Nat Hazards
DOI 10.1007/s11069-014-1078-7

ORIGINAL PAPER

Natural and man-made influences on suicides in northwestern Russia

O. I. Shumilov · E. A. Kasatkina · T. B. Novikova · M.-L. Sutinen · A. V. Chramov · A. V. Enykeev

Received: 30 March 2013 / Accepted: 3 February 2014

Abstract Our main aim was to identify the impacts of natural (solar activity, geomagnetic disturbances) and man-made factors on suicides in northwestern Russia. Data on a total of 908 suicides in the town of Kirovsk (Murmansk oblast) were analyzed for the period from 1948 to 2010. The rates of suicides were analyzed with respect to seasons of the year. We have identified three maxima in the seasonal distribution of the number of suicides [March–May ($P < 0.001$), July ($P = 0.006$), October ($P < 0.001$)], which coincide with maxima in the distribution of the most intense (Ap > 150 nT) magnetic storms. Multi-taper method-spectrum analysis revealed periodicities ($\sim$9–10 and $\sim$25 years) which may be related to the main cycles of solar activity. The periods of $\sim$3.1–3.5 and $\sim$2–2.3 years are probably the third and the fifth harmonics of 11-year solar cycle, respectively. These periods are correlating with similar periodic variations in geomagnetic aa-indexes and meteorological parameters. It was determined the statistically significant ($r = 0.8$; $P = 0.005$) relationship between suicide and Cu emissions from Cu–Ni smelters of Russian North for the period 1997–2009.

Keywords Suicide · Solar activity · Geomagnetic disturbances · Socioeconomic factors · Pollution · Water quality · Russia

O. I. Shumilov (✉) · E. A. Kasatkina
Polar Geophysical Institute, Kola Science Centre RAS, Fersmana STR. 14, 184209 Apatity, Murmansk Region, Russia
e-mail: oleg@aprec.ru

T. B. Novikova
Main Hospital, Kola Science Centre RAS, 184209 Apatity, Russia

M.-L. Sutinen
Rovaniemi Research Unit, Finnish Forest Research Institute, 96301 Rovaniemi, Finland

A. V. Chramov
Baltic State Technical University, 190005 Saint Petersburg, Russia

A. V. Enykeev
Kirovsk Central Hospital, Kirovsk, Russia

Published online: 14 February 2014

1 Introduction

The problem of growing suicide rate has recently become of current concern not only in Russia but also in the most industrially developed countries. According to the World Health Organization data, the lowest level of suicide is registered in some Middle East countries, for example, in Egypt (0.03) and some South American countries (WHO http://www.who.int). Russia and some other countries of the former Soviet Union (Belarus, Ukraine, Lithuania, Latvia, Estonia), as well as some Western ones (Finland, Belgium, Hungary etc.) are included in the group of countries with a high suicide rate (over 20 persons per 100 thousand people) (WHO http://www.who.int). In Russia, this index in 2000 reached the value of 39.4, which exceeds more than an order the value of suicide level in 1838 (2.9) (Makinen 2006). The geographical distribution of suicide mortality showed large differences between regions of Russia. Republics of Komi and Udmurtia had the highest suicide rates for males (over 105 persons per 100 thousand people), while the rates were low in Dagestan (3.6) and Ingushetia (1.1) (Makinen 2006).

When studying the impact of environment parameters changes on the dynamics of suicides, an inevitable question arises about the relative role of socioeconomic and natural factors. In Russia, mortality has increased steeply in the first part of the 1990s, after the collapse of the Soviet Union (Lester 1998; Makinen 2000, 2006; Shkolnikov et al. 1998). Possible explanations of this recent phenomenon have been discussed in the literature including social stress, a collapse of medical care, environmental pollution, alcohol consumption (Lester 1998; Makinen 2006; Nemtsov 2003; Shkolnikov et al. 1998). All these interpretations were socioeconomic in nature. On the other hand, a number of studies were devoted to the issue of a possible relationships between some heliogeomagnetic factors and suicides and mental illness (Babayev and Allahverdiyeva 2007; Berk et al. 2006; Cherry 2002, 2003; Cornelissen and Halberg 2006; Dimitrov 1999; Dimitrov et al. 2009; Halberg et al. 2005; Mendoza and de la Pena 2010; Palmer et al. 2006; Partonen et al. 2004; Persinger 1995; Souetre et al. 1987; Stoupel et al. 1995).

The goal of the present paper is to identify the effects of space weather and socioeconomic factors within the distribution of the number of suicides in northwestern Russia.

2 Materials and methods

Kirovsk (67.6 N, 33.7 E) is a town in Murmansk oblast, with the population of approximately 30 thousands. It is located at the spurs of the Khibiny Massif, 175 km south of Murmansk, right at the auroral zone of geomagnetic activity, where the intensity and occurrence level of geomagnetic disturbances and pulsations grow in a wide frequency band. On the other hand, Murmansk oblast is one of the industrialized and densely populated regions of Russia, where copper–nickel, iron, apatite–nepheline and rare earth ores are widely developed and processed. Statistics data of the period of 1948–2010 (756 months) for town of Kirovsk have been used in the analysis. Date, gender and age were recorded for each case. Information for this study was obtained from the official death certificates that were collected in the registry office.

There were calculated the rates of mortality from suicides and cardio-vascular diseases (the number of cases per 100 thousand people). To determine the similarities and differences between the suicides and other parameters, we calculated Spearman's rank correlation coefficient. The seasonal distribution data validity was verified with the help of Student criterion, using MATLAB applied software package. To study the presence of periodicity in variations of the yearly number of suicides, we used the multi-taper method (MTM) of the power spectrum analysis (Thomson 1982). MTM spectral analysis was performed with the help of the SSA–MTM software toolkit (Ghil et al. 2002). Significance was tested at the 90 and 95 % confidence level against a red-noise background (Mann and Lees 1996; Ghil et al. 2002).

Monthly temperature data from Kandalaksha (67.2N, 32.4E) were used in this study. The Ap index is a measure of the general level of geomagnetic storm activity over the planet. In this study, daily Ap indices from 1 January 1948 to 31 December 2010 were obtained from the World Data Centre for Geomagnetism, Kyoto, Japan (http://wdc.kugi.kyoto-u.ac.jp). The data on proton events were borrowed from the paper (Levitsky 1970), as well as at the site (ftp://ngdc.noaa.gov/STP/SOLAR_DATA).

3 Results

During the period (1948–2010) investigated, 908 suicides were committed, while 694 of them were committed by men. It is known that the number of completed suicides among men exceeds about three times that among women (Souetre et al. 1987; Cibis et al. 2012), which is confirmed by the statistics data for Kirovsk. The largest number of suicides occurred in 1949 (70.3 persons per 100 thousand people) and the smallest one occurred in 1985 (15.2).

Figure 1 presents variations of the rates of mortality from cardio-vascular diseases (I_h) and suicides (I_S) in Kirovsk during the period of 1948–2010. We can see that there are certain differences between the two curves. Firstly, a sharp increase has been observed in the mortality level as a result of cardio-vascular diseases since 1991 (more than twice compared to the period of 1948–1990), which, most likely, was connected with socio-economic stresses of that period (see Fig. 1a). As we can see from Fig. 1a, in the maximum of the curve (1996), the value of the rate ($I_h = 623$) of mortality exceeds almost three times the average value for the period of 1948–1990 ($I_h = 230$) (see Fig. 1a). Secondly, it should be noted that socioeconomic factors did not lead to any appreciable increase in the number of suicides in the time interval of 1991–1997 ($I_S = 43$) compared with the previous period ($I_S = 35$; the increase made just 20 %) (see Fig. 1b).

The comparative analysis did not reveal any significant differences in seasonal distributions of suicides, committed by men and women. Seasonal patterns of suicides for the period of 1948–2010 are illustrated in Fig. 2. It is clearly seen three distinct maxima [March–May ($P < 0.001$), July ($P = 0.006$), October ($P < 0.001$)]. Seasonal distributions of the most intense (Ap > 150 nT) magnetic storms and solar proton events (SPEs) for the period studied are presented in Fig. 2b, c. We can see that all three maxima in the distribution of suicides (two equinoctial ones and one in July) coincide with peaks in the distribution of the most intense magnetic storms [March ($P < 0.01$), July ($P < 0.001$), October ($P < 0.01$)]. The high value of the correlation coefficient ($r = 0.65$, $P = 0.05$) seems to confirm the assumption of the existence of the relationship between the dynamics of suicide and geomagnetic activity. Annual distribution of SPEs has a significant ($P < 0.01$) peak in April–May, which is also traced in the rhythm of suicides (Fig. 2a, c).

Next, we applied MTM spectral analysis to the annual time series of I_S. MTM analysis revealed periods of ~9–10, ~3.1–3.5 and ~2–2.3 years at confidence level of ≥90 % (see Fig. 3). Another peak at ~25 years was seen to exist at nearly the same 90 % confidence level (see Fig. 3).

Fig. 1 Variations of mortality rates (the number of deaths per 100,000 persons) in Kirovsk during 1948–2010 **a** as a result of cardio-vascular diseases (I_h), **b** suicides (I_S)

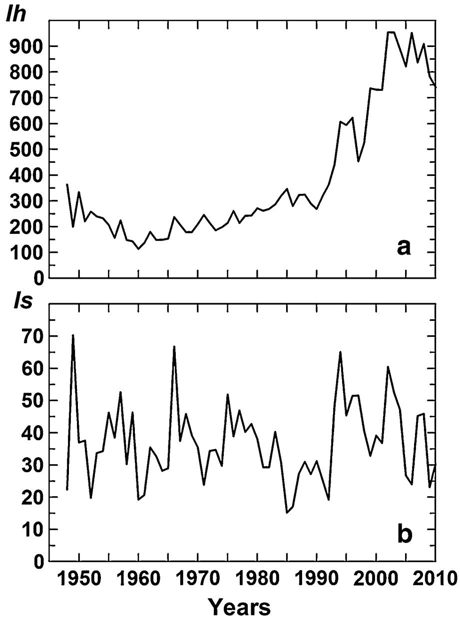
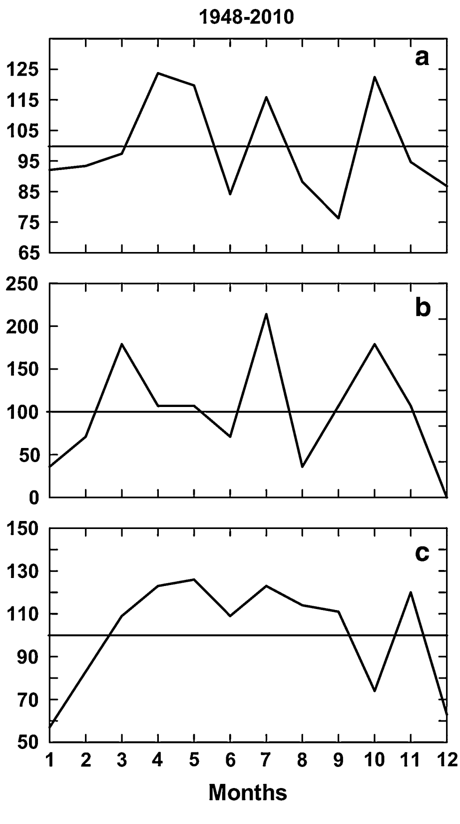


Fig. 2 Seasonal distribution of the number of suicides in Kirovsk (Murmansk region) (**a**) the most intense (Ap > 150 nT) magnetic storms (**b**) the number of solar proton events (**c**) during the period of 1948–2010. The *vertical axes* are scaled to percentages above and below the mean value (100 %)



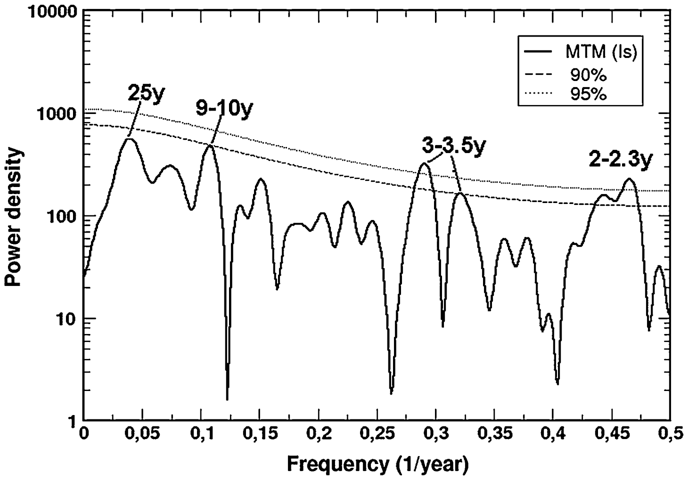


Fig. 3 MTM spectrum analysis of suicide rates in Kirovsk over 1948–2010. The *dashed lines* denote the 90 and 95 % levels of significance, respectively. *Digital values* are the significant periods

In this paper, we also tried to investigate the impact of local factors on the dynamics of suicide. Earlier it was noted (Persinger 1987) that the high content of such heavy metals as Cu, Al, Zn and Li in drinking water may cause serious mental disorders. As it was noted earlier, Murmansk oblast is one of the industrialized regions of Russia. One of the largest Russian nickel–copper plant "Severonikel" is located in the town of Monchegorsk (67.9N, 32.9E) at a distance of 80 km from the town of Kirovsk. Drinking water for Kirovsk comes from underground sources, for Monchegorsk town—from the Lake Moncha—which is located in the area of environmental contamination of the plant "Severonikel". According to the research concentration of Cu in drinking water of the town of Monchegorsk (0.0883 mg/l) is nearly 80 times higher than in Kirovsk (Nikanov et al. 2002). Figure 4 shows the variation of mortality from suicide in Kirovsk and Monchegorsk and emissions of Cu (tons/year) from "Severonikel" plant (Karnachev et al. 2011) for the period from 1995 to 2009. It is seen that in the case of Monchegorsk two curves are in good agreement (Fig. 4b), which can not be said about Kirovsk (Fig. 4a). The high value of the correlation coefficient ($r = 0.8$, $P = 0.005$) confirms the assumption of the existence of the relationship between the dynamics of suicide and Cu content in water and atmosphere of Monchegorsk.

4 Discussion

It is generally accepted that suicide rate increases during economic depressions (Lester 1998; Sartorius 1995; Shkolnikov et al. 1998). On the other hand, Makinen (2000, 2006) showed that economic changes seemed to exert less influence on suicide rates than has been accepted. After the collapse of the Soviet Union, the number of suicides in the Northern Caucasus and Asia still remains low (Makinen 2000, 2006). On the other hand, in the former republics of the European part of the USSR (Russia, Ukraine, Belarus, Kazakhstan, Latvia, Lithuania, Estonia) at that time, it was detected some increase in suicides with a subsequent decline to 2000 (Makinen 2006). The same situation was observed in

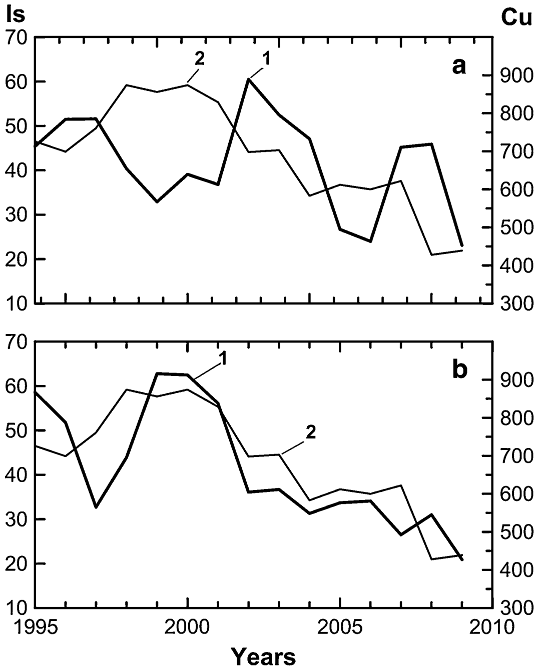


Fig. 4 Variations of suicide rates *I*s in Kirovsk (curve 1)—(**a**) and Monchegorsk—(**b**) variations of atmospheric Cu emissions (tons/year) by "Severonikel" plant (curve 2)

Murmansk region (see Fig. 1b). According to our results, major socioeconomic shock in Russia after 1990 and its consequences did not produce much more suicides. The maximum suicide rate was reached in 1949 (70.3 persons per 100 thousand people) (see Fig. 1b). In a contrast to suicide cyclical patterns, a sharp increase has been observed in the cardio-vascular diseases mortality since 1991 (more than twice compared to the period of 1948–1990), which, most likely, was connected with socioeconomic stresses of that period (see Fig. 1a). It should be noted that in some studies the growth of mortality in Russia is explained by the completion of the anti-alcohol campaign and increased alcohol consumption in the 1990s (Nemtsov 2003; Norstrom 2011).

Seasonal patterns of suicidal behavior were usually associated with "unfavorable" seasons (October–November and March–April), which are characterized by frequent weather changes, intense changes of the length of light day and increased frequency of geomagnetic disturbances (equinoctial maxima of geomagnetic activity) (Souetre et al. 1987; Partonen et al. 2004). Geomagnetic activity is a component of space weather and related to the process of interaction of solar plasma streams with the magnetosphere of the Earth. It is known that the bimodal pattern of seasonal variation with equinoctial maxima in March–April and September–October is typical for the distribution of storms in the weak-to-moderate categories of storm intensity (Gonzalez et al. 2002). This is caused by the seasonal change in the geometry of the Earth's magnetic field relative to the direction of the interplanetary magnetic field (IMF) (Russel and McPherron 1973). Later Gonzalez et al. (1993) showed the presence of a peak in July for the monthly number of days with maximum value of Ap $\geq$ 150 nT. The recent studies testify as well to the presence of an additional maximum in July in the seasonal distribution of very intense magnetic storms (Gonzalez et al. 2002; Echer et al. 2011). This additional peak is clearly seen in the seasonal distributions of suicides and powerful (Ap $\geq$ 150 nT) magnetic storms (Fig. 2a, b).

As to the second peak (May) in the spring equinoctial maximum in suicides distribution (see Fig. 2a), it is, possibly, connected with another cosmophysical agent, for example, with solar corpuscular emission. In Fig. 2c, we can see that in the seasonal distribution of SPEs there is a certain maximum in May ($P < 0.01$), which is also traced in the distribution of suicides by seasons during 1948–2010. The influence of proton events on the mortality rate as a result of cardio-vascular diseases and suicides has been reported by Stoupel et al. (1995). Our results (Shumilov et al. 1998) also confirm that a significant number of proton events (over 40 %) are accompanied by the growth of the number of sudden diseases of cardio-vascular type and mental disorders in the high latitudes (Spitsbergen archipelago).

Seasonal effects in the distribution of suicides have been studied in various world areas (Erazo et al. 2004; Hakko et al. 1998; Halberg et al. 2005; Heerlein et al. 2006; Lahti et al. 2006; Partonen et al. 2004; Souetre et al. 1987; Zhang et al. 2011). By the results of the carried out studies, we can make a conclusion that the bimodal distribution of suicides with two equinoctial maxima, typical for distribution of geomagnetic disturbances, is observed, mainly, in northern latitudes and increases with latitude (Lahti et al. 2006; Partonen et al. 2004). In the middle latitudes, a bimodal distribution of suicides is either poorly manifested (Erazo et al. 2004) or transformed in a distribution with a one spring maximum (Heerlein et al. 2006; Souetre et al. 1987). A significant summer maximum in suicidal behavior, which had been registered by our data, can be explained by the relatively long period of observations. This result confirms the geophysical character of seasonal patterns of suicides in high latitudes. The absence of July maximum in the seasonal patterns of suicides in Finland for the period of 1987–1999 reported by Partonen et al. (2004) can be explained by the rare enough appearance of magnetic storms of such intensity (Ap $>$ 150 nT), which reduces the probability of their observation within a relatively small time interval of several years.

As it was mentioned above, Murmansk oblast is located at high latitudes within the auroral zone of geomagnetic activity. Due to the specific configuration of the geomagnetic field lines, high latitudes are quite different from middle and low latitudes in the intensity and the spatial and temporal characteristics of the heliogeophysical factors. MTM spectral analysis of the distribution of suicides in Kirovsk revealed periodicities of $\sim$9–10 and $\sim$25 years attributing to solar cycles, named after Schwabe and Hale, respectively. The periods of $\sim$3.1–3.5 and $\sim$2–2.3 years are probably the third and the fifth harmonics of Schwabe cycle, respectively. These periods are correlating with similar periodic variations in sector structure of IMF (Gonzalez et al. 1990; Mufti and Shan 2011), geomagnetic aa-indexes (Mufti and Shan 2011). Similar cyclicity was found in the suicide rates in Bulgaria and Finland (Dimitrov 1999; Dimitrov et al. 2009). It should be noted, that beyond long-term cycles of 11–13 years of suicides in Finland, the latter work has also reported a 3–5-year cyclicity in such environmental factors as temperature and aa-index (Dimitrov et al. 2009). Our spectral analysis (not shown) also revealed a 2.5–3 year periodicity in the local temperature dynamics. In our view, there is hardly any causal link between temperature and suicides, at least at high latitudes. This conclusion does not contradict the results of Ruuhela et al. (2009). According to their results, global solar radiation had the best explanatory power, while temperature and precipitation had only a minor impact on suicide rates in Finland (Ruuhela et al. 2009).

Electromagnetic emissions (EME) are considered as the most probable cosmophysical factors that influence the human organism. One of possible mechanisms of impact in our opinion, the most probable is the capability of solar proton events and X-ray flares to affect the ionosphere condition and, thus, to change the frequency characteristics of "Schumann resonances" (Schlegel and Fullekrug 1999; De et al. 2010). Electromagnetic oscillations within the frequency interval (5–60 Hz), or "Schumann resonances", are natural oscillations of the Earth-ionosphere resonator (Cherry 2002). As known, the spectrum of bioelectrical activity of the human brain is subdivided into basic rhythms: delta rhythm (0.5–3.5 Hz), theta rhythm (4–7 Hz), alpha rhythm (8–13 Hz) and beta rhythm (14–22 Hz and higher) (Cherry 2002). At the interaction of resonance character, synchronization of rhythms of the brain bioelectrical activity with geomagnetic field variations or electrical field of the atmosphere can occur.

Another important property of EME, found experimentally, is its capability of affecting the secretion of melatonin—one of the main hormones (the hormone of pineal gland or epiphysis)—which is one of the most important regulators of the immune system and biological rhythms in animals and men (Cherry 2002). Melatonin also performs the function of a free radicals absorber and an antioxidant in organism (Cherry 2002). Free radicals, being products of metabolism in the organism and the result of its interaction with harmful factors of the environment (ionizing radiation, agrochemicals etc.), play an important triggering part in mechanisms of carcinogenesis and aging (Cherry 2002). Probably, in high latitudes, in conditions of Polar day and Polar night, the geomagnetic disturbances, with a well manifested daily course, perform the part of an exterior synchronizer of biological processes in human organism by affecting the melatonin production (Weydahl et al. 2001). Some studies deal with EME influence on the change of intracellular concentration of calcium ions, which may result in the increase of contents of free radicals (Cherry 2002; Stevens and Davis 1996). Cherry (2002) combined all results and hypothesized that the Schumann resonance signal is the biophysical mechanism for the health effects of solar and geomagnetic activity because it is detected by the brain where it interacts with the brain waves by resonant interaction with neurons calcium ions and it alters the melatonin level.

Persinger (1987) reported that the high content of such heavy metals as Cu, Al, Zn and Li in drinking water may cause serious mental disorders. Our results confirm the assumption of the existence of the relationship between the dynamics of suicide and Cu content in water and atmosphere of Monchegorsk (see Fig. 4). This conclusion was obtained for the first time. Previously, the effect of man-made pollution on the level and dynamics of suicide has not been studied in Russia. In this case, a sufficiently large number of works devoted to the study of the causes of diseases specific to areas of industrial pollution and related to the genitourinary, respiratory and digestive system, as well as tumors (Nikanov et al. 2002). It should be noted that the results obtained by Moiseenko et al. (2006) on the highest rates of accumulation of heavy metals (Ni, Cu, Cr, Cd and Pb) in the liver and kidneys of the residents of Monchegorsk is indirect evidence for our conclusion. In any case, it is necessary to continue research in this area. A comparative analysis of suicide dynamics in these two cities probably indicates that the influence of heliogeophysical disturbances on suicide rates in high latitudes is found only in a relatively “clean” areas. The high level of environmental contamination seems “to block” this effect (see Fig. 4b). The results indicate a multifactor external influence (socioeconomic, heliogeophysical and local man-made) on the dynamics of suicide in high latitudes.

5 Conclusions

1. In the seasonal distribution of suicide in Kirovsk, there are three maxima [March–May ($P < 0.001$), July ($P = 0.006$), October ($P < 0.001$)], coinciding with the maxima in the distribution of the most intense (Ap $\geq$ 150 nT) magnetic storms.
2. Multi-taper method-spectrum analysis revealed periodicities ($\sim$9–10 and $\sim$25 years) which may be related to the main cycles of solar activity. The periods of $\sim$3.1–3.5 and

$\sim$2–2.3 years are probably the third and the fifth harmonics of 11-year solar cycle, respectively. These periods are correlating with similar periodic variations in geomagnetic aa-indexes and local temperature.

3. Levels and trends of mortality from suicide in Monchegorsk located in the area of environmental contamination differ significantly from the indicator in Kirovsk.
4. It was revealed a statistically significant dependence ($r = 0.8$, $P = 0.005$) of the dynamics of suicide in Monchegorsk on Cu emissions into the atmosphere by "Severonikel" plant for the period 1995–2009.
5. The results obtained indicate the existence of a variety of factors (socioeconomic, heliogeophysical and local man-made) influencing on the dynamics of suicide in high latitudes.

Acknowledgments We thank Professor M.A. Persinger (Canada) for fruitful comments and support of our research. We as well would like to thank Doctor B.D. Dimitrov (UK) for valuable and constructive remarks.

References

Babayev ES, Allahverdiyeva AA (2007) Effects of geomagnetic activity variations on the physiological and psychological state of functionally healthy humans: some results of Azerbaijani studies. Adv Space Res 40:1941–1951

Berk M, Dodd S, Henry M (2006) Do ambient electromagnetic fields affect behavior? A demonstration of the relationship between geomagnetic storm activity and suicide. Bioelectromagnetics 27:151–155

Cherry N (2002) Schumann resonances, a plausible biophysical mechanism for the human health effect of solar/geomagnetic activity. Nat Hazard 26:279–331

Cherry N (2003) Schumann resonance and sunspot relations to human health effects in Thailand. Nat Hazard 29:1–11

Cibis A, Mergl R, Bramesfeld A, Althaus D, Niklewski G, Schmidtke A, Hegerl U (2012) Preference of lethal methods is not the only cause for higher suicide rates in males. J Affect Disord 136:9–16

Cornelissen G, Halberg F (2006) Chronomics of suicides and the solar wind. Br J Psychiatry 189:567–568

De SS, De BK, Bandyopadhyay B, Suman P, Haldar DK, Barui S (2010) Studies on the shift in the frequency of the first Schumann resonance mode during a solar proton event. J Atmos Sol Terr Phys 72:829–836

Dimitrov B (1999) Cyclicity of variations in the frequency of suicides in Bulgaria. Med Leg Baltica 8:26–31

Dimitrov BD, Atanassova PA, Rachkova MI (2009) Cyclicity of suicides may be modulated by internal or external $\sim$11-year cycles: an example of suicide rates in Finland. Sun Geosph 4:50–54

Echer E, Gonzalez WD, Tsurutani BT (2011) Statistical studies of geomagnetic storms with peak Dst $\leq$ -50 nT from 1957 to 2008. J Atmos Sol Terr Phys 73:1454–1459

Erazo N, Baumert J, Ladwig KH (2004) Sex-specific time patterns of suicidal acts on the German railway system. An analysis of 4003 cases. J Affect Disord 78:1–9

Ghil M, Allen RM, Dettinger MD, Ide K, Kondrashov D, Mann ME, Robertson AW, Saunders A, Tian Y, Varadi F, Yiou P (2002) Advanced spectral methods for climatic time series. Rev Geophys 40:3.1–3.41

Gonzalez WD, Gonzalez ALC, Tsurutani BT (1990) Dual-peak cycle distribution of intense geomagnetic storms. Planet Space Sci 38:181–187

Gonzalez ALC, Gonzalez WD, Dutra SLG (1993) Periodic variation in the geomagnetic activity: a study based on the *Ap* index. J Geophys Res 98:9215–9231

Gonzalez ALC, Silbergleit VM, Gonzalez WD, Tsurutani BT (2002) Irregularities in the semiannual variation of the geomagnetic activity. Adv Space Res 30:2215–2218

Hakko H, Rasanen P, Tiihonen J (1998) Seasonal variation in suicide occurrence in Finland. Acta Psychiatr Scand 98:92–97

Halberg F, Cornelissen G, Panksepp J, Otsuka K, Johnson D (2005) Chronomics of autism and suicide. Biomed Pharmacother 59:100–108

Heerlein A, Valeria C, Medina B (2006) Seasonal variation in suicidal deaths in Chile: its relationship to latitude. Psychopathol 39:75–79

Karnachev IP, Kokljanov EB, Zagvozdina OI (2011) Characteristics of sustainable development in environmental and industrial areas of Kola Peninsula under the development of mineral resources in the region. Her MGTU 14:743–750

Lahti A, Rasanen P, Karvonen K, Sarkioja T, Meyer-Rochow VB, Hakko H (2006) Autumn peak in shooting suicides of children and adolescents from northern Finland. Neuropsychobiology 54:140–146
Lester D (1998) Suicide and homicide after the fall of communist regimes. Eur Psychiatry 13:98–100
Levitsky LS (1970) A catalogue of flares with cosmic rays, absorption in the polar cap and solar radio burst in centimeter waves range. Bull Crime Astrophys Obs 42:203–229 (in Russian)
Makinen IH (2000) Eastern European transition and suicide mortality. Soc Sci Med 51:1405–1420
Makinen IH (2006) Suicide mortality of Eastern European regions before and after the Communist period. Soc Sci Med 63:307–319
Mann ME, Lees JM (1996) Robust estimation of background noise and signal detection in climatic time series. Clim Chang 33:409–445
Mendoza B, de la Pena SS (2010) Solar activity and human health at middle and low geomagnetic latitudes in Central America. Adv Space Res 46:449–459
Moiseenko TI, Voinov AA, Megorsky VV, Gashkina NA, Kudriavtseva LP, Vandish OI, Sharov AN, Sharova Yu, Koroleva IN (2006) Ecosystem and human health assessment to define environmental management strategies: the case of long-term human impacts on an Arctic lake. Sci Total Environ 369:1–20
Mufti S, Shan GN (2011) Solar-geomagnetic activity influence on Earth's climate. J Atmos Sol Terr Phys 73:1607–1615
Nemtsov A (2003) Suicides and alcohol consumption in Russia, 1965–1999. Drug Alcohol Depend 71:161–168
Nikanov AN, Chramov AV, Serpov VY, Konokhov ML, Proletarskaya EL (2002) On the question of the influence of water hardness on the mineral composition of the hair of children. In: Modern problems of public health exposing to intensive impact of harmful factors of natural and industrial environment. St. Petersburg, pp 119–122
Norstrom T (2011) The role of alcohol in the Russian mortality crisis. Addiction 106:1957–1965
Palmer SJ, Rycroft MJ, Cermack M (2006) Solar and geomagnetic activity, extremely low frequency magnetic and electric fields and human health at the Earth's surface. Surv Geophys 27:557–595
Partonen T, Haukka J, Viilo K, Hakko H, Pirkola S, Isometsa E, Lonnqvist J, Sarkioja T, Vaisanen E, Rasanen P (2004) Cyclic time patterns of death from suicide in northern Finland. J Affect Disord 78:11–19
Persinger MA (1987) Geopsychology and geopsychopathology: mental processes and disorders associated with geochemical and geophysical factors. Experientia 43:92–104
Persinger MA (1995) Sudden unexpected death in epileptics following sudden, intense, increases in geomagnetic activity: prevalence of effect and potential mechanisms. Int J Biometeorol 38:180–187
Russel CT, McPherron RL (1973) Semiannual variation of geomagnetic activity. J Geophys Res 78:92–108
Ruuhela R, Hiltunen L, Venalainen A, Pirinen P, Partonen T (2009) Climate impact on suicide rates in Finland from 1971 to 2003. Int J Biometeorol 53:167–175
Sartorius N (1995) Recent changes in suicide rates in selected Eastern European and other European countries. Int Psychopediatr 7:301–308
Schlegel K, Fullekrug MJ (1999) Schumann resonance parameter changes during high energy particle precipitation. J Geophys Res 104:10111–10117
Shkolnikov VM, Cornia GA, Leon DA, Mesle F (1998) Causes of the Russian mortality crisis: evidence and interpretations. World Dev 26:1995–2011
Shumilov OI, Kasatkina EA, Raspopov OM (1998) Heliomagnetic activity and the level of extreme situations in the Polar cap. Biophys 43:632–637
Souetre E, Salvati E, Belugou JL, Douillet P, Braccini T, Darcourt G (1987) Seasonality of suicides: environmental, sociological and biological covariations. J Affect Disord 13:215–225
Stevens RG, Davis S (1996) The melatonin hypothesis: electric power and breast cancer. Environ Health Perspect 106:135–140
Stoupel E, Abramson E, Sulkes J, Martfel J, Stein N, Handelman M, Shimshoni M, Zadka P, Gabbay U (1995) Relationship between suicide and myocardial infarction with regard to changing physical environmental conditions. Int J Biometeorol 38:199–203
Thomson DJ (1982) Spectrum estimation and harmonic analysis. Proc IEEE 70:1055–1067
Weydahl A, Sothern RB, Cornelissen G, Wetterberg L (2001) Geomagnetic activity influences the melatonin secretion at latitude 70°N. Biomed Pharmacother 55:57–62
World Health Organization World health statistics. Geneva. http://www.who.int
Zhang J, Gao Q, Jia C (2011) Seasonality of Chinese rural young suicide and its correlates. J Affect Disord 134:356–364