Abnormal Changes in the Density of Thermal Neutron Flux in Biocenoses Near the Earth Surface

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We revealed an increase in the density of thermal neutron flux in forest biocenoses, which was not associated with astrogeophysical events. The maximum spike of this parameter in the biocenosis reached 10,000 n/(sec×m^2). Diurnal pattern of the density of thermal neutron flux depended only on the type of biocenosis. The effects of biomodulation of corpuscular radiation for balneology are discussed.

Key Words: *thermal neutrons; biocenosis*

Background neutron fluxes are related to secondary emission due to the interaction of sun and galactic rays with the Earth atmosphere and magnetosphere, as well as to fluxes from the Earth crust [2,4]. Neutron flux near the Earth surface is mainly associated with thermalization of thermal neutrons (0.02-0.50 eV) in the atmosphere. The background flux of thermal neutrons (10 n/(sec×m^2) depends on geographic location. This value increases with increasing the altitude and depends on radon emission and latitude [2,3,8]. Moreover, it increases by many times during solar flares. Previous studies revealed the existence of strong biological responses to ultraweak fluxes of thermal neutrons (V. V. Lednev *et al.*) [1,6,11]. These data suggest that thermal neutrons has a function of messengers, which allows the perception of astrogeophysical events by living organisms. Zone monitoring showed that the thermal neutron flux in the European part of Russia sharply increases in forest biocenoses. Here we described this phenomenon and evaluated its significance for balneology.

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MATERIALS AND METHODS

The detector for the study of the thermal neutron flux (Institute of Pulse Technique, Rosatom) included 6 thermal neutron counters (SNM18, filling with 97% ^{3}He and 3% Ar, 405 kPa), which operated under proportional conditions. The data were transferred to a computer. Detector sensitivity to thermal energy neutrons (0.02-0.50 eV) was 180 (pulses×cm^2)/n. For 24-h monitoring of the thermal neutron flux in biocenoses, a counter was placed at a height of 0.2-0.4 m from the ground. Study was performed in the following areas: pine forest (*Pinus silvestris* L.) and thick underbrush (average tree height 5 m, stocking rate 1 pine per 10 m^2); hazel grove (*Corylus avellana* L.) and underbrush (average bush height 4.5 m, stocking rate 20-25 stems per 1 m^2); mixed forest and underbrush of firs (*Picea excela* L., average height 4 m, lower branch spread 2 m, stocking rate 1 fir per 10 m^2), maple bush (*Acer tataricum* L., average height 4-4.5 m, stocking rate 6 pieces per 1 m^2), and hazel grove (*Corylus avellana* L., average height 2.5 m, stocking rate 5 stems per 1 m^2); and biocenosis of young oak tress (*Quercus pedunculata* Ehrh., height 2-2.5 m), hazel grove (height 3 m, stocking rate 20-25 stems per 1 m^2), and young maple bush

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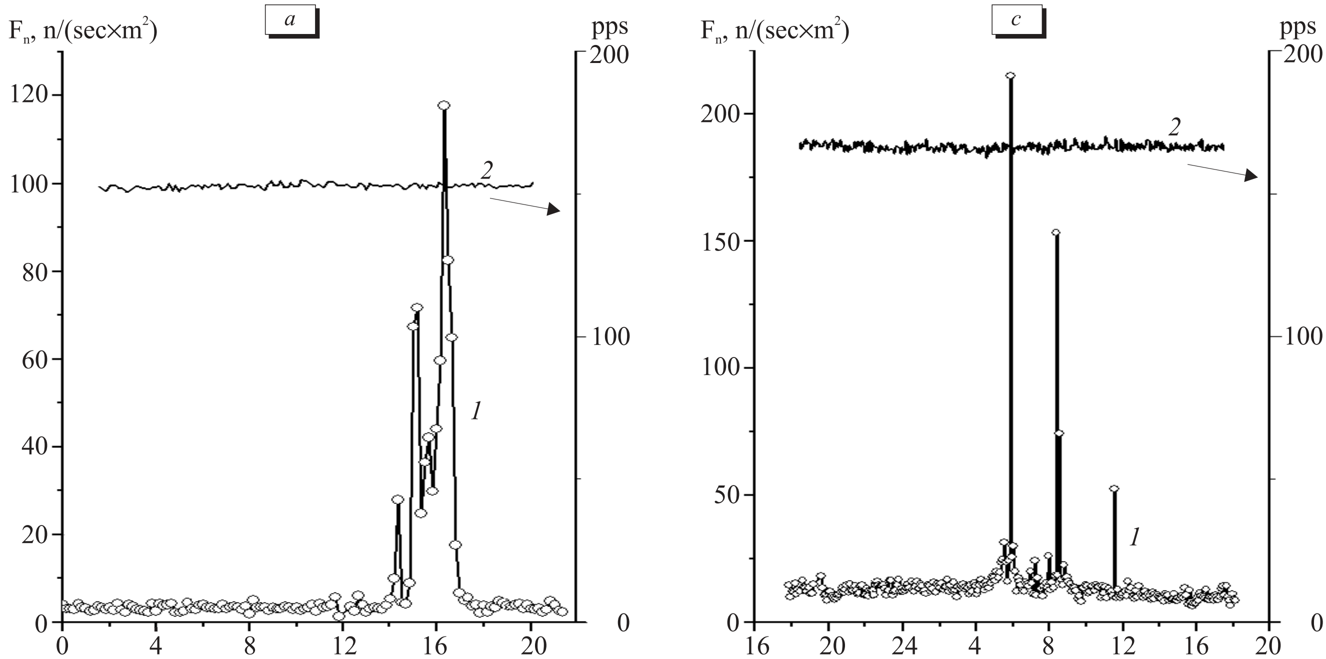
(*Acer platanoides* L., height 1-1.5 m, stocking rate 2 stems per 1 m^2). The pine forest was located in the coast zone of the Blue bay near Gelendzhik. This territory belongs to the Southern Department of the Institute of Oceanography (sea level, 44°34' N, 37°58' E). Other biocenoses were in the Zhevnevo village, Moscow region (200 m above sea level, 55°52' N, 37°03' E). The measurements were performed in 3-5 repetitions (2004-2006). The results of study with a similar detector of thermal neutrons served as the control. In addition to measurements in biocenoses, the thermal neutron flux was recorded in permanent single-storey brick buildings situated at a distance of no more than 50 m from the woodland. Background neutron parameters estimated with 2 detectors over 10 min differed not more than by 10% (confidence probability 0.99, *n*=500). Time variations in the hadronic component of secondary ground emission for cosmic rays of more than 100 MeV were evaluated using a 24NM64 neutron monitor (Institute of Earth Magnetism, Ionosphere and Wave Propagation, Russian Academy of



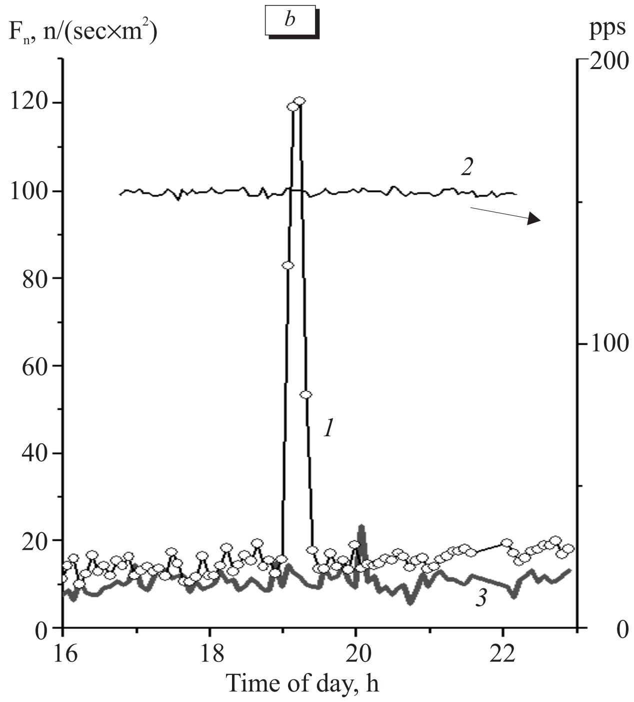


Fig. 1. Diurnal pattern of thermal neutron flux in forest biocenoses (*1*) and hadronic component of secondary ground emission for cosmic rays of more than 100 MeV (*2*). (*a*) Mixed forest and thick underbrush, pine dominance (June 22, 2004); (*b*) hazel grove and underbrush (August 4, 2005); (*c*) time variations in the thermal neutron flux in hazel grove before foliage expansion (May 18, 2006); (*d*) mixed forest (fir, maple, and underbrush; August 8-9, 2005).

Sciences, Troitsk). The measurements were performed under "quite" space weather (Institute of Earth Magnetism, Ionosphere and Wave Propagation).

RESULTS

Monitoring (2004-2006) revealed an abnormal increase in the neutron flux in biocenoses. An increase in the density of thermal neutron flux was observed in various biocenoses at different periods (Fig. 1). Measurement of the density of thermal neutron flux (F_n) in biocenosis of pine forest revealed the peak of complex shape. The thermal neutron flux increased from 14.00 to 17.00. These changes were accompanied by the increase in F_n from 20 to 200 n/(sec×m^2) (Fig. 1, *a*). The measurement of F_n in biocenosis of hazel grove detected only 1 peak (Fig. 1, *b*). The neutron flux increased from 17.00 to 17.30 and reached 120 n/(sec×m^2). The mixed biocenosis (fir, maple, underbrush) was characterized by 3 peaks of thermal neutrons (Fig. 1, *c*): 6.00, 215 n/(sec×m^2); 8.00-9.00, 155 n/(sec×m^2); and 11.30-12.00, 53 n/(sec×m^2). In another mixed biocenosis of oak, hazel grove, and Tatarian maple, 24-h variations in thermal neutrons were within 4 orders of magnitude. They reached maximum (up to 10,000 n/(sec×m^2)) in the nighttime, but decreased to the minimum at 12.00 (Fig. 2, curve *1*). According to the reports of the Institute of Earth Magnetism, Ionosphere and Wave Propagation (Russian Academy of Sciences), these spikes of the neutron flux were not associated with solar flares or other cosmic events (Fig. 1, curve *2*; Fig. 2, curve *1*). Visual examination showed that the maximum height depends on biocenosis biomass. These data are consistent with the results of our previous experiments with resting eggs of brine shrimp (*Artemia salina*) [6]. The shape of these dependences probably depends on the number and composition of species in the biocenosis. Abnormal spikes were not found in biocenoses before foliage expansion (Fig. 1, *b*).

F_n spikes in biocenoses exceeded the background particle density in buildings and woodless regions of motorway by 1-4 orders of magnitude (Table 1; Fig. 2, curves *1* and *2*). They were comparable with neutron irradiation on the board of the airliner (Table 1). An abnormal increase in F_n may be related to the interaction of neutrons with a multiheterogeneous medium of the living substance (stationary trap for slow neutrons). This interaction is described by the equation of neutron transfer in heterogeneous media [9]. Stationary retardation of a part of the neutron flux may occur in the biocenosis due to dispersion and re-reflection at the interphase boundary, which is followed by emission of "excess" neutrons at a certain time (Figs. 1 and 2). For example, these processes proceed during the measurement of plant cell turgor. This conclusion is derived from the circadian rhythm of neutron number (Fig. 2, curve *1*). Time variations in F_n serve as an integral characteristic of the biocenosis. The energy range of slow neutrons may be used as an additional identifier. The biomass may be characterized by thermalization of epithermal neutrons that are "invisible" for a counter. It should be emphasized that the degree of thermalization increases due to the trapping effect.

Mechanisms for the influence of thermal neutrons on living organisms probably include the promotion of oxide reductase processes due to electron generation during free neutron decay ($n \rightarrow p+e$, half-

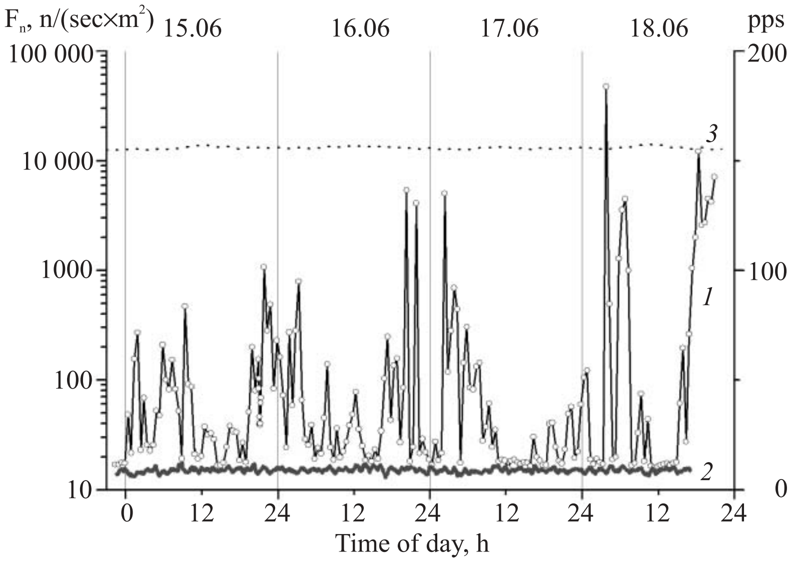


Fig. 2. Diurnal pattern of thermal neutron flux: biocenosis of oak, hazel grove, and maple (*1*); building near the biocenosis (*2*); and hadronic component of secondary ground emission for cosmic rays of more than 100 MeV (*3*).

TABLE 1. Level and Variability of the Background Thermal Neutron Flux Near the Earth Surface at Various Latitudes and Attitudes above Sea Level under Conditions of Quite Space Weather

Region of measurement	Data of measurement	Density of thermal neutron flux, n/(sec×m^2)		
		F_n	minF	maxF
78-67° N, 8200 m above sea level	08.04.2006	1130±30	1080	1220
56° N, Moscow region, 150 m above sea level	06.08.2005	15±1	13	16
	13.10.2004	9.0±0.5	8	11
45° N, Southern Department of the Institute of Oceanography (Russian Academy of Sciences), 10 m above sea level	12.06.2004	12±1	9	15
45° N, Caucasian reserve, 2300 m above sea level	12.06.2004	42±1	41	44

Note. N, north latitude. Neutron counting was performed with storage at 10-min intervals over 24 h. F_n, mean arithmetic value of flux density±mean square deviation (confidence probability 0.95, *n*=500); minF, minimum flux density; maxF, maximum flux density. The measurements were performed at a height of 8200 m above sea level (Spitsbergen—Moscow flight, AN-74TK-100 airplane).

decay period 11 min) [7] and increase in background variations during thermal neutron capture by protium [5]. Published data show that the thermal neutron radiation capture cross-section for protium is one-fourth of the total scattering cross-section [7]. The biological effect of ultraweak thermal neutron fluxes was detected in various organisms [1,6,11]. Corpuscular radiation of this type may serve as one of the major intermediates in the response of living organisms to astrogeophysical events. F_n is characterized by specific time variations and presence of long-lasting spikes in biocenoses. They not only exceed the background level near the Earth surface at various latitudes and attitudes above sea level (Table 1), but also are comparable with corpuscular radiation during air flights at high altitudes (Table 1) [10]. The data indicate that this phenomenon may be considered as a factor for the maintenance of microclimate. Our results and published data on monitoring of thermal neutrons [2, 3,8] indicate that various landscapes and biocenoses may be typed by spatial-and-time variations in F_n. This approach holds promise to perform a quantitative study of balneological characteristics of the place.

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