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Some results of study of variations of light ions concentration and their connections with the ionizing radiation and sub-micron aerosol content in air under the conditions of Tbilisi city

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Results of analysis of variations of sum light ions concentration (**N**, cm^{-3}) and their connections with radon (**Rn,** Bq/m^3), galactic cosmic rays intensity (**Q**, Imp/hour) and content of sub-micron aerosols by diameter ≥ 0.1 micron (**S**, cm^{-3}) in surface boundary layer of Tbilisi city are given.

Measurements of radon, ions and aerosols were conducted 4 times a day at height 3 floor of the building of the cloud chamber of Institute of Geophysics (8 meters above the level of soil, 41.754º N, 44.927º E, the height - 450 m above sea level), into 9, 12, 15 and 17-18 hour. The neutron component of galactic cosmic rays was measured by neutron monitor continuously (Cosmic Rays Station of Institute of Geophysics). The data about daily mean values of the investigated parameters for 2010 year without taking into account weather conditions (356 days, from 9 to 17-18 h) are analyzed.
The results in tables 1-4, fig. 1-11 and two block - diagram are given.

Table 1 Statistical characteristics of daily mean values of radon content in air, galactic cosmic rays intensity, sub-micron aerosols and sum light ions concentrations in Tbilisi in 2010

Parameter	Year				Cold period				Warm period			
	Rn	*Q*	*S*	*N*	*Rn*	*Q*	*S*	*N*	*Rn*	*Q*	*S*	*N*
Min	0.7	7452	352	269	0.7	7452	352	269	1.2	8089	413	516
Max	13.0	10016	15729	2516	13.0	10016	12256	2516	6.9	9416	15729	1817
Mean	4.0	8676	2714	917	5.2	8579	2885	830	2.9	8772	2544	1004
Stdev	2.4	357	2086	333	2.8	429	1920	393	0.9	232	2230	231
C_v, %	58.8	4.1	76.9	36.3	54.5	5.0	66.6	47.4	31.6	2.6	87.7	23.0
Count	356				177				179			

Table 2 Weekly variations of daily mean values of sub-micron aerosols and sum light ions concentrations in Tbilisi in 2010

Parameters	Year		Cold period		Warm period	
	S	*N*	*S*	*N*	*S*	*N*
Week-days	2834	899	3048	798	2622	998
Weekends	2402	967	2461	911	2343	1021
Difference	432	-68	587	-113	279	-23
α	0.05	0.1	0.1	0.15	low significant	no significant

Table 3 Linear correlation between of daily mean values of logarithm of summary light ions, radon content in air, galactic cosmic rays intensity and logarithm of sub-micron aerosols concentrations in Tbilisi

Parameters	Year, R min = 0.10, α =0.05				Cold period, R min = 0.15, α= 0.05				Warm period, R min = 0.15, α=0.05			
	Lg N	*Rn*	*Q*	*Lg S*	*Lg N*	*Rn*	*Q*	*Lg S*	*Lg N*	*Rn*	*Q*	*Lg S*
Lg N	1	-0.63	0.13	-0.55	1	-0.65	0.08	-0.72	1	-0.09	-0.11	-0.31
Rn	-0.63	1	-0.13	0.49	-0.65	1	-0.02	0.62	-0.09	1	0.08	0.37
Q	0.13	-0.13	1	0.09	0.08	-0.02	1	0.04	-0.11	0.08	1	0.31
Lg S	-0.55	0.49	0.09	1	-0.72	0.62	0.04	1	-0.31	0.37	0.31	1

Table 4 The values of coefficients of equations of the multiple linear regression of daily mean values of logarithm of summary light ions concentrations with radon content in air, galactic cosmic rays intensity and logarithm of sub-micron aerosols concentrations in Tbilisi

Coefficient	Year		Cold period		Warm period	
	$Lg\,N = a \cdot Rn + b \cdot Q + c \cdot Lg\,S + d$					
	Value	95% (+/-)	Value	95% (+/-)	Value	95% (+/-)
a	-0.030666	0.005984	-0.022396	0.008245	0.002969	0.016155
b	0.000045	0.000035	0.000040	0.000043	-0.000008	0.000063
c	-0.181446	0.046313	-0.319389	0.075481	-0.102144	0.052270
d	3.268864	0.312837	3.724387	0.420465	3.386666	0.524170
R^2 multiple	0.49, α = 0.001		0.59, α = 0.001		0.10, α = 0.05	
Shares of Rn, Q and Lg Q in the limits of variation scope for variations of Lg N, %						
Share of Rn	12.8		9.5		0.6	
Share of Q	3.9		3.5		0.3	
Share of Lg S	10.2		17.1		5.4	

Fig. 1 Linear correlation of logarithm of sum light ions (LgN) and sub-micron aerosols (LgS) content with radon (Rn) concentration in air of Tbilisi sity. Annual data.

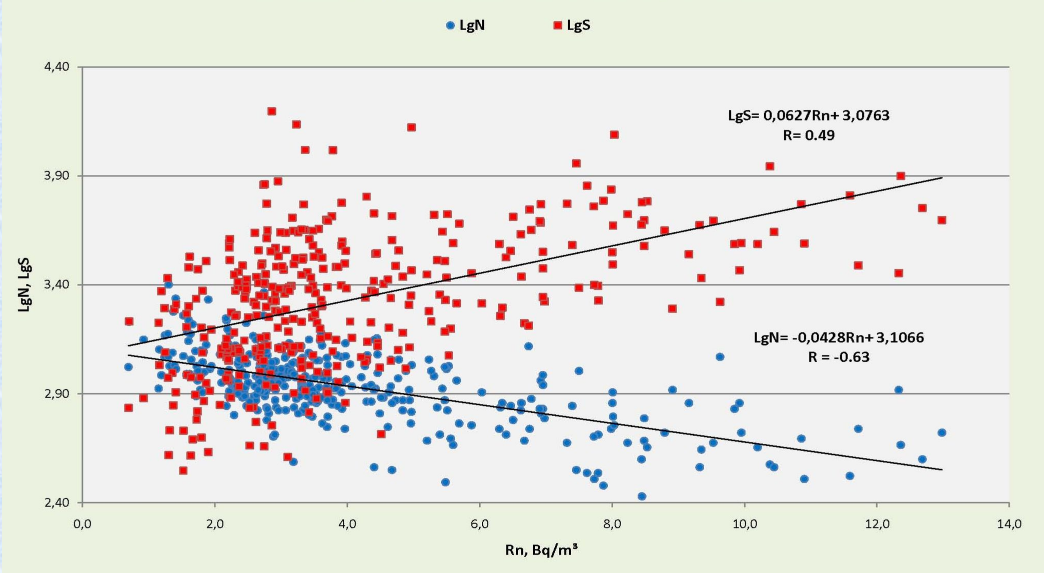


Fig. 2 Linear correlation of logarithm of sum light ions (LgN) and sub-micron aerosols (LgS) content in air of Tbilisi sity with galactic cosmic rays intensity (Q). Annual data.

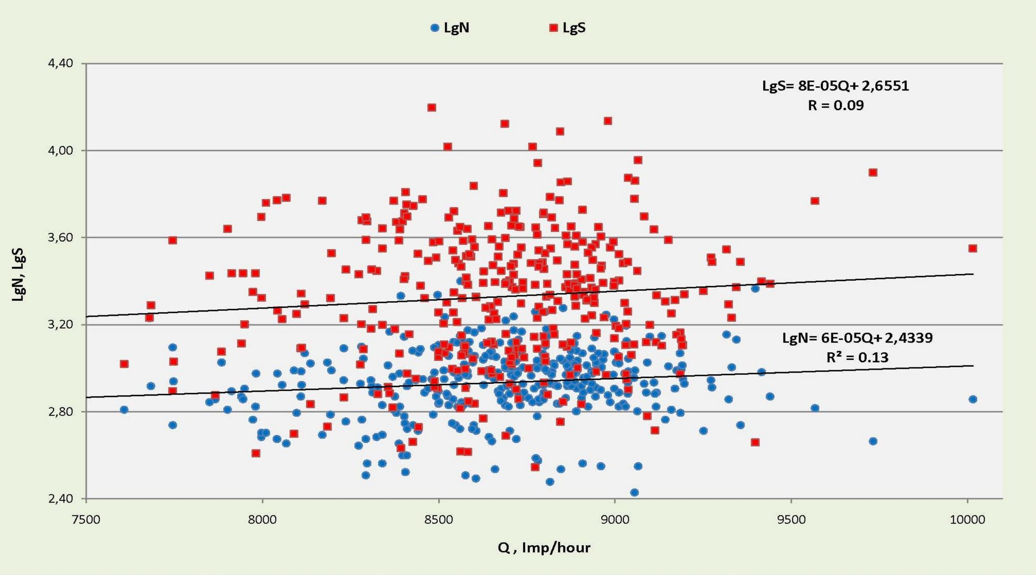


Fig. 3 Linear correlation of logarithm of sum light ions (LgN) and sub-micron aerosols (LgS) content with radon (Rn) concentration in air of Tbilisi sity. Cold period.

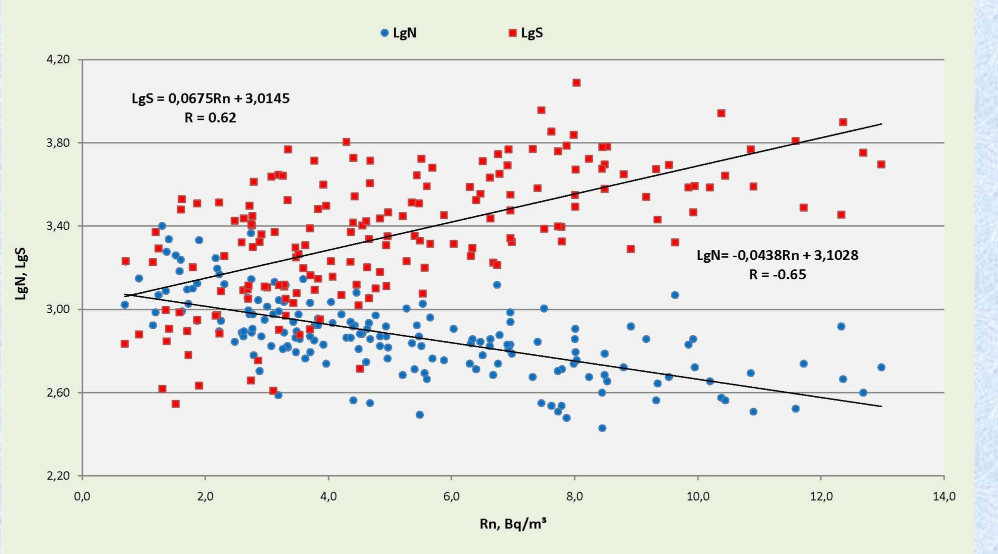


Fig. 4 Linear correlation of logarithm of sum light ions (LgN) and sub-micron aerosols (LgS) content in air of Tbilisi sity with galactic cosmic rays intensity (Q). Cold period.

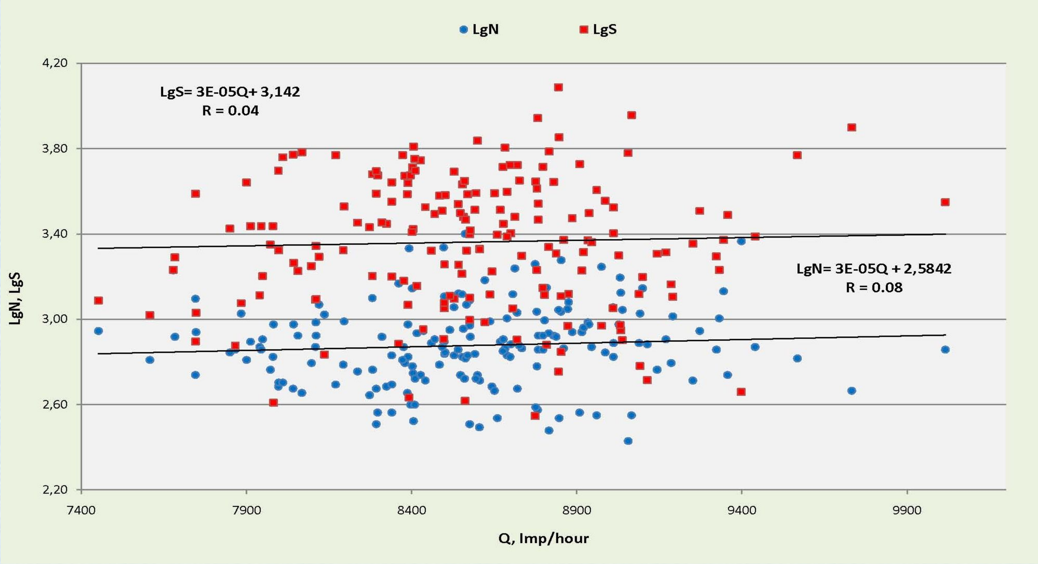


Fig. 5 Linear correlation of logarithm of sum light ions (LgN) and sub-micron aerosols (LgS) content with radon (Rn) concentration in air of Tbilisi sity. Warm period.

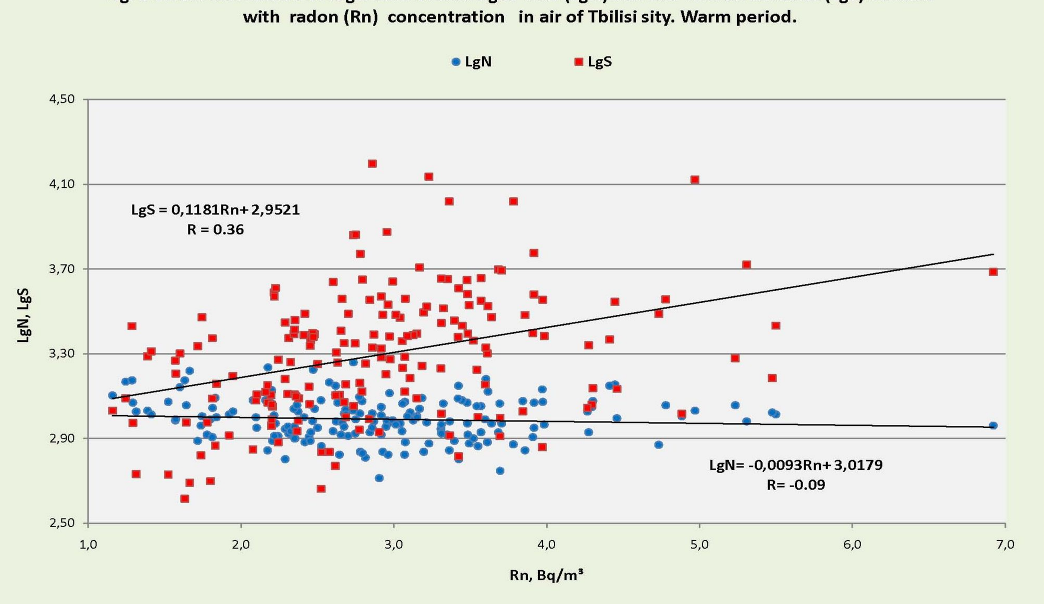


Fig. 6 Linear correlation of logarithm of sum light ions (LgN) and sub-micron aerosols (LgS) content in air of Tbilisi sity with galactic cosmic rays intensity (Q). Warm period.

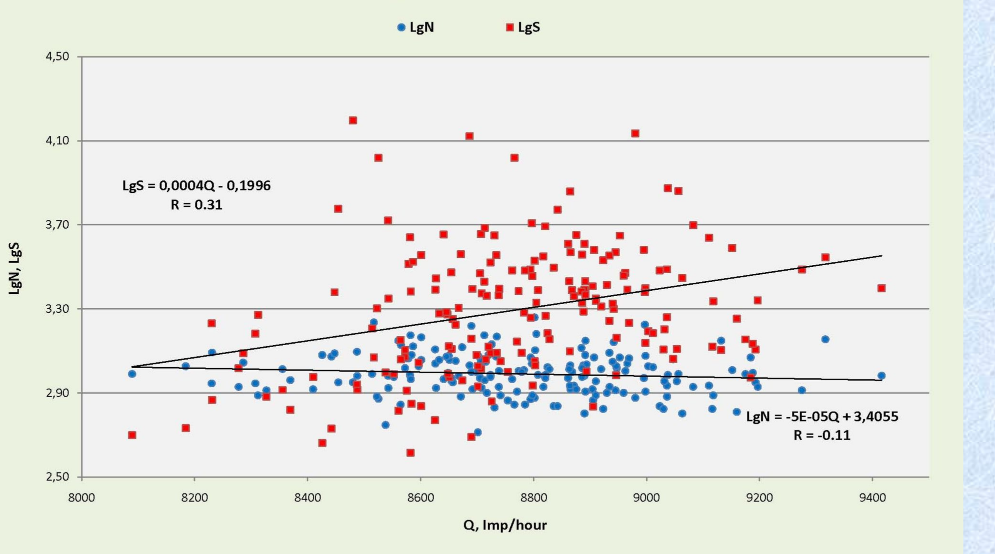


Fig. 7 Linear correlation between logarithm of sum light ions (LgN) and sub-micron aerosols (LgS) content in air in cold and warm period.

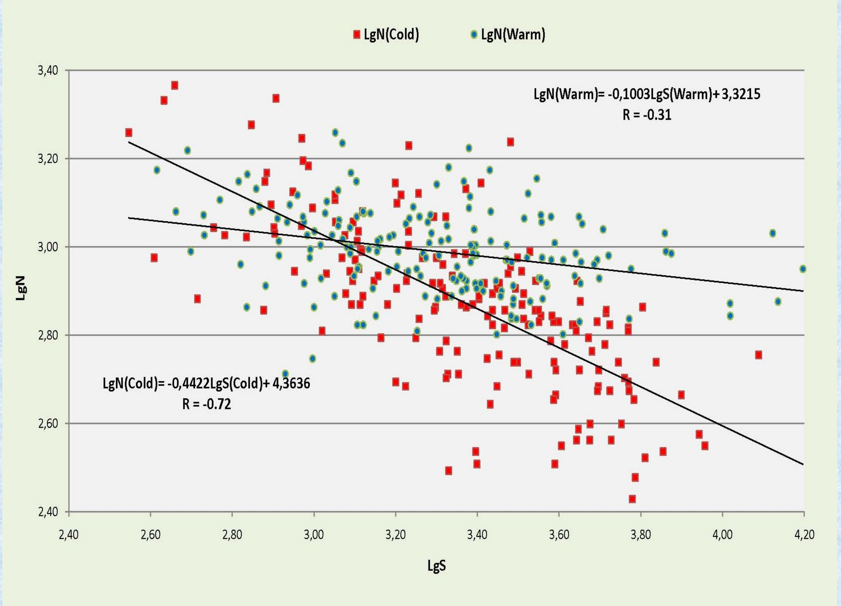


Fig. 8 Correlation between radon and sum light ions concentration in Tskaltubo Cave

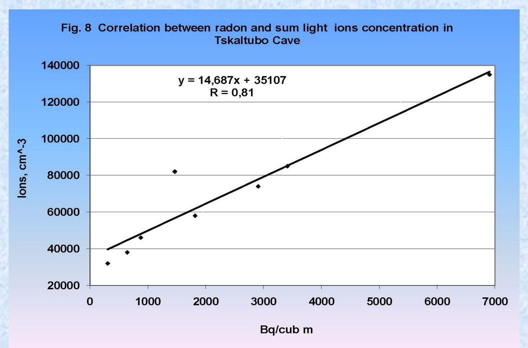


Fig. 9 Correlation between cosmic rays intensity and sum air electric conductivity in Dusheti (1969-1982)

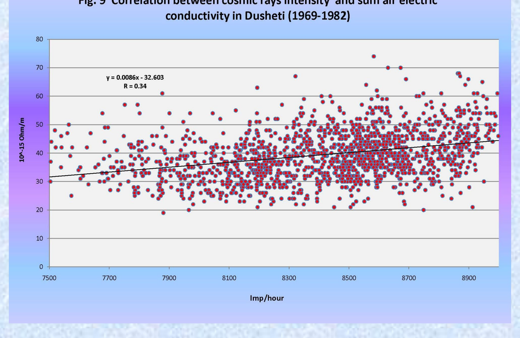


Fig. 10 Correlation between gamma - radiation and small ions concentration in 111 points of Western Georgia

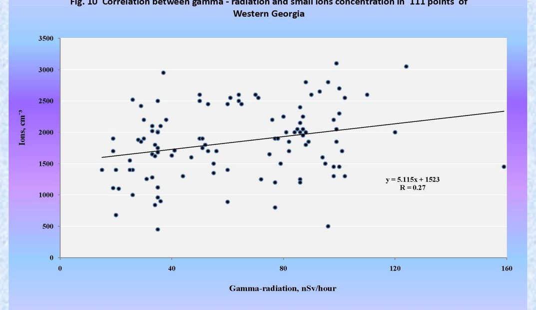
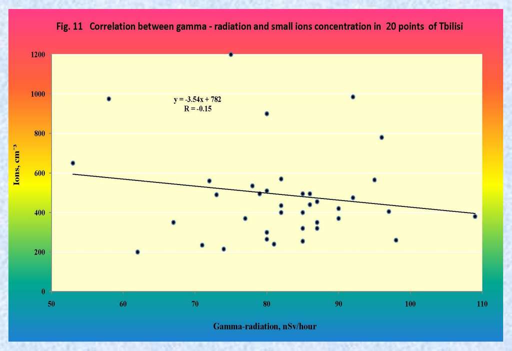
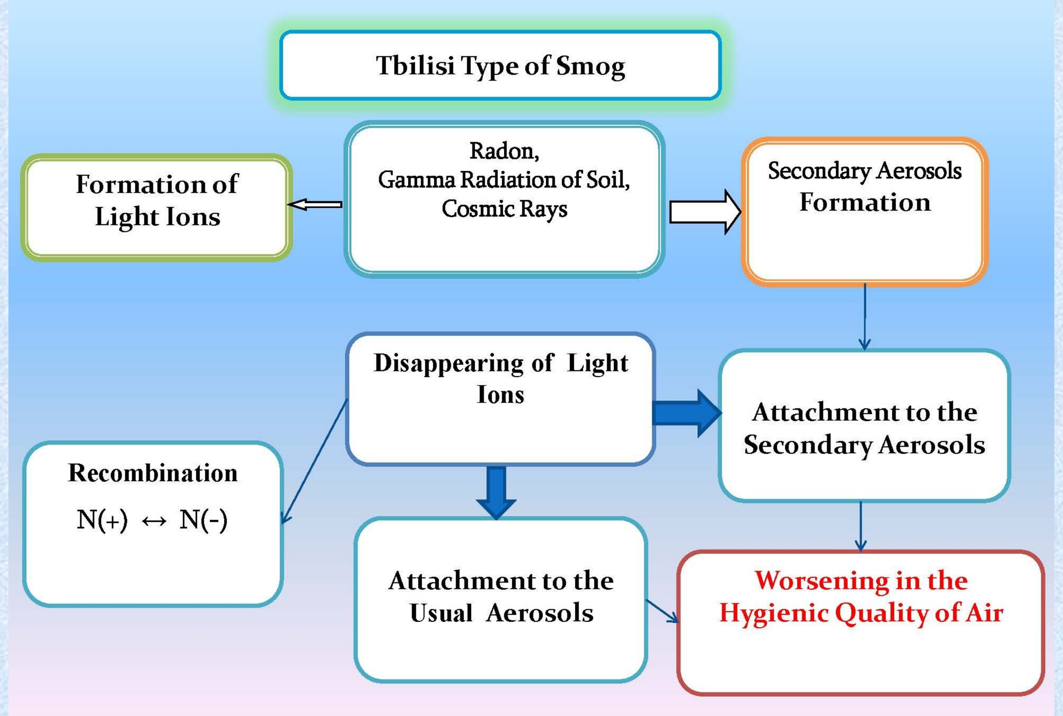
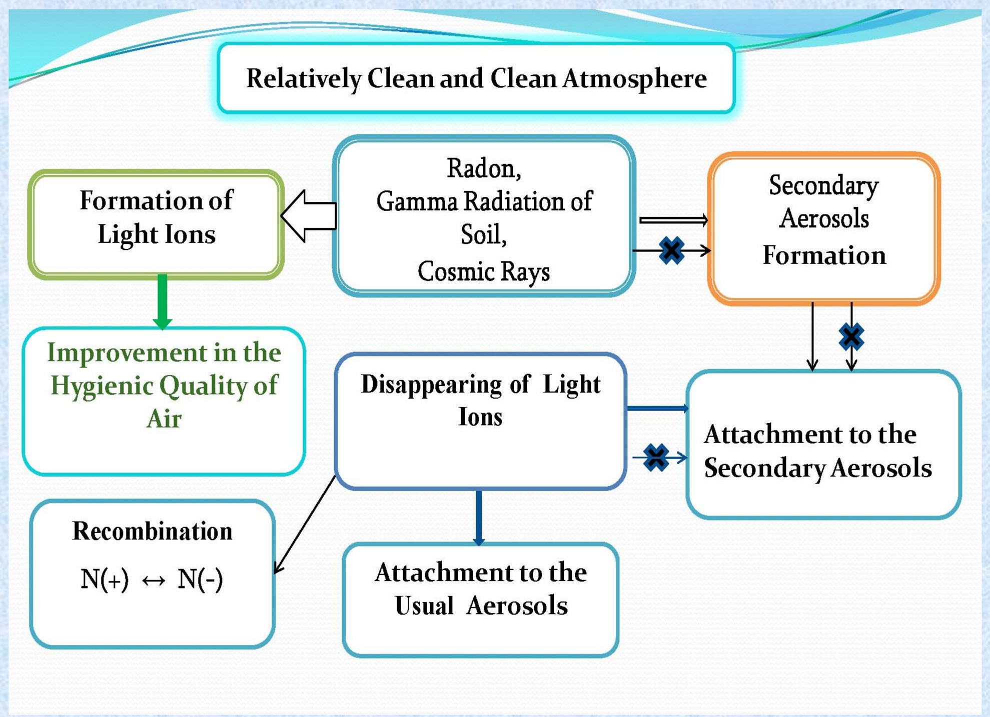


Fig. 11 Correlation between gamma - radiation and small ions concentration in 20 points of Tbilisi







•The statistical characteristics of daily mean values of **Rn**, **Q**, **S** and **N** in Tbilisi in table 1 are presented. The minimally necessary level of the sum light ions content for the favorable influence on the health (1000 cm^{-3} and more) are observed: year - not more than 35 % of the measurements cases, cold period – 23%, warm period – 46 %.

•Average values of the sum ions and sub-micron aerosol concentrations in the week-days and weekends (table 2) respectively comprise - **N**: year – 899 and 967 (the difference is significant), cold season – 798 and 911 (the difference is significant), warm season –998 and 1021 (the difference is no significant); **S**: year – 2834 and 2402 (the difference is significant), cold season – 3048 and 2461 (the difference is significant), warm season –2622 and 2343 (low significant difference).

• Formation of secondary aerosols according to the scheme gas →particle considerably depends on of radon concentration in air (fig. 1, 3, 5).

•The weak direct effect, almost absence of effect or strongly feedback effect of intensity of ionizing radiation (**Rn, Q**) with the light ions content in atmosphere in Tbilisi are revealed (table 3, fig. 1-6, 11).

•The connection of the **N** and **S** takes the reverse classical form (table 3, fig. 7). Under the normal conditions the concentration of light ions always directly depends on the intensity of the ionizing radiation (fig. 8-10).

•For year and cold period variations of **LgN** by variations of **Rn** and **LgS** are mainly caused (table 4). In the warm period variations of **LgN** practically do not depend on variations of **Rn** and weakly depend on variations of **LgS**.

•In the strongly polluted cities and the localities the ionizing radiation (radon, cosmic rays, gamma radiation) instead of the well-known effect of an increase of the concentration of light ions (or air electrical conductivity) can lead to the inverse effect, their decrease. This phenomenon in Tbilisi was discovered (Tbilisi type of smog). Moreover, for radon - for all periods of year with weaker inverse correlation into the warm half-year. For the cosmic rays - weak direct connection during the year and in the cold period, and reverse - into the warm half-year. The well-known balance equation relating the formation and disappearing of light ions **N** taking into account the influence of the ionizing radiation on the formation of secondary aerosols can take the form: $dN/dt = q - \alpha' N^2 - \beta S N - \beta' S(q) N$, where: **q** is the intensity of ion formation, **α´**- recombination coefficient, **S** - usual aerosol concentration, **S(q)** – secondary aerosol concentration as **q** function, **β** and **β´** - coefficient of the capture of light ions by usual and secondary aerosols respectively. Depending on the nature of the connection between q and **N(q)** under the conditions of the strongly contaminated atmosphere (similar to Tbilisi) negative correlation between q and **N** is completely possible (left and right block – diagram).