishes were incubated in thermostat at 28–30 °C for 3–10 days. The isolates were observed and counted on Petri dishes containing 25–250 colony forming units (CFU). CFU per gram of soil sample was expressed as logarithm at the base of 10. The enumeration of bacteria was performed in triplicates.

For initial identification of bacteria, morphological characters of colony and cells were studied.

Identification of isolates up to genus was carried out by traditional scheme based on the morphological, physiological, cultural and biochemical properties (Data not published) [7].

The frequency for representatives of each genus in soil was determined by counting method on corresponding selective media. Ratio of different genus was determined by percent.

Results and discussion

The diversity of microflora is expressed in upper horizon of soil (5–20 cm). This layer is rich in oxygen and besides, intensively proceeds biochemical conversion processes of organic compounds, in which microorganisms occupy significant position. In its turn, these conversions influence on composition of microbial populations and their growth and development.

Microbial biocenosis of soil includes great number of genera and species among them representatives of the genera *Pseudomonas, Bacillus, Rhodococcus* are more important [8]. Bacilli perform ammonification of proteins and urea and destroy phosphororganic compounds; pseudomonades actively participate in mineralization of organic substances and perform reduction of nitrates to molecular nitrogen, and rhodococci actively participate in self-cleaning and self-remediation processes of soil. In addition, rhodococci destroy complex organic and mineral compounds, including constituent compounds of humus.

The content of total number of bacteria and frequency of occurrence for representatives of certain genera in different types of soils from various regions of Georgia are given in the Table.

Based on bacterial monitoring of the studied soils it might be said that soils of Georgia differ from each other both by qualitative and quantitative composition (Table).

By total amount of bacteria, the soils may be arranged ascending as follows:

Western Georgia – red ► yellow ► yellow podzolic ► raw carbonate ► alluvial ► yellow brown forest ► mountain meadow ► brown forest ► bog.

Eastern Georgia – meadow cinnamonic ► cinnamonic ► alluvial ► saline ► brown forest ► mountain meadow ► meadow grey cinnamonic ► raw carbonate ► mountain meadow ► grey cinnamonic ► black.

Southern Georgia – brown forest ► brown forest black ►chernozem.

The study of total amount of bacteria in same types of soils of Western and Eastern Georgia have shown that the data are different in alluvial (5.6 and 4.6 Log10 CFU/g) and brown forest soils (7.22 and 6.25 Log10 CFU/g), and similar in raw carbonate soils (6.87 and 6.67 Log10 CFU/g) that is in correlation with the amount

Table 1
Bacterial composition of different type of soils of Georgia.

Regions of Georgia	Sampling sites	Types of soils	pH	mg/kg			Amount of bacteria			
				N[a]	P[a]	K[a]	Log10 CFU/g	*Bacillus*, %	*Pseudomonas*, %	*Rhodococcus*, %
Western Georgia	Surami Pass	Yellow brown forest	5.3	10,03	–	48.50	5.77	28	20	**52**
	Simoneti Lane	Raw carbonate	7.15	19,88	6,57	337.56	6.87	**52**	18	30
	vil. Motsameta	Yellow	5.96	10,39	–	79.58	6.80	**52**	32	16
	vil. Anaseuli	Red	3.9	11,99	–	98.74	3.48	20	22	**58**
	vil. Chaladidi	Bog	6.5	11,91	–	116.74	7.87	**67**	11	22
	Bank of river Gubistskali	Alluvial	7.5	13,87	9,67	43.68	4.60	23	**44**	33
	vil. Partskhakana	Yellow podzolic	5.45	12,23	–	52.92	4.43	**50**	36	14
	vil. Bakhmaro	Mountain meadow	4.15	13.12	45.42	139.26	4.70	**47**	23	30
	vil. Bakhmaro	Brown forest	5.01	11,96	12,55	148.90	5.72	34	**47**	19
Eastern Georgia	Site near to the Agricultural University of Georgia	Meadow cinnamonic	7.15	22.79	48.88	805.60	5.72	**48**	20	32
	vil. Sabaduri	Brown forest	6.53	21.81	0.0	113.94	6.25	28	**45**	27
	Digomi, terrace of Mtkvari River	Alluvial	7.69	22.61	12.32	235.40	5.93	23	**52**	25
	vil. Qarsani	Cinnamonic	7.2	31.99	6.88	331.54	5.86	**44**	18	38
	vil. Magharo	Raw carbonate	7.05	28.88	6.01	242.43	6.67	27	15	**58**
	Shiraqi valley	Black	7.56	41.31	125.09	966.51	8.80	32	37	31
	vil. Tsnori	Saline	8.27	21.53	37.66	223.64	6.10	**65**	14	21
	Jvari pass (vil. Stepantsminda)	Mountain forest meadow	8.32	24.18	0.00	66.20	6.84	**50**	18	32
	Jvari pass (vil. Stepantsminda)	Mountain meadow	7.55	37.99	0.00	36.73	6.30	**55**	12	33
	Marneuli	Meadow grey cinnamonic	7.7	31.86	64.82	390.39	6.48	**44**	19	37
	vil. Marabda	Grey cinnamonic	7.4	27.01	0.00	52.12	7.91	**42**	22	36

[a] The data are provided by the group of chemists in the frame of the SRNSF project# FR/191/10–105/14; by Bold are given the frequency of occurrence for prevailed genera.