

## Solar Geomagnetic and Interplanetary Relations of Suicidal Death in Slovakia during the Period of 1997 -2010

P. L. VERMA

Department of Physics  
Government Vivekanand P. G. College  
Maihar Satna M. P., India

### Abstract:

*We have studied the relationship between death due to suicide incidents in Slovakia and various Solar, Interplanetary and Geomagnetic Activity parameters, such as Sunspot Numbers (SSN), Solar Flare Index (SFI), Sudden Storm Commencements (SSC), and geomagnetic activity parameter  $A_p$ ,  $K_p$  Indices observed during the period of 1997 to 2010. The results of the data analysis shows that the number of deaths due to suicide is well correlated with the yearly mean of Sunspot Numbers (SSN), Solar Flare Index (SFI), Sudden Storm Commencements (SSC), and geomagnetic activity parameter  $K_p, A_p$ , Indices. We have calculated negative correlation, with correlation coefficients of -0.44, -0.36, between the yearly total number of deaths due to suicide and the  $K_p, A_p$ , (magnitude) Indices.. A good medium negative correlation, with a correlation coefficient of -0.54, -0.56, has been found between the yearly total number of deaths due to suicide and the yearly mean of the SSN and SFI. From the statistical analysis of sudden storm commencements (SSC), and death due to suicide, we have obtained a good medium negative correlation, with correlation coefficient of -0.52, between the yearly total number of deaths due to suicide and Sudden Storm Commencements (SSC).*

**Key words:** Suicide Incidents, Sunspot Numbers (SSN), Solar Flare Index (SFI), and Sudden Storm Commencements (SSC), Geomagnetic Activity Indices.

## 1. Introduction

The state of the near-Earth space environment is governed by the Sun and is very dynamic on all spatial and temporal scales (Bothmer & Daglis, 2006). The Sun poses a health and safety threat to humans (Palmer et al., 2006) and all kinds of human activities (Jansen et al. 2000). The Geomagnetic Field, which protects the Earth from the Solar Wind and Cosmic rays is also essential to the evolution of life; variations in the Geomagnetic Field can have either direct or indirect effects on human physiology and health, even when the magnitude of the disturbance are small. Over the last two decades, heliobiological studies have been carried out by researchers in many parts of the world. The history of heliobiological studies are well described in (Palmer, 2006; Breus, 2002, 2003; Ragulskaya, 2007) and in reviews such as (Davydo, 1996). The relationship between geophysical factors and the physiological, psychological states of human beings were analyzed in Michael Persinger's review, where more than 95 western authors were taken into consideration (Persinger, 1997). In Zhadin's review, the results of the investigations of about 170 Russian scientists, who have been working in this field of study during the last 20-30 years were presented (Zhadin, 2001). It is inferred from these studies that changes in geomagnetic conditions mostly affect the activity of regulating systems, which are related to higher cortical mechanisms of regulation and the sub-cortical integrative apparatuses, which are responsible for an organism's organization of routine activity, and for adapting to the changes in a physical environment (Babayev & Allahverdiyeva 2005). Other scientists, such as Babayev and Allahverdiyeva, have already studied the effects of geomagnetic activity on human physiological states and revealed that geomagnetic disturbances affect mainly the emotional and vegetative spheres of human beings, while characteristics pertaining to personality traits do not undergo significant

change (Babayev & Allahverdiyeva 2007; Babayev et al. 2007). In 2003, Charmaine Gordon and Michael Berk studied the correlation between geomagnetic activity and suicide rates. Gordon and Berk (2003) correlated geomagnetic activity with suicide rates spanning a 13 year period from January 1980 to 1992, and found a significant correlation ( $r = 0.6964$ ) between the mean total of suicides and the mean average of geomagnetic storm activity. Babayev (2007, 2008) had studied the possible effects of solar, geomagnetic and cosmic ray variability on human physiological and cardiovascular health in the middle latitudes; he concluded that both weak and severe geomagnetic storms affect the functional state of the human brain and amplify the negative emotional background of an individual. Babayev also concluded that heart rate variations in humans are affected by variations in geomagnetic activity and cosmic ray intensity. Different types of geomagnetic storms (i.e. magnetic-cloud origin vs. those caused by high-speed solar wind streams) affect the cardio-vascular system in different ways. Some other investigators have observed how geomagnetic activity affects arterial blood pressure (ABP), heart rate variability (HRV), the electrical conductivity of biologically active points (Babayev & Allahverdiyeva 2007; Baevsky et al. 1997; Cornelissen 2002; Ghione et al. 1997; Khabarova et al. 2009; Otsuka K et al. 2001), as well as geomagnetic activity effects on cardio-vascular diseases, myocardial infarctions morbidity and mortality, cardiac arrhythmia, brain strokes, and occupational, traffic accidents (Gurfinkel et al. 1998; Oraevskii et al. 1998; Ptitsyna 1998). Recently some researchers have studied suicide incidents, which are related to physiological changes in the human brain, in relation to different Solar and Geomagnetic Activity parameters and have obtained some very interesting results. Verma (2012) has studied the relationship between death due to suicide in India and various Solar Activity (SA) parameters; i.e. Sunspot Numbers (SSN), Solar Flare Index (SFI), Coronal Index (CI) and Cosmic Ray Intensity

(CRI) observed during the period of 1989 to 2011. The data shows that the number of Suicide Incidents of male, female, and average is well correlated with yearly averages of the SSN, SFI, and CI; as well as being positively correlated with CRI. Verma (2013) studied Suicide Incidents in relation to the geomagnetic activity parameters, such as the planetary Ap, Kp, and Dst Indices for the period of 1989-2010, and found large negative correlations between Suicide Incidents and the yearly averages of geomagnetic activity parameters: the Kp, Ap, and Dst indices. In this investigation the Suicide Incident in Slovakia is considered for statistical analysis with the Solar, Interplanetary and Geomagnetic Activity parameters for the period of 1986-2010, in order to explore which of the Solar, Interplanetary and Geomagnetic phenomena are responsible for this event.

## **2. Data Sources**

Solar Activity (SA) parameters, Sunspot Numbers (SSN), Solar Flare Index (SFI), and interplanetary parameters, such as Sudden Storm Commencement (SSC) are taken from STP Solar Data (<http://www.ngdc.noaa.gov/stp/solardataservices>).

Data from the geomagnetic activity parameters Kp, Ap, Indices' values have been taken from OMNI Web Data System (<http://omniweb.gsfc.nasa.gov>). The data of Suicide Incidents in Slovakia has been taken from the National Health Information Center for the period of 1997-2010 available at <http://www.nczisk.sk/Documents/publikacie/2012/zs1305.pdf>).

**Table-Suicidal Death in Slovakia and Solar, Interplanetary and Geomagnetic Activity Indices during the period of 1997-2010.**

Years	Male Suicidal Death	Female Suicidal Death	Total Suicidal Death	Yearly total of Kp Index	Yearly total of Ap Index	Yearly mean of Solar Flare Index	Yearly mean of SSN	Yearly total of SSC
1997	356	105	461	5657	3090	1.01	21	28
1998	371	78	449	7364	4404	4	64.6	35
1999	397	68	465	7983	4593	6.39	93.3	30
2000	383	76	459	8621	5524	7.61	119.6	45
2001	376	90	466	7649	4744	6.8	111	42
2002	443	71	514	8236	4805	4.56	104	46
2003	447	92	539	10444	7966	3.46	63.7	13
2004	409	78	487	7960	4916	1.6	40.4	28
2005	487	89	576	7719	4945	1.91	29.8	26
2006	407	59	466	5887	3120	0.54	15.2	20
2007	427	63	490	5530	2751	0.47	7	14
2008	531	100	631	5329	2566	0.03	2.9	19
2009	534	75	609	3290	1451	0.02	3.1	21
2010	534	78	612	4584	2196	0.39	16	15

### 3. Methods of Analysis

In this study a statistical method correlation has been used. The correlation is one of the most common, as well as the most useful statistics. A correlation is a single number that describes the degree of relationship between two variables. The correlation coefficient, symbolized as  $r$ , is a numerical summary of a bivariate relationship and can range from -1.00 to +1.00. Any  $r$  that is positive indicates a direct or positive relationship between two measured variables. Negative  $r$  indicates indirect or inverse relationship.

The formula for the correlation is:

$$r = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]}}$$

Where:

$N$  = number of pairs of scores,  $\sum XY$  = sum of the products of paired scores,  $\sum X$  = sum of x scores,  $\sum Y$  = sum of y scores,  $\sum X^2$  = sum of squared scores,  $\sum Y^2$  = sum of squared score

The scale of correlation coefficient is

.8 to 1.0 or -.8 to -1.0 (very large relationship)

.6 to .8 or -.6 to -.8 (large relationship)

.4 to .6 or -.4 to -.6 (good medium relationship)

.2 to .4 or .2 to -.4 (weak relationship)

.0 to .2 or .0 to -.2 (weak or no relationship)

We have also used scatter plots to see the trend of correlation between suicidal death and solar interplanetary and geomagnetic activity parameters.

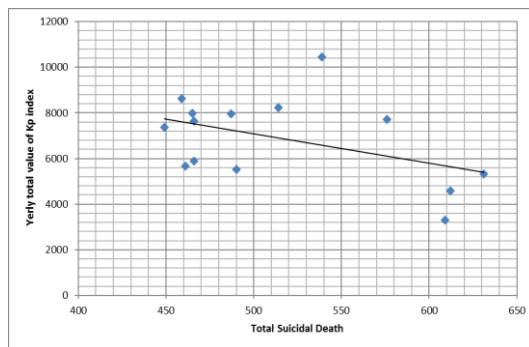
#### 4. Data Analysis and Results

From the data analysis of Table 1 and Figures 4, 5 it is inferred that the death due to suicide in Slovakia are related to the yearly average of SSN and SFI. Around Solar Maximum, where the yearly Sunspot Numbers (SSN) and yearly mean of Solar Flare Index (SFI) are at a maximum, the death due to suicide has been found to be comparatively low in comparison to corresponding Solar Minimum, where the yearly average of Sunspot Number (SSN) and Solar Flare Index (SFI) are at a maximum.

Further the analysis of the data of Table 1 and Figure 3, 4, 5 shows that death due to suicide is related to Interplanetary and Geomagnetic Activity parameters. The deaths due to suicide are negatively correlated with the annual Sudden Storm Commencements (SSC), the yearly total of Geomagnetic Activity parameters such as the Planetary Kp, Ap,. The following main results have been obtain through the statistical analysis of Sunspot Numbers (SSN), Solar Flare Index (SFI),

Sudden Storm Commencements (SSC), and Planetary Kp, Ap Indices along with the male, female Suicide Incidents:

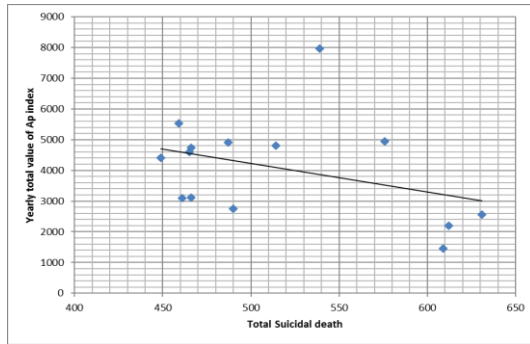
1- From the data analysis of yearly death due to suicide incidents and yearly total of Kp index listed in Table 1, it is observed that death due to suicide incidents are negatively correlated with geomagnetic activity parameter Kp index .We have calculated negative correlation with correlation coefficient -0.44 by statistical formula. We have also plotted scatter plot between yearly death due to suicide incidents and total value of Kp index in Figure 1.The trend line of the Figure shows that the death due to suicide incidents are negatively correlated with total value of Kp index .(Figure 1)



**Figure-1:** Shows scatter plot between yearly total value of Kp index and yearly total death due to suicide incidents in Slovakia for the period of 1997-2010 showing negative correlation with correlation coefficient -0.44.

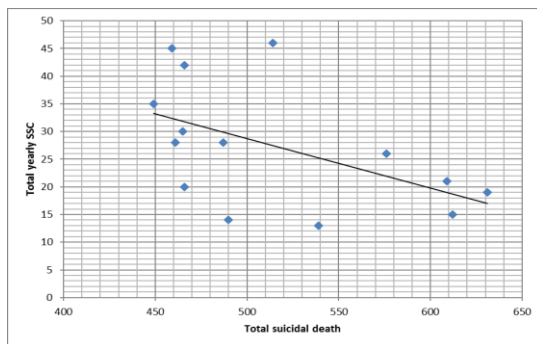
2- From the data analysis of yearly death due to suicide incidents and yearly total of Ap index listed in Table 1, it is observed that death due to suicide incidents are negatively correlated with geomagnetic activity parameter Ap index .We have calculated negative correlation with correlation coefficient -0.36 by statistical formula. We have also plotted scatter plot between yearly death due to suicide incidents and total value of Ap index in Figure 2.The trend line of the Figure shows

that the death due to suicide incidents are negatively correlated with total value of Ap index .(Figure 2)



**Figure-2:** Shows scatter plot between yearly total value of the Ap index and yearly total death due to suicide incidents in Slovakia for the period of 1997-2010, showing negative correlation with correlation coefficient-0.36.

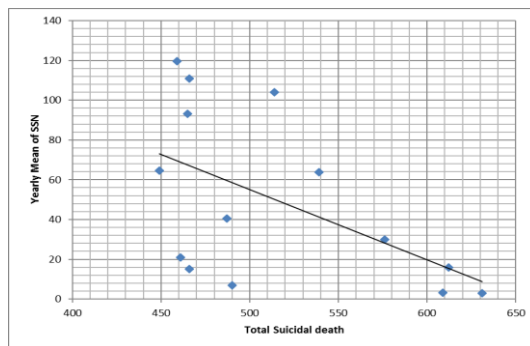
**3-** From the data analysis of yearly death due to suicide incidents and yearly total SSC it is observed that death due to suicide incidents are negatively correlated with SSC .We have calculated good medium negative correlation with correlation coefficient -0.52 by statistical formula. We have also plotted scatter plot between yearly death due to suicide incidents and total value SSC in Figure 3. The trend line of the Figure shows that the death due to suicide incidents is negatively correlated with total value of Ap index (Figure 3).





**Figure-3:** Shows scatter plot between yearly total value of the SSC and yearly total death due to suicide incidents in Slovakia for the period of 1997-2010 showing negative correlation with correlation coefficient-0.52.

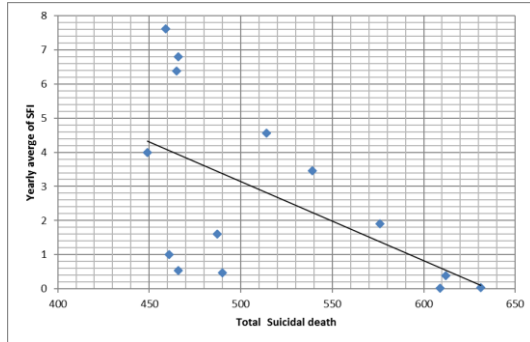
4- From the data analysis of yearly death due to suicide incidents and yearly mean of SSN given in Table 1, it is observed that death due to suicide incidents are negatively correlated with yearly mean of sunspot numbers (SSN) .We have calculated negative correlation with correlation coefficient -0.54 by statistical formula. We have also plotted scatter plot between yearly death due to suicide incidents and yearly mean of SSN in Figure 4 .From the trend line of the Figure it is inferred that the death due to suicide incidents are negatively correlated with yearly mean SSN (Figure 4).



**Figure-4:** Shows scatter plot between yearly mean of the sunspot numbers (SSN) and yearly total death due to suicide incidents in Slovakia for the period of 1997-2010 showing negative correlation with correlation coefficient-0.54.

5- From the data analysis of yearly death due to suicide incidents and yearly mean of solar flare index (SFI) , it is observed that death due to suicide incidents are negatively correlated with SFI .We have calculated good medium negative correlation with correlation coefficient -0.56 by statistical formula. We have also plotted scatter plot between yearly death due to suicide incidents and yearly mean of SFI in

Figure 4 .The trend line of the Figure shows that the death due to suicide incidents are negatively correlated with yearly mean SFI .(Figure 5)



**Figure-5:** Shows scatter plot between yearly mean of the solar flare index (SFI) and yearly total death due to suicide incidents in Slovakia for the period of 1997-2010 showing negative correlation with correlation coefficient -0.56.

## 5. Discussion and Conclusion

From our study I determined Negative correlation, with a correlation coefficient of -0.44 between the yearly mean of Kp index and the yearly total number deaths due to suicide, -0.36, between the yearly mean of Ap index and the yearly total number of deaths due to suicide -0.54, between the yearly average of the Sunspot Numbers (SSN) and the yearly total number of deaths due to suicide. -0.56, has been found between the yearly mean of the Solar Flare Index (SFI) and the yearly total number of male deaths due to suicide, -0.52, has been found between yearly total number of Sudden Storm Commencements (SSC) and the yearly total number of deaths due to suicide. These results clearly indicates that the death due to suicide is closely related to geomagnetic activity parameters Kp and Ap index, interplanetary parameters sudden storm commencements and solar activity parameter sunspot number (SNN) and solar flare index (SFI). These results are same as I have obtained in my previous studies

(Verma .2013, 2012) in which suicide incidents India has been analyzed with geomagnetic activity parameters, such as the planetary Ap, Kp, and Dst Indices for the period of 1989-2010, and found large negative correlations between Suicide Incidents and the yearly averages of geomagnetic activity parameters: the Kp, Ap, and Dst indices and death due to suicide in India and various Solar Activity (SA) parameters; i.e. Sunspot Numbers (SSN), Solar Flare Index (SFI), Coronal Index (CI) and Cosmic Ray Intensity (CRI) observed during the period of 1989 to 2011 and inferred that the number of suicide incidents of male, female, and average is well correlated with yearly average of SSN, SFI, and CI and positively correlated with CRI. I have found good medium negative correlation with correlation coefficient -0.54, -0.53, and -0.54 between the average of SSN and male, female, total, and rate of suicide incidents occurring yearly. Negative correlation with correlation -0.55, -0.61, -0.57, and -0.52 had also been found between CI and female, total, and rate of suicide (per 1000000) suicide incidents. Further we have determined large negative correlation with correlation coefficient -0.65, -0.69, -0.67, and -0.62 between SFI and male, female, total, rate of suicide (per 1000000) suicide incidents. From the results of these studies it is very clear that death due to suicide is closely related to solar and geophysical phenomena but which of the solar interplanetary or geophysical mechanism is mainly responsible is not known clearly .It is expected that particular changes in the ambient electromagnetic and acoustical signals caused by Heliogeophysical factors could promote the exacerbation of the mental state and even act as a trigger of the suicidal behavior. However, the clarification of the mechanisms behind the impact of Solar, Interplanetary and Geophysical factors on humans requires more detailed studies.

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