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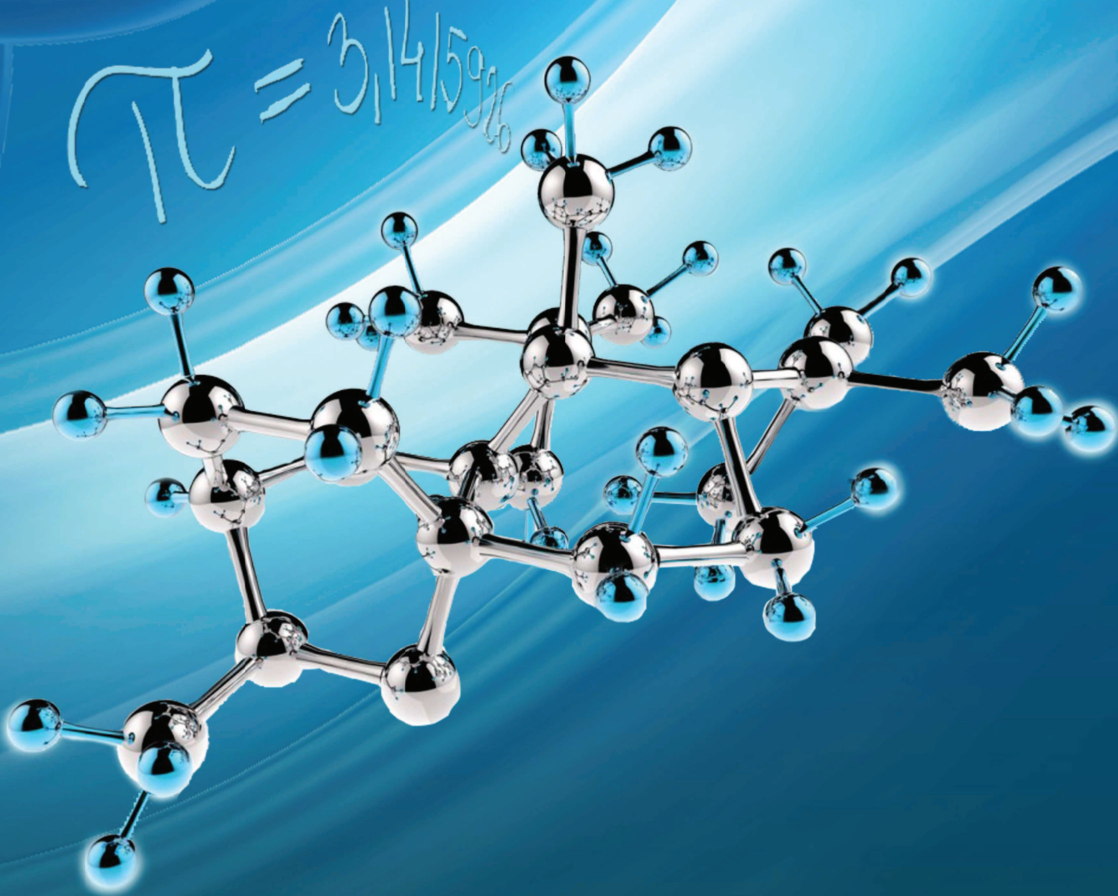

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"THE LIGHT RISING FROM THE EAST"

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PRESENTATION

Dear Colleagues,

First of all, let me express that our university, set off with the motto 'the light arising from the east', has completed its physical structure to a large extent and is going on its development through scientific activities. In this context, we are glad to present "Eastern Anatolian Journal of Science" (EAJS), a newly appeared scientific journal under the name of Ağrı İbrahim Çeçen University.

Today, universities need to get their power of existence from their own studies by setting strong relationships with economic, social and cultural resources of their territory as access to information has been simplified, education has become a lifelong activity and rivalry has become dominant. One of the basic features of universities is to produce information, science and technology to serve to next generation and to the people of the region as well as the country, since the responsibilities of universities are not restricted to equip their students with occupation. Universities are those institutions where scientific, technologic, cultural and social benefits are shared with society. In other words, one of the responsibilities of universities is to become institutional leaders as well. Under abovementioned conscious of responsibility, Ağrı İbrahim Çeçen University leads and collaborates with private and official institutions as well as leading the society. Our university endeavours to convey its scholarly studies to social, cultural, technologic and commercial products by developing interdisciplinary collaboration.

We think that, university is a place where reasoning, questioning, sense of responsibility, imagination, gaining a universal vision towards learning is learnt along with learning to learn. Regardless of the conditions, the methods of accessing information are investigated at universities.

Universities are universal and dynamic institutions. They are driving powers of their people, society, country and civilization in terms of development. A sustainable, beneficial, humanistic, peaceful and ecologic development necessitates lifelong learning and teaching. University education is one of the crucial phases of a person's educational life; and universities are those institutions where beneficial and scientific knowledge is created and the knowledge is transmitted. The ways of accessing knowledge is also taught at universities. All kinds of views are discussed at universities. Universal peace and love is organised at universities where the main principle is based on the fact that the most dutiful person is the one who is of help to others.

Our university aims to provide successful careers to the students by gaining the way approaching to the problems within the scope of solutions oriented and the skill of thinking analytically.

By constituting a prestigious and well-known university on the Gateway of Civilization among the universities in the world, Ağrı İbrahim Çeçen University's vision is to be a leading university that works within the light of Atatürk's Principles and Reforms, to carry out education in high-quality standards accepted all over the world, to raise young people that have professional and communication abilities required by the 21st century's global competition atmosphere, to carry out satisfactory scientific researches, to utilize from regional sources in ideal manner, to work with a human centred mentality, to manage competing in science, technology, art and sports internationally, to own social responsibility and citizenship conscious; to implement "Modern Education Programmes", and to contribute scientific, technological, cultural life of our region and country via combining this programme with particular social, cultural and human science programmes.

Our university carries out the educational facilities by taking the students, the reason of our university's existence, into the centre. Interactive education model is adopted in our university. Our university aims to provide successful careers to the students by gaining the way approaching to the problems within the scope of solutions oriented and the skill of thinking analytically. Ağrı İbrahim Çeçen University will become a universal university making powerful relations with the society by the scientific studies and education services and adopting the universal values and also making effort to be a leading university in higher education.

Ağrı İbrahim Çeçen University has science education units at several schools such as Patnos Sultan Alpaslan Faculty of Natural Sciences and Engineering, Faculty of Science and Letters, Faculty of Education, Vocational

School. EAJS will provide great opportunities to our university's scholars and this will improve the quality and quantity of our university's academic activities. Besides, considering neighbourhood with countries such as Russia and Iran, the journal will contribute international recognition of our university. The articles which will be published in EAJS will have a great role in the cultural development of our city and region.

EAJS will provide our students and scholars the opportunity of getting the genuine science from its sources as well as enabling us to publish our scholars' scientific works which are of good quality. In this regard, our university will become more renowned in international scientific communities.

I, hereby, would like to send my sincere thanks to the editorial board, exclusively to the Editor-in-Chief, of EAJS for their precious efforts. I'd like to express my gratitude to all our authors and contributing reviewers. I believe we will see the best papers of scholars in EAJS. Last but not least, my special thanks go to the respectable businessman Mr. İbrahim Çeçen, who unsparingly supports our university financially and emotionally, to his team and to the director and staff of IC foundation.

Prof. Dr. İrfan ASLAN
Rector

FROM EDITOR-in-CHIEF

On behalf of the Editorial Board and my Associate Editor, I am very happy to announce the publication of the first issue of Eastern Anatolian Journal of Science (EAJS). I believe that EAJS, which is the fruit of an intensive and devoted teamwork, will have an invaluable contribution to the scientific world.

At the end of busy schedule of nearly one year, we have now achieved to publish the first issue of EAJS under the name of Ağrı İbrahim Çeçen University. As part of our efforts, we have decided on the frequency and publication type of the journal as well as determining aim and scope.

Then, we have contacted with distinguished scholars in order to appoint the Editorial Board members. Meanwhile, we have officially launched the journal's website and completed necessary infrastructure for ULAKBİM's JournalPark membership.

As a result of this meticulous work, we reunite six research articles from Chemistry, Earth Sciences, Mathematics and Physics disciplines with readers. These articles, which have undergone review and language editing process, have been published in the first issue of EAJS. I would like to thank to all contributing authors and reviewers of this issue.

Ağrı İbrahim Çeçen University, which was founded in 2007 and completed its physical development in a short time, is on its way to be at the top among Turkish universities. With his great efforts for our university, Prof. Dr. İrfan Aslan, our esteemed rector, sets the goal of being also a top-ranking university in scientific sense. My sincere thanks go to Prof. Dr. İrfan Aslan, the president of Ağrı İbrahim Çeçen University, for supporting and motivating us in every respect. Special thanks are also due to the Associate Editor of EAJS, Dr. Ahmet Ocak Akdemir, for completing all legal procedures that are necessary for the publication of EAJS. I am also grateful to our section editors and members of editorial board of the journal. I express my gratitude to the members of technical committee of the journal for the design and proofreading of the articles.

Last but not least, I owe Mr. İbrahim Çeçen, distinguished businessman, and the staff of IC Foundation a debt of gratitude for their boundless support on the publication process of our journal.

I invite scientists from all branches of science to contribute our journal by sending papers for publication in EAJS.

Prof. Dr. Yusuf BAYRAK
Editor-in-Chief
Dean of Patnos Sultan Alpaslan Faculty of
Natural Sciences and Engineering

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Eastern Anatolian Journal of Science

An Evaluation of Earthquake Hazard Parameters in and around Ağrı, Eastern Anatolia, Turkey

YUSUF BAYRAK[1], AYSE NUR ATMIŞ[1], FATMA TEMELLİ[1], HIWA MOHAMMADI[2], ERDEM BAYRAK[3], ŞEYDA YILMAZ[3], TUĞBA TÜRKER[3]

[1] Ağrı İbrahim Çeçen University, Ağrı, Turkey
[2] Shiraz University, Department of Earth Sciences, Iran
[3] Karadeniz Technical University, Department of Geophysics, Trabzon, Turkey

Abstract

The earthquake hazard parameters of *a* and *b* of Gutenberg-Richter relationships, return periods, expected maximum magnitudes in the next 100 years and probabilities for the earthquakes for certain magnitude values are computed using the earthquakes occurred between 1900 and 2014 years in and around Ağrı. The relation of *LogN=4.73-0.68M* is calculated for the studied area. The mapping of *b* values show that the regions in the east and southeast of Ağrı, east of Horasan and around Patnos where low *b* values are computed have high stress levels and capacity to generate large earthquakes in the future. It is found that earthquakes larger than 5.5 may be occurred in the regions where *b* values lower than 0.8 have been observed in the next 100 years. The return periods for magnitudes between 5.0 and 7.3 are estimated between 5 and 176 years in the studied area, respectively. The probabilities of an earthquake with *M*=6.0, 6.5 and 7.0 in the next 100 years are computed 99%, 86% and 59%, respectively. The largest earthquake occurred in the studied area is 7.3 and its occurrence probability is 43% in the next 100 years. The faults around Ağrı are seismically active and have potential for an earthquake larger than 6.0. Since the sediment basin of Ağrı is very young and alluvial layer is tick, there is very high hazard on the buildings and human's life in Ağrı.

Keywords: b values, return period, expexted maxium, magnitude, Ağrı, Eastern Anatolia.

1. Introduction

The region in and around Ağrı (42.0-44.2 °E and 39.0-40.5 °N) covers seismically tectonic features such as Ağrı Fault, Bulanık Fault, Çaldıran Fault, Ercis Fault, Horasan Fault, Çobandede Fault Zone, Iğdır Fault, Malazgirt Fault, Balıklıgölü Fault Zone, Kağızman Fault Zone, Doğubayazıt Fault Zone, Karayazı Fault and Tutak Fault Zone. Since these faults produce some large earthquakes (04 April 1903 Malazgirt (M=6.3), 13 September 1924 Pasinler (M=6.8), 24 November 1976 Çaldıran (M=7.3) and 30 October 1983 Horasan–Narman (M=6.8) during instrumental earthquake time period, it is very important to reveal earthquake hazard and risk in the area (BOZKURT 2001).

Many quantitative methods have been applied over the years to estimate seismicity in various regions of the world. Several local and regional seismic hazard studies (ASLAN 1972; BATH 1979; YARAR *et al*. 1980; ERDIK *et al*. 1999; KAYABALI and AKIN 2003; BAYRAK *et al*. 2005; 2009) have been performed in order to estimate the seismic hazard in Turkey using the statistical processing of instrumental earthquake data.

The most popular method used is the frequency-magnitude relationship of Gutenberg-Richter (G-R). A large number of studies on *a* and *b* parameters of G-R relationship have been presented since Gutenberg and Richter introduced their law about the earthquake magnitudes distribution. The different methods such as least square (LS) or maximum likelihood estimation (MLE) can be applied to compute these parameters which are very important in earthquake hazards and risk studies. The different hazard parameters such as the mean return period for an earthquake occurrence, the most probable maximum magnitude of earthquakes in a certain time interval and the probabilities for the large earthquakes occurrences during certain times using the parameters of G-R relationships. BAYRAK *et al*. (2015) applied this method to the different regions of the East Anatolian Fault.

Aim of this study is to evaluate the earthquake hazard in and around Ağrı in terms of different hazard parameters. For this purpose, the mean return period, expected maximum magnitude of earthquakes in the next 100 years and the probabilities for the large earthquakes occurrences in the next 25, 50 and 100 years are computed from the parameters of G-R relationships using MLE.

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Corresponding author:
Yusuf Bayrak, PhD
Agri İbrahim Çeçen University, Ağrı, Turkey
E-mail: ybayrak@agri.edu.tr

2. Data

The database used was compiled from different sources and catalogs such as Turkey National Telemetric Seismic Network (TURKNET), Incorporated Research Institutions for Seismology (IRIS), the International Seismological Centre (ISC) and The Scientific and Technological Research Council of Turkey (TUBITAK) and is provided in different magnitude scales. The catalogs include different magnitudes scales (M_b body wave magnitude, M_s surface wave magnitude, M_L local magnitude, M_D duration magnitude and M_W moment magnitude), the origin time epicenter and depth information of earthquakes.

An earthquake data set used in seismicity or seismic hazard studies must certainly be homogenous, in other words, it is necessary to use the same magnitude scale. However, the earthquake data obtained from different catalogs have been reported in different magnitude scales. Therefore, all earthquakes must be defined in the same magnitude scale. BAYRAK *et al.* (2009) developed some relationships among different magnitude scales (M_b body wave magnitude, M_s surface wave magnitude, M_L local magnitude, M_D duration magnitude and M_W moment magnitude) in order to prepare a homogenous earthquake catalog from different data sets.

We prepared a homogenous earthquake data catalog for M_s magnitude using relationships and have considered only instrumental part of the earthquake catalogue (1900-2014). Finally, the catalog includes 1569 earthquakes with $M_s \geq 1.1$. The graphs of magnitude-earthquake number and years-cumulative earthquake number are shown in Figure 1. The recorded earthquake numbers have increased after 1976 depending on installed seismograph stations in the studied area. Also, a large amount of magnitude of recorded earthquakes are lower than 4.0 and the size of nine earthquakes are larger than 6.0.

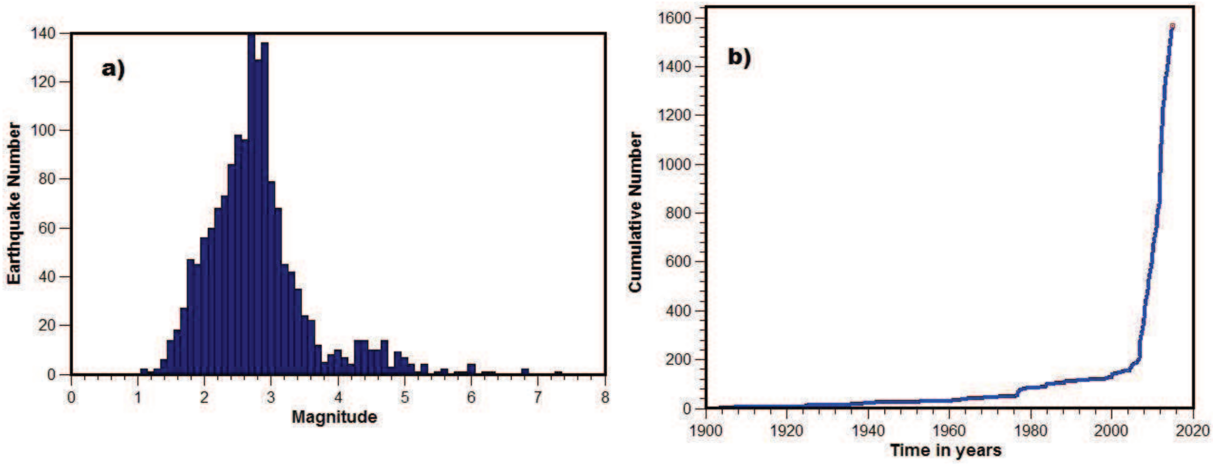

Figure 1. The graphs of, a) Earthquake number versus magnitude and b) cumulative number versus time for earthquakes in and around Ağrı

3. Tectonics and Seismicity

The neotectonic evolution of the eastern Anatolian region has been dominated by the collision of the Arabian plates with the Eurasian plate along the Bitlis-Zagros suture zone (Figure 2). The eastern Anatolian contractional province including the eastern Anatolian high plateau and the Bitlis-Pötürge thrust zone consists of an amalgamation of fragments of oceanic and continental crusts that squeezed and shortened between the Arabian and Eurasian plates. This collisional and contractional zone is being accompanied by the tectonic escape of most of the Anatolian plate to the west by major strike-slip faulting on the right-lateral north Anatolian transform fault zone and left-lateral east Anatolian transform fault zone which meet at Karlıova (ELITOK and DONMEZ 2011).

Depending on a N–S compressional tectonic regime, intra-plate deformation is dominant in the eastern Anatolian. Conjugate strike-slip faults of dextral and sinistral character paralleling to North and East Anatolian fault zones are the dominant structural elements of the region. Some of these structures include Ağrı Fault (AF), Bulanık Fault (BF), Çaldıran Fault (ÇF), Ercis Fault (EF), Horasan Fault (HF), Çobandede Fault Zone (ÇFZ), Iğdır Fault (IF), Malazgirt Fault (MF), Balıklıgölü Fault Zone (BFZ), Kağızman Fault Zone (KFZ), Doğubayazıt Fault Zone (DFZ), Karayazı Fault (KYFZ) and Tutak Fault Zone (TFZ), in the studied area shown by rectangular area in Figure 1. Many pull-apart basins have developed along these structures (e.g., Erzurum and Ağrı basins). Although the conjugate strike-slip fault system dominate the active tectonics of eastern Anatolia, the E–W trending basins of compressional origin form the most spectacular structures of the region as they indicate the N–S convergence and shortening of the Anatolian plateau. Muş, Lake Van and Pasinler basins form the best examples of ramp basins in the region (BOZKURT 2001).

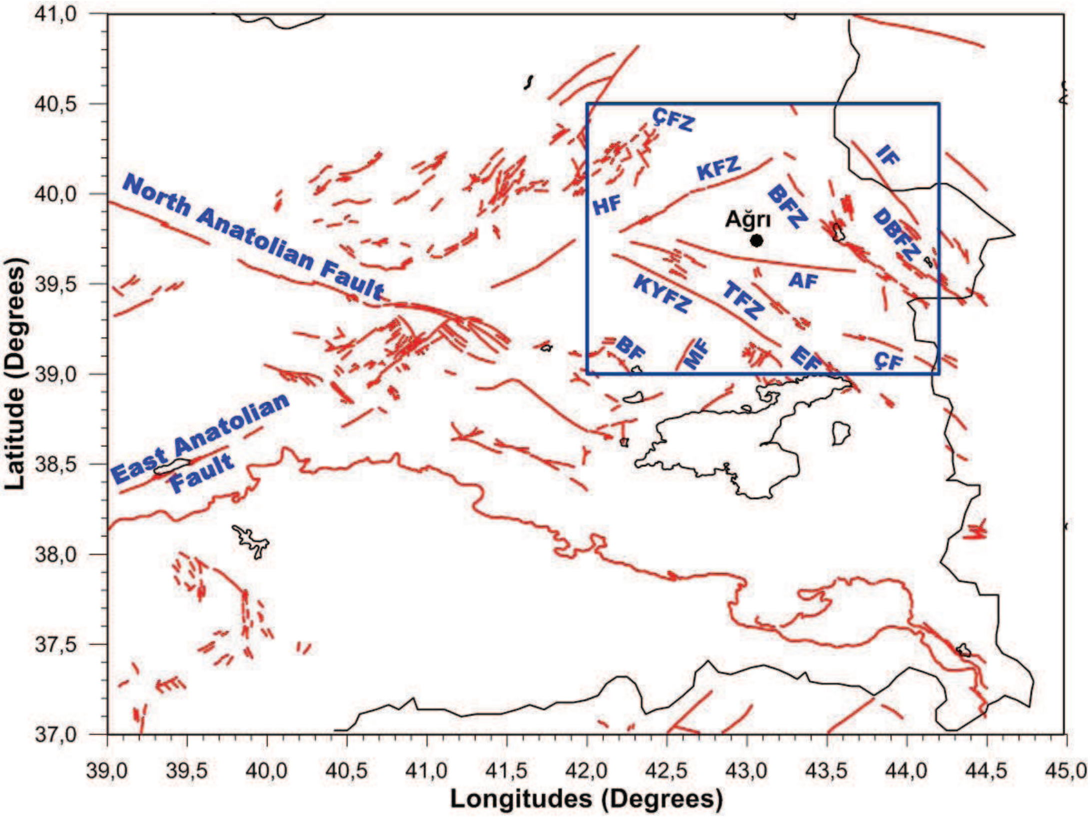

Figure 2. The tectonics in and around Ağrı. The rectangle shows the study area. Ağrı Fault (AF), Bulanık Fault (BF), Çaldıran Fault (ÇF), Ercis Fault (EF), Horasan Fault (HF), Çobandede Fault Zone (ÇFZ), Iğdır Fault (IF), Malazgirt Fault (MF), Balıklıgölü Fault Zone (BFZ), Kağızman Fault Zone (KFZ), Doğubayazıt Fault Zone, Karayazı Fault (KYFZ) and Tutak Fault Zone (TFZ) (BOZKURT, 2001).

The epicenter distribution of earthquakes larger than M=3.0 is shown in Figure 3. The faults in the studied area are seismically active and form the source for many earthquakes. The largest earthquakes, listed in Table 1, occurred in the region are 04 April 1903 Malazgirt (M=6.3), 13 September 1924 Pasinler (M=6.8), 24 November 1976 Çaldıran (M=7.3) and 30 October 1983 Horasan–Narman (M=6.8) (BOZKURT 2001).

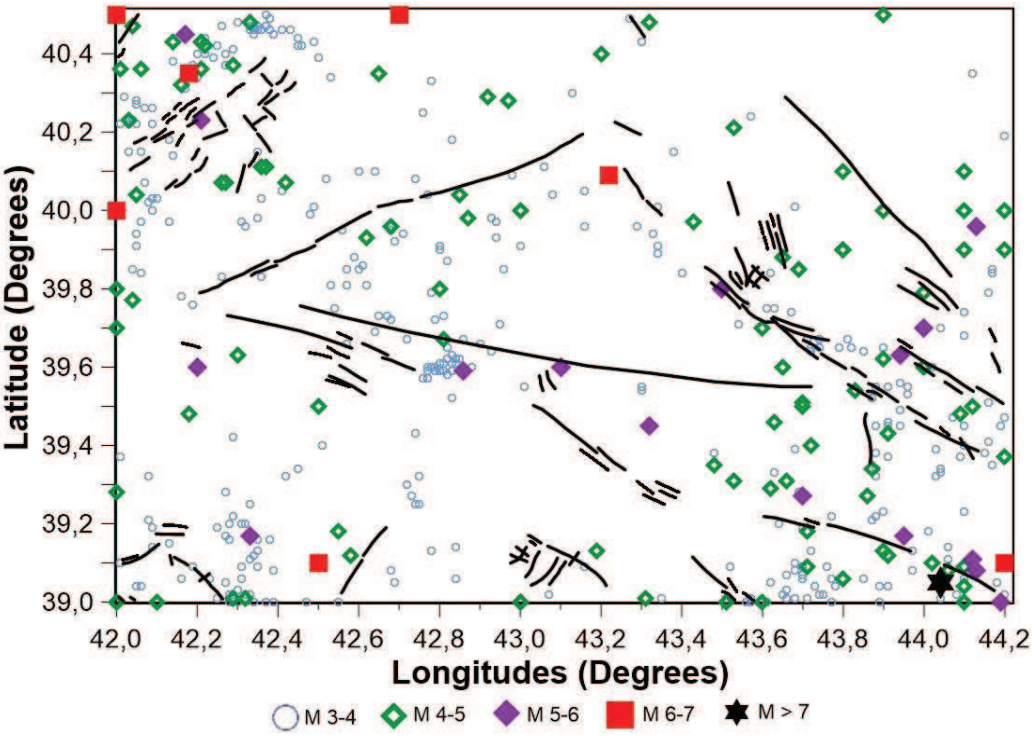

Figure 3. The epicenter distribution of earthquakes occurred in around Ağrı.

Table 1. The large earhquakes occurred in and around Ağrı.

Date	Magnitude (M_S)	Location
28 04 1903	6.30	Malazgirt (42.50°E, 39.10°N)
13 09 1924	6.80	Pasinler (42.00°E, 40.00°N)
01 05 1935	6.00	Kars-Digor (43.22°E, 40.09°N)
15 04 1960	6.00	Horasan-Narman (42.00°E, 40.50°N)
24 11 1976	7.30	Çaldıran-Muradiye (44.20°E, 39.10°N)
30 10 1983	6.80	Horasan (42.18°E, 40.35°N)

4. Methods

The empirical relationship, known as G–R law, between the frequencies of earthquake occurrences and magnitudes can be expressed in the following formula:

$$LogN = a - bM \quad (1)$$

where N is the cumulative number of earthquakes with a magnitude of M and greater, *a* and *b* are constants. *b* is the slope of the frequency–magnitude distribution, and a is the activity level of seismicity. GUTENBERG and RICHTER (1944) firstly estimated the constants known as seismicity parameters. The parameter a exhibits significant variations from region to region as it depends on the level of seismic activity, the period of observation and the length of the considered area as well as the size of earthquakes. The *b* value for a region not only reflects the relative proportion of the number of large and small earthquakes in the region, but is also related to the stress conditions over the region. Many factors can cause perturbation of the normal *b* value. On average, the *b* value is near unity for most seismically active regions on the Earth (e.g. FROHLICH and DAVIS 1993). In a tectonically active region, the *b* value is normally close to 1.0 but varies between 0.5 and 1.5 (PACHECO *et al*. 1992; WIEMER and WYSS 1997). However, a detailed mapping of *b* value often reveals significant deviations. The spatial variations of *b* values are related to the distribution of stress and strain (MOGI 1967; SCHOLZ 1968). In addition, some researchers link the *b*-value with the parameters of the rupture process. An example is SCHORLEMMER *et al.* (2005), who showed that the *b*-value is dependent on the faulting style. As pointed out by AMITRINO (2012), in laboratory experiments with brittle rocks, the *b*-value depends on the mechanical loading, which is the type of faulting, the confining pressure, or the roughness of the fault sliding surfaces. These observations agree with the dependence of the *b*-value on friction and/or mean stress. The distinction between these two factors remains difficult because they are correlated, as friction decreases when the confining pressure increases (GOEBEL *et al*. 2012). On the other hand, high *b* values are reported from areas of increased geological complexity (LOPEZ *et al*. 1995), indicating the importance of a multifracture area. Increased material heterogeneity or crack density results in high *b* values (MOGI 1962). Thus, a low *b* value is related to a low degree of heterogeneity, large stress and strain, large velocity of deformation and large faults (MANAKOU and TSAPANOS 2000).

b values were first estimated by GUTENBERG and RICHTER (1944) for various regions of the world. They suggested that *b* values range from 0.45–1.50, while MIYAMURA (1962) found that *b* values change from 0.40–1.80 according to the geological age of the tectonic area. Global seismicity has been studied by several authors, and it has been found that *b* values vary between 1.0 and 1.6 (MOGI, 1962), 0.8–1.2 (McNALLY 1989), 0.6–1.5 (UDIAS and MEZCUA 1997) and 0.53–1.19 (BAYRAK *et al*. 2002). The *b* value for any region can be computed using several methods such as linear least squares regression or by MLE which is the most robust and widely accepted method in which the *b* value is calculated using the formula (AKI 1965);

$$b = \frac{log_{10}e}{\bar{M} - M_{min}} = \frac{0,4343}{\bar{M} - M_{min}} \quad (2)$$

Where $\bar{M}$ is the average magnitude, and M_{min} is the minimum value of the magnitude presenting the data. In order to evaluate these parameters, we used to ZMAP 6 software package (WIEMER 2001).

The parameter at depends on the seismicity of the area, on the time interval for which we have reported events and also on the surface area S outlined by the epicenters. For seismicity study purposes usually at is expressed in one year by the equation:

$$a_1 = a - \log t \quad (3)$$

where *t* is the whole time period covered by the data set.

The expected time interval for the occurrence of an earthquake with a magnitude greater than or equal to *M* is defined as the mean return periods T_m and is given by:

$$T_m = \frac{10^{bM}}{10^{a_1}} \quad (4)$$

This quantity is adopted as a measurement of seismicity. The most probable maximum magnitude of earthquakes in a time period of *t* years:

$$M_t = \frac{a_1 + \log t}{b} \quad (5)$$

The probability P_t for an earthquake occurrence with magnitude ≥ M during the time span of t years:

$$P_t = 1 - \exp(-10^{a_1 - bM} t) \quad (6)$$

In this paper, we aimed to make a quantitative appraisal of earthquake hazard parameters in and around Ağrı. Particularly the analysis of the expected time interval for the occurrence of an earthquake, the most probable maximum magnitude of earthquakes in a given time period and the probability of an earthquake occurrence supply information on the earthquake hazard. We used a M_S magnitude scale in these equations since our catalogue is uniform of M_S.

5. Discussion and Conclusions

We used 1569 earthquakes occurred between 1900-2014 years in the region of 42.0-44.2 °E and 39.0-40.5 °N in order to evaluate earthquake hazard parameters in and around Ağrı. For this purpose, *a* and *b* parameters of G-R relationships, return periods, expected maximum magnitudes in the next 100 years and probabilities for the earthquakes for certain magnitude values are computed.

In this study, *b* value is calculated using ZMAP 6 software (WIEMER 2001). In particular, the *b* value was obtained by MLE estimation, using Equation (2). An estimation of standard deviation (δb) in *b* value can be obtained using the equation derived by AKI (1965) and modified by SHI and BOLT (1982):

$$\delta b = 2.3 b^2 \sqrt{\frac{\sum (M_i - M)^2}{n(n-1)}} \quad (7)$$

where, *n* is the sample size.

The cut-off magnitude (M_c) for the studied area shown in Figure 3 was estimated to be equal to 2.7 ± 018 with 90% goodness of fit level (Figure 4). The *a* and *b* values for this sequence shown in Figure 4 were estimated to be equal to 4.73 ± 0.22 and 0.68 ± 0.04, respectively with 90% goodness of fit level. The *b* value is lower than the global mean value of 1.0, which indicates that the data consists of larger earthquakes and high differential crustal stress in the region (WIEMER and KATSUMATA 1999; WIEMER and WYSS 2002).

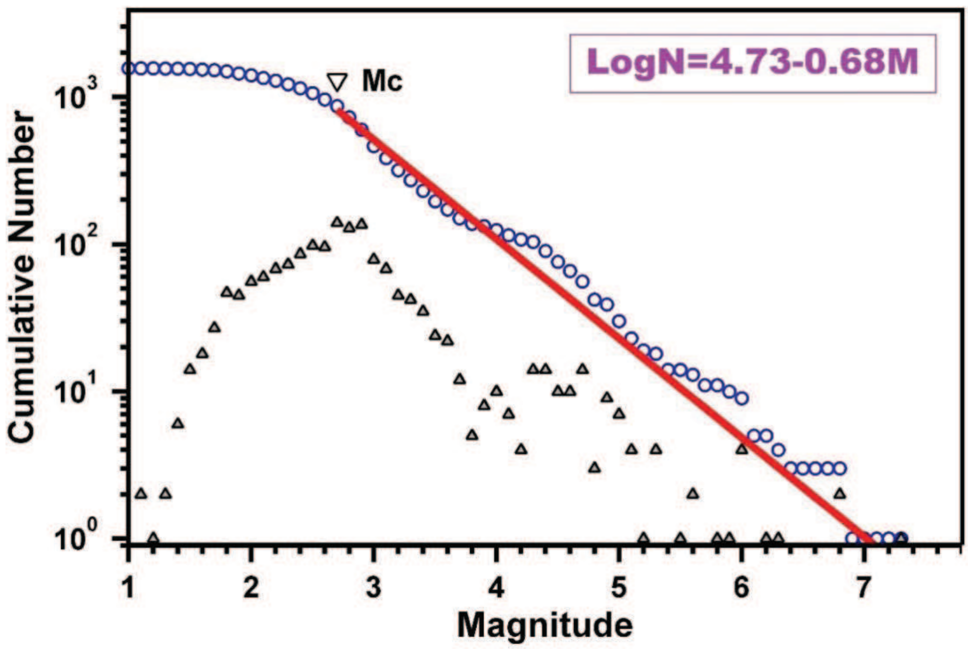

Figure 4. The relationship of Gutenberg- Richter for the earthquakes occurred in around Ağrı.

Spatial mapping of *b* values provides detailed information about seismotectonic situation in the studied area. For this purpose, data are projected onto a plane to visualize values of *b* as a function of space. The mapping of *b* values is performed in a 0.1° × 0.1° grid, selecting the nearest 50 events in each node and 25 events of the minimum number. The estimated *b* value varies from 0.4 to 1.55 as seen from Figure 5. The *b* values lower than 0.8 are related to the area with high-stress regions including IF, DBFZ, BFZ, ÇF, EF and HF. *b* values between 0.8 and 1.0 are found in the region covering TF and KYFZ. It is observed *b* values larger than 1.0 in the west, northwest and southwest of Ağrı. It reveals that this region is associated with highly heterogeneous and fractured rock matrix that may be associated with fluids or viscous materials with fluids into the fractured rock matrix (SINGH *et al*. 2012a, b). The regions in the east and southeast of Ağrı, east of Horasan and around Patnos are related to *b* values lower than 0.8. It can be concluded that these regions have high stress levels and capacity to occur large earthquakes in the future time.

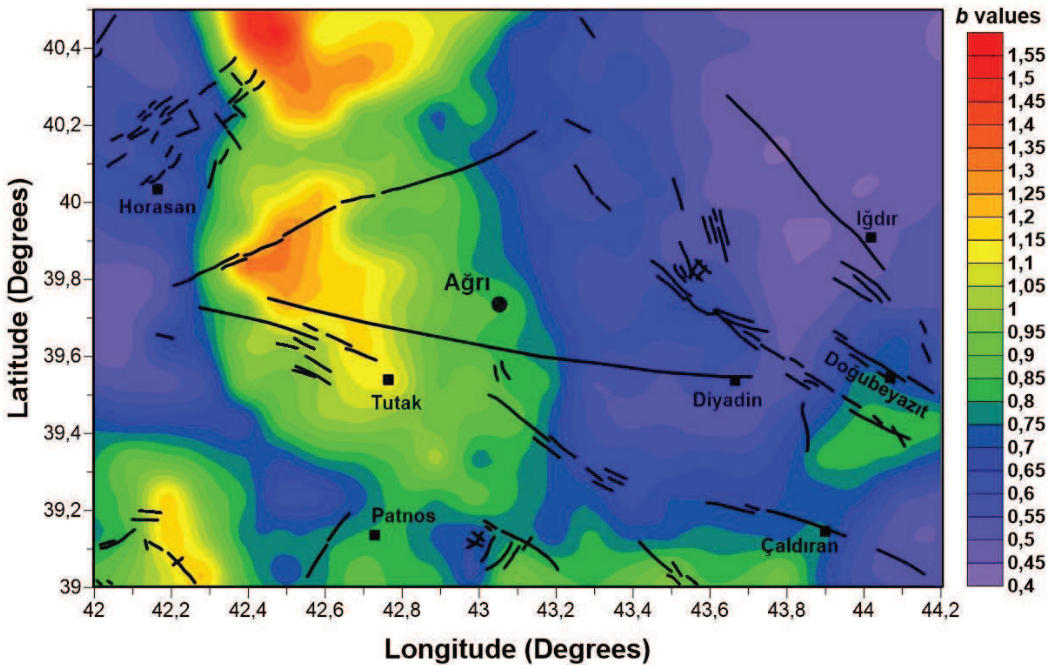

Figure 5. The spatial distribution of b values computed from Gutenberg-Richter relationships for the earthquakes occurred in around Ağrı.

Spatial mapping of M_{100} values which computed by Equation 5 is shown in Figure 6. M_{100} is the most probable maximum magnitude of earthquakes in a time period of next 100 years. The mapping of M_{100} values is performed in a 0.1° × 0.1° grid interval. The computed values change between 3.6 and 7.0 as shown in Figure 6. The values larger than 6.0 are computed in the IF, DBFZ, ÇF, HF and ÇFZ which produce large earthquakes as shown in Figure 2. The earthquake hazard level in the regions of Doğubeyazıt-Iğdır, Horasan-Pasinler and Çaldıran-Muradiye is very high and there is a probability to occur an earthquake larger than 6.0 in this region in the next 100 years. The magnitudes of expected earthquakes in the region between Ağrı and Horasan are lower than 5.0. The results show that there is an earthquake hazard about 5.5 around Patnos. The results show that the earthquakes larger than 5.5 may be occurred in the regions of the east and southeast of Ağrı, Horasan-Pasinler and around Patnos where *b* values lower than 0.8 have been observed (Figure 5), It can be concluded that these regions have high stress levels and capacity to occur large earthquakes in the next 100 years.

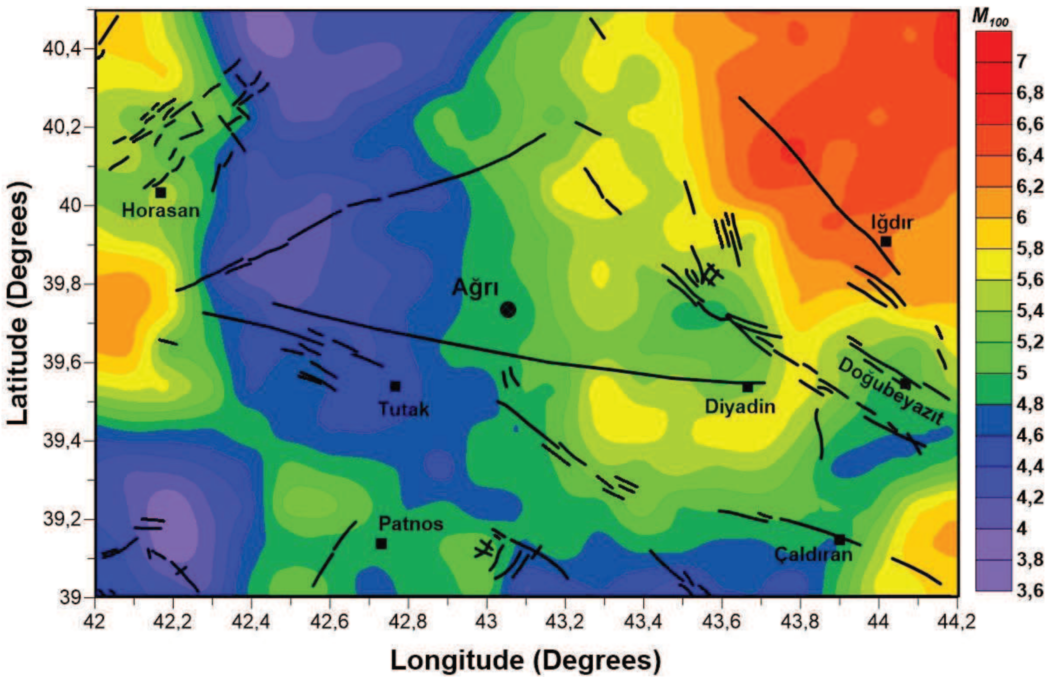

Figure 6. The spatial distribution of M_{100} values (expected maximum earthquake in the next 100 years) computed from Gutenberg-Richter relationships for the earthquakes occurred in around Ağrı.

Earthquake recurrence times (return periods, T_m) computed from equation 4 and the probability of occurrence computed from equation 6 using the parameters of G-R relationship for the earthquakes larger a certain magnitude value during a given time span are listed in Table 2. Also, earthquake hazard curves expressed in terms of the return period and probabilities of earthquakes are shown in Figures 7 and 8. The mean return periods estimated for the studied area change between 5 and 176 years for magnitudes of 5.0-7.3 as listed in Table 2 and shown in Figure 7. For example, an earthquake equal to 6.0 which could cause damage to buildings and lost human may be occurred every 23 years. This is very high seismic risk value and we can conclude that the studied area very dangerous. Earthquake hazard curves expressed by the probability expected for earthquakes with the maximum observed magnitudes and plotted for magnitudes (and during the time span of 25, 50 and 100) are shown in Figure 8. The probabilities of an earthquake with *M*=6.0, 6.5 and 7.0 in the next 100 years are 99%, 86% and 59%, respectively. The magnitude of the largest earthquake occurred in the studied area is equal to 7.3 and the probability of it in the next 100 years is 43%.

Table 2. The large earhquake risk values for next 25, 50 and 100 years.

M_s	Earthquake Risk (%) Years			Return Period(T_m)
	25	50	100	
5.0	0.99	1.00	1.00	5
5.1	0.99	1.00	1.00	6
5.2	0.98	1.00	1.00	7
5.3	0.96	1.00	1.00	8
5.4	0.93	1.00	1.00	9
5.5	0.9	0.99	1.00	11
5.6	0.86	0.98	1.00	13
5.7	0.82	0.97	1.00	15
5.8	0.77	0.95	1.00	17
5.9	0.71	0.92	0.99	20
6.0	0.66	0.88	0.99	23
6.1	0.6	0.84	0.97	27
6.2	0.54	0.79	0.96	32
6.3	0.49	0.74	0.93	37
6.4	0.44	0.68	0.9	44
6.5	0.39	0.63	0.86	51
6.6	0.34	0.57	0.81	59
6.7	0.3	0.51	0.76	69
6.8	0.27	0.46	0.71	81
6.9	0.23	0.41	0.65	95
7.0	0.2	0.36	0.59	111
7.1	0.18	0.32	0.54	129
7.2	0.15	0.28	0.48	151
7.3	0.13	0.25	0.43	176

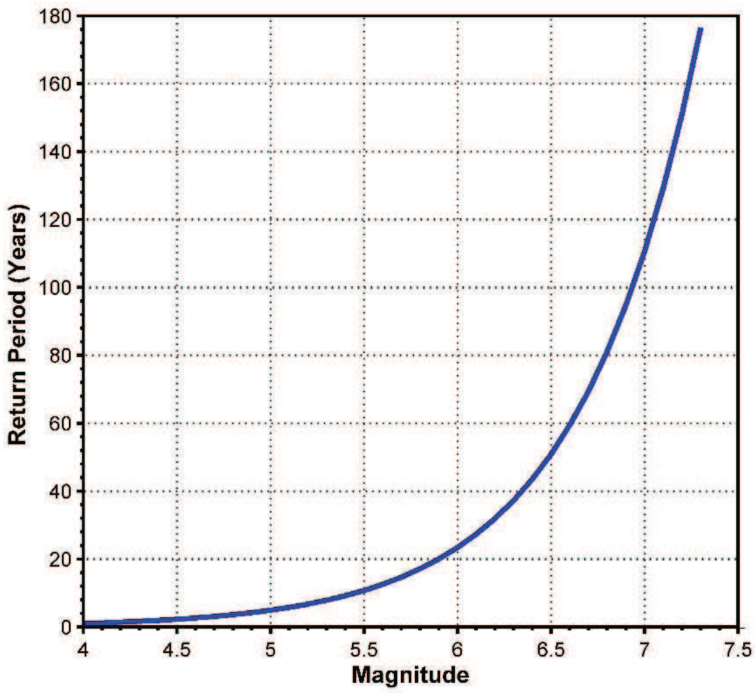

Figure 7. The return periods of earthquakes in around Ağrı.

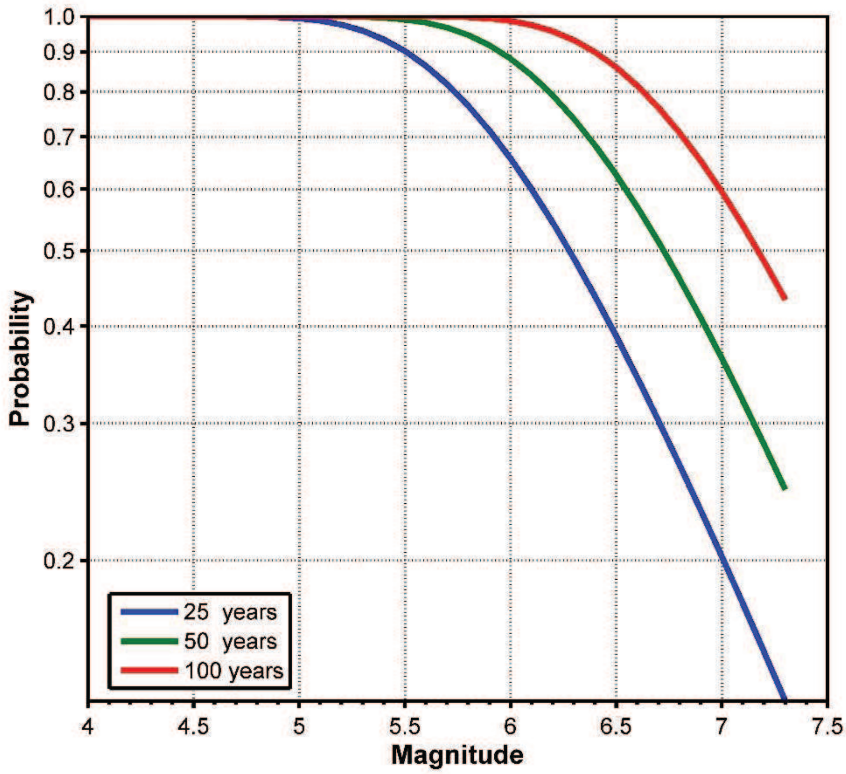

Figure 8. The probabilities for earthquakes for next 25, 50 and 100 years in around Ağrı.

There is not any risk to occur earthquake larger than 5.0 in the center of Ağrı according to spatial distribution of *b* and M_{100} shown in Figures 6 and 7 in the next 100 years. But, Ağrı is surrounded by active faults and probability of earthquakes greater than 6.0 in these faults is very high. There is a liquefaction risk in Ağrı due to a young sediment basin and alluvial layer is tick. We can concluded that there is very high hazard on the buildings and human's life considering liquefaction associated with an earthquake might occur and this alluvium layer grows up to ten times the earthquake waves (SEMBLAT *et al*. 2005).

6. Results

The earthquake hazard parameters in and around Ağrı was evaluated for time interval of 1900-2014 years. For this purpose, *a* and *b* parameters of G-R relationships, return periods, expected maximum magnitudes in the next 100 years and probabilities for the earthquakes for certain magnitude values are computed. *a* and *b* values for this time period were estimated to be equal to 4.73 and 0.68, respectively. This *b* value shows that that the data consists of larger earthquakes and high differential crustal stress in the region. The regions in the east and southeast of Ağrı, east of Horasan and around Patnos have high stress levels and capacity to occur large earthquakes in the future time according to the mapping of *b* values. It is found that earthquakes larger than 5.5 may be occurred in the regions where *b* values lower than 0.8 have been observed in the next 100 years. The return periods in the studied area are estimated between 5 and 176 years for magnitudes of 5.0-7.3. The probabilities of an earthquake with M=6.0, 6.5 and 7.0 in the next 100 years are computed 99%, 86% and 59%, respectively. The probability of the largest earthquake occurred in the studied area is 43% in the next 100 years. The faults around Ağrı are seismically active and have potential to an earthquake larger than 6.0. Since the sediment basin of Ağrı is very young and alluvial layer is tick, there is very high hazard on the buildings and human's life in Ağrı.

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A Preliminary Indoor Gamma-ray Measurements in Some of the Buildings at Karadeniz Technical University (Trabzon, Turkey) Campus Area

HAKAN ÇINAR[1], SUNA ALTUNDAŞ[1]

[1] Karadeniz Technical University, Department of Geophysical Engineering, Trabzon, Turkey

Abstract

Indoor gamma radiation dose rate and natural radionuclide concentrations (^{238}U, ^{232}Th, and ^{40}K) were measured inside former Geoscience Faculty Buildings of Karadeniz Technical University in Trabzon using a 512-channel portable gamma-ray spectrometer with a sodium iodide during the six-month period. Spectrometry data were collected on all floors for each building. The average radionuclide concentrations of ^{238}U, ^{232}Th, ^{40}K and dose rate in the buildings were found to be about 4.07 ppm, 11.58 ppm, % 1.98 and 79.03 nGy/h for Dean Building, 4.81 ppm, 13.38 ppm, % 2.52 and 94.2 nGy/h for Geophysical Engineering Building, 4.03 ppm, 13.14 ppm, %2.59 and 89.99 nGy/h for Geology Engineering Building, 3.76 ppm, 14.15 ppm, %2.68 and 92.34 nGy/h for Geomatics Engineering Building, respectively. In addition to this, the radiation hazard parameters (absorbed dose in the air, radium equivalent activity, internal hazard index and annual effective dose equivalent) for indoor environment were calculated and then jointly interpreted in order to find out the whether a radiological hazard exists in these buildings. As a result from this study, there is no significant radiologic hazard for human in studied buildings.

Keywords: Gamma-ray spectrometer, Uranium, Thorium, Potassium, Indoor radiation level, Radiation hazard parameters.

1. Introduction

Earth has a radioactivity since its existence. Radionuclides (radioactive elements) found in nature can be divided into three categories RAVISANKAR *et al.* (2012): The first one is called as primordial (terrestrial) radionuclides, which are naturally occurred in the Earth's crust since creation of the Earth. The second is cosmogenic radionuclides formed as a result of cosmic-rays from space includes energetic protons, electrons, gamma ray, and x-ray. And the last one is human produced radionuclides enhanced or formed due to human actions.

Natural radionuclides are the components of the Earth. These are widely spread in Earth's environment and exist in soil, sediment, water, building materials, plants and air. They are even found in the human body. There is nowhere on the Earth that one cannot find natural radioactivity. Radionuclides are unstable atoms that undergo spontaneous nuclear transformations and release excess energy in the form of ionizing radiation. The majority of human exposure to ionizing radiation occurs from natural sources (i.e. cosmic rays and terrestrial radiation) UNSCEAR (2000). Gamma rays as an electromagnetic ray often accompany the emission of alpha or beta particles from a nucleus. Gamma ray accounts for the majority of external human exposure to radiation from all source types due to its high penetration ability (ATSDR 1999; AL-SALEH 2007). Physical and chemical processes occurring following the radiation exposure involve successive changes at the molecular, cellular, tissue and whole body levels that may lead to a wide range of health effects varying from simple irritation, radiation-induced cancer, and hereditary disorders to immediate death (ATSDR 1999). Indoor exposure to gamma rays is often greater than outdoor exposure if earth materials are used as construction materials (HAZRATI *et al*. 2010).

All building materials such as concrete, brick, sand, aggregate, marble, granite, limestone, gypsum, etc., contain mainly natural radionuclides, including uranium (^{238}U) and Thorium (^{232}Th) and their decay products, and the radioactive potassium (^{40}K). The knowledge of the natural radioactivity of building materials is important for the determination of population exposure to radiations, as most of the residents spend about 80% of their time indoors. Building materials contribute to natural radiation exposure in two ways. First, by gamma radiation, from ^{40}K, ^{238}U, ^{232}Th, and their decay products to an external whole body dose exposure and secondly by radon exhalation to an internal dose exposure due to deposition of radon decay products in the human respiratory tract (STOULOS *et al.* 2003).

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Corresponding author:
Hakan Çınar, PhD
Karadeniz Technical University, Trabzon, Turkey
E-mail: hakcinar61@gmail.com

During the last decades, there has been an increasing interest in the study of radioactivity in various building materials, and in-situ determination of indoor and outdoor radiation levels and their main effects on living environment (KUMAR *et al.* 2003; AHMAD and MATIULLAH HUSSAIN 1988; AMRANI and TAHTAT 2001; BERETKA and MATHEW, 1985; CHONG and AHMAD 1982; MOLLAH *et al.* 1986; VIRESHKUMAR *et al.* 1999; ZAIDI *et al.* 1999; EL-ARABI 2005; EL-TAHAWY and HIGGY 1995; KHAN *et al.* 2002; MCAULAY and MORAN 1988; ALI *et al.* 1996; STOULOS *et al.* 2003; TUFAIL *et al.* 2007, BALCIOĞLU and APAYDIN 2013, ÇINAR *et al.* 2013).

Indoor gamma exposure measurements-related studies have mainly been carried out using Gamma-ray spectrometry and HPGe detector by various authors (CLOUVAS *et al.* 2001; BALDASSARRE and SPIZZICO 2002; CLOUVAS *et al.* 2004; XINWEI and XIAOLAN 2006; BRAHMANANDHAN *et al.* 2007; MAVI and AKKURT 2010; MEHRA *et al.* 2010; MEHDIZADEH *et al.* 2011; CEVIK *et al.* 2011; DAMLA *et al.* 2012; QUARTO *et al.* 2013). Soil-originated bricks and roof-tiles and their raw material in the Salihli-Turgutlu area were tested in situ for natural radiation levels using a gamma-ray spectrometer by UYANIK *et al.* (2013). DAMLA *et al.* (2011) measured the natural radioactivity of the bricks and roofing tiles in the seven region of the Turkey. CELIK *et al.* (2010) determined radioactivity levels in Ordu soil and building materials using gamma-ray spectrometry. As a result of this study, calculated all hazard parameters were found to be within the acceptable limits.

The main aim of this work is to measure indoor concentration levels (indoor gamma exposure) of naturally occurred ^{40}K, ^{238}U and ^{232}Th in former Geoscience Faculty Buildings of Karadeniz Technical University using the 512-channel (NaI) gamma-ray spectrometer. Moreover, using obtained data, it is mainly aimed to calculate radiological hazard parameters such as the absorbed gamma dose rate in the air at 1 m above the ground level, annual effective dose, radium equivalent activity, and internal hazard index. Also, radionuclide concentrations that could be measured inside of buildings are graphed in order to show variations on the natural radiation level. Apart from these, all the calculated parameters are compared with the worldwide acceptable values in order to assess the possible radiological risks for human health in the studied buildings.

2. Materials and Method

In order to obtain the radiometric data for this study, indoor gamma exposure measurements were carried out, using the 512-channel (NaI) portable gamma-ray spectrometer (GF Instrument) (Figure 1), in the former Geoscience Faculty Buildings (Geophysical Engineering, Geology Engineering, Geomatics Engineering Departments and Engineering Faculty Dean Building).

Gamma-ray spectrometer was delivered with a factory calibration set to high-volume standards. To create a new user calibration, the probe is placed at the middle of the calibration pad. Concentrations of the calibration pad corrected by the geometrical factor (i.e. multiplied by the geometrical factor value). Geometrical factor G = 1-h/r, where h is the height of the middle of the detector above the pad (the value is given in the description of the probes) and r is the diameter of the pad. The recommended time for recalibration is 3–5 years (For more detailed information see IAEA 2003) (GF INSTRUMENTS 2009). The total energy window of instrument was set from 100 keV to 3.00 MeV. One channel is equal to 5,877 keV. The 1.76 MeV ^{214}Bi peaks of the ^{238}U series were used for the equivalent uranium analysis (eU), whereas equivalent thorium (eTh) was determined from the 2.62 MeV ^{208}Tl peak of the ^{232}Th series. The concentration of radioactive potassium was determined directly from 1.46 MeV ^{40}K (KALYONCUOĞLU 2014).

Indoor gamma exposure measurements were performed in each floor of the buildings during the six-month period from November to April. Time duration of each measurement is about 300 seconds per point.

Figure 1. The Gamma-ray spectrometer (NaI detector and control unit)

As a result of the measurements, Potassium (K, %), equivalent Thorium (eTh, ppm), equivalent Uranium (eU, ppm) and dose rate (D, nGy/h) values for each point were obtained.

Measured radionuclide concentrations were converted to the main activity unit (Bq/kg) using an appropriate conversion factor given in Table 1 in order to determine the radiation hazard parameters of each point. After the activity concentrations of radionuclides determined, hazard parameters such as adsorbed dose rate in air, radium equivalent activity, annual effective dose equivalent, and internal hazard index for points inside the building were calculated.

Table 1. Conversion factors from equivalent concentration (ppm, %) to activity (Bq/kg) (IAEA 1989)

% 1 K	313 Bq/kg	^{40}K
eU (1ppm)	12,35 Bq/kg	^{238}U or ^{226}Ra
eTh (1ppm)	4,06 Bq/kg	^{232}Th

The calculations described below were performed to determine the radiological risk in addition to the measured natural radionuclide concentrations. Gamma dose rate in air, one meter above the ground, is used for the description of terrestrial radiation, and is usually expressed in nGy/h or pGy/h. The absorbed dose rate due to gamma radiation of naturally occurring radionuclide (^{238}U, ^{232}Th, and ^{40}K), were calculated on guidelines provided by (UNSCEAR 2000).

$$D(nGy/h) = 0.462A_U + 0.621A_{Th} + 0.0417A_K \quad (1)$$

Where 0.462, 0.621 and 0.0417 are the conversion factors for ^{238}U, ^{232}Th and ^{40}K assuming that the contribution natural occurring radionuclide can be neglected as they contribute very little to total dose from environmental background.

To estimate annual effective doses, account must be taken of the conversion coefficient from absorbed dose in air to effective dose and the indoor occupancy factor. The average numerical values of those parameters vary with the age of the population and the climate at the location considered.

In the UNSCEAR 1993 Report, the Committee used 0.7 SvGy/y for the conversion coefficient from absorbed dose in air to effective dose received by adults and 0.8 for the indoor occupancy factor, i.e. the fraction of time spent indoors is 0.8. The annual effective dose is determined as follows: (UNSCEAR 1993).

$$AEDE\ (mSv/y) = D(nGy/h)x8760\ (h/y)x0.8x0.7(SvG/y) \quad (2)$$

To represent the activity levels of ^{238}U, ^{232}Th and ^{40}K which take into account the radiological hazards associated with them, a common radiological index has been introduced. This index is called radium equivalent activity (Ra_{eq}) and is mathematically defined by (UNSCEAR 2000).

$$Ra_{eq}(Bq/kg) = A_U + 1.43A_{Th} + 0.077A_K \quad (3)$$

Where A_U, A_{Th} and A_K are the specific activities of Uranium, Thorium, and Potassium respectively. This equation is based on the estimation that 10 Bq/kg of ^{238}U equal 7 Bq/kg of ^{232}Th and 130 Bq/kg of ^{40}K produced equal gamma dose. The maximum value of Ra_{eq} must be less than 370 Bq/kg.

To reflect the internal exposure, a widely used hazard index, called the internal hazard index (H_{in}), which is defined as following:

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (4)$$

The value of the index must be less than the unity in order to keep the radiation hazard to be insignificant unity corresponds to the upper limit of radiation equivalent activity (370 Bq/kg).

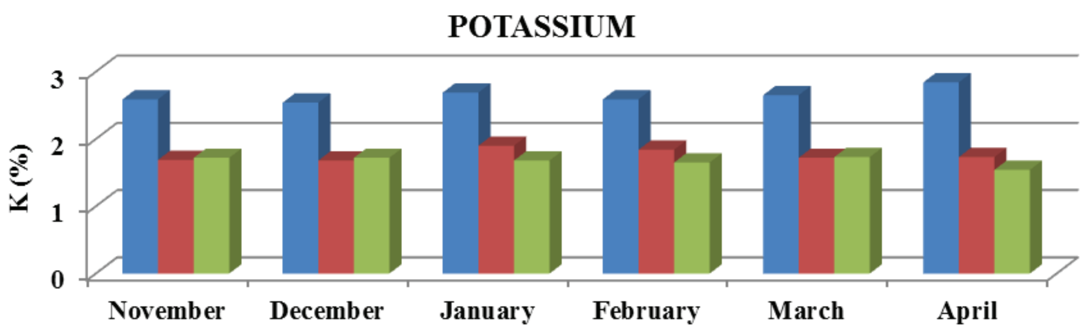
3. Result and Discussions

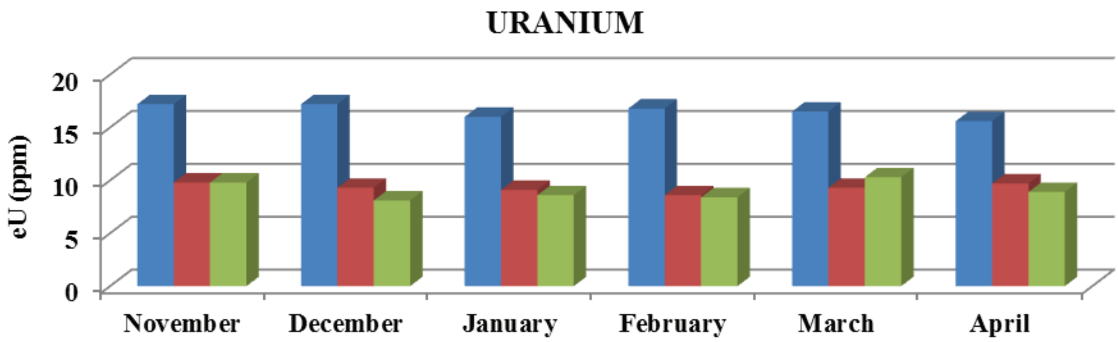
The indoor gamma exposure measurements were performed inside (including all floors) of buildings (Geophysical, Geology, and Geomatics Engineering Departments and Engineering Faculty's Dean Building) during six-month period using portable NaI (Tl) detector in order to determine total gamma dose rates and radionuclide concentrations. Table 2 shows the average values of the ^{238}U, ^{232}Th, ^{40}K concentrations, measured (D) and calculated absorbed dose in air ($D_{absorbed}$), radium equivalent activity (Ra_{eq}), internal hazard index (H_{in}) and annual effective dose equivalent for indoor environment (AEDE) of buildings.

In general, these buildings are more than thirty years old. They were constructed with bricks, concrete (including sea-gravels as an aggregate) and sea-sands. Accordingly, relative contribution of different natural gamma emitters (^{238}U, ^{232}Th and ^{40}K) to the gamma dose rate varies from building to building due to the construction materials. Following figures (Figs 2, 3, 4 and 5) show semi-annual radionuclide and dose rate distributions for each building.

Table 2: Semi-annual average values for the radionuclide concentrations and the gamma radiation hazard indices for studied buildings (including each floors and entire building).

		U (ppm)	Th (ppm)	K (%)	D (nGy/h)	$D_{absorbed}$ (nGy/h)	$Ra_{(eq)}$ (Bq/kg)	H_{in}	AEDE (mSv/y)
Dean Building	Basement floor	5,58	16,55	2,65	108,01	109,8	229,05	0,804	0,53
	Ground floor	3,3	9,3	1,76	65,35	66,23	137,24	0,48	0,32
	First floor	3,33	8,9	1,54	63,75	64,47	133,92	0,47	0,31
	Entire Building	4,07	11,58	1,98	79,03	80,16	166,3	0,584	0,386
Geophysical Engineering	Basement floor	3,83	11,93	2,29	82,05	83,41	172,11	0,59	0,409
	Ground floor	5,35	14,1	2,49	98,75	99,94	208,26	0,741	0,490
	First floor	5,083	13,76	2,58	97,41	98,81	205,12	0,723	0,484
	Second floor	4,98	13,75	2,745	98,81	100,40	207,64	0,727	0,492
	Entire Building	4,81	13,38	2,52	94,2	95,64	198,28	0,695	0,468
Geology Engineering	Basement floor	3,55	10,5	2,31	76,96	78,28	160,68	0,55	0,384
	Ground floor	4,05	13,85	2,67	92,75	94,76	194,93	0,661	0,464
	First floor	4,12	13,41	2,675	92,083	93,99	193,32	0,659	0,461
	Second floor	3,88	13,73	2,68	91,71	93,68	192,40	0,649	0,459
	Third floor	4,58	14,23	2,65	96,46	98,33	203,27	0,701	0,482
	Entire Building	4,036	13,14	2,59	89,99	91,80	188,92	0,644	0,45
Geomatics Engineering	Basement floor	4,06	14,56	2,73	95,65	97,65	200,87	0,678	0,479
	Ground floor	3,91	13,83	2,6	91,28	93,13	191,62	0,648	0,456
	First floor	3,33	14,08	2,72	90,1	92,28	188,64	0,62	0,452
	Entire Building	3,76	14,15	2,68	92,34	94,35	193,71	0,648	0,462





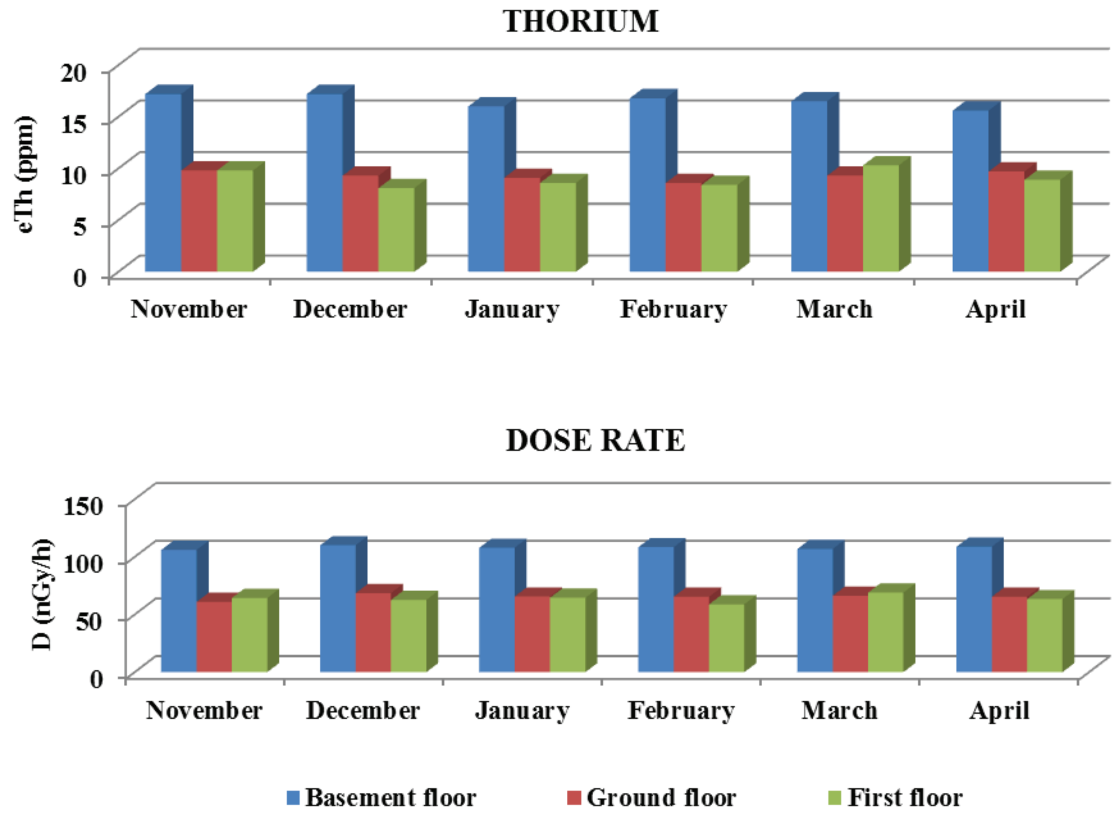
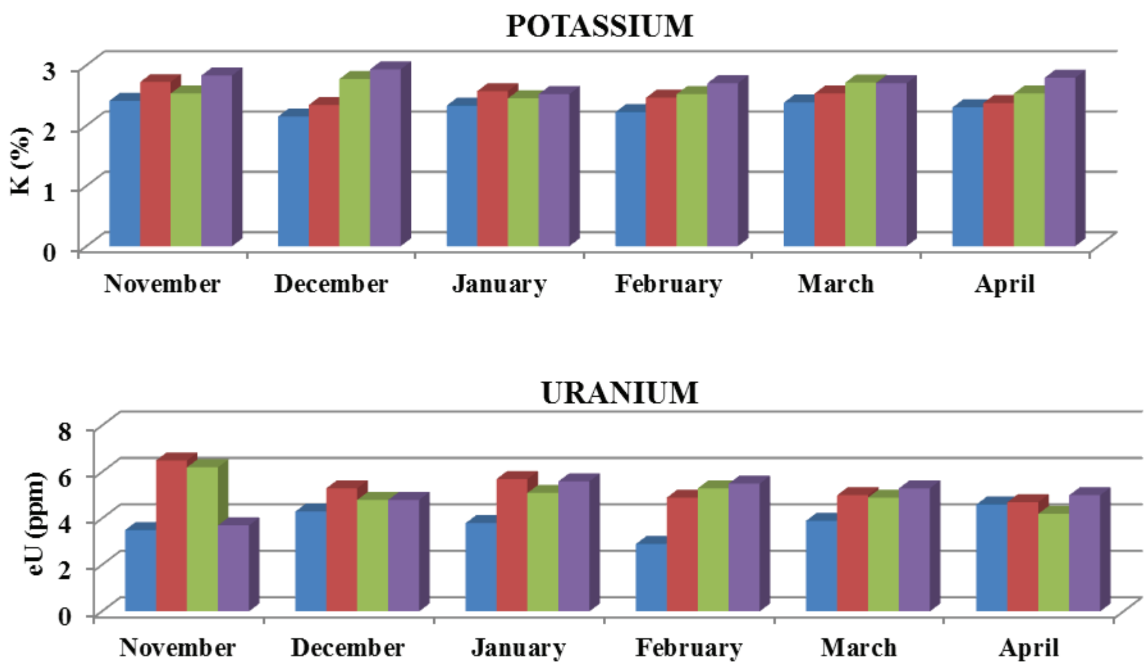


Figure 2. Distribution of ^{40}K, ^{238}U, ^{232}Th and dose rate for Engineering Faculty's Dean building.



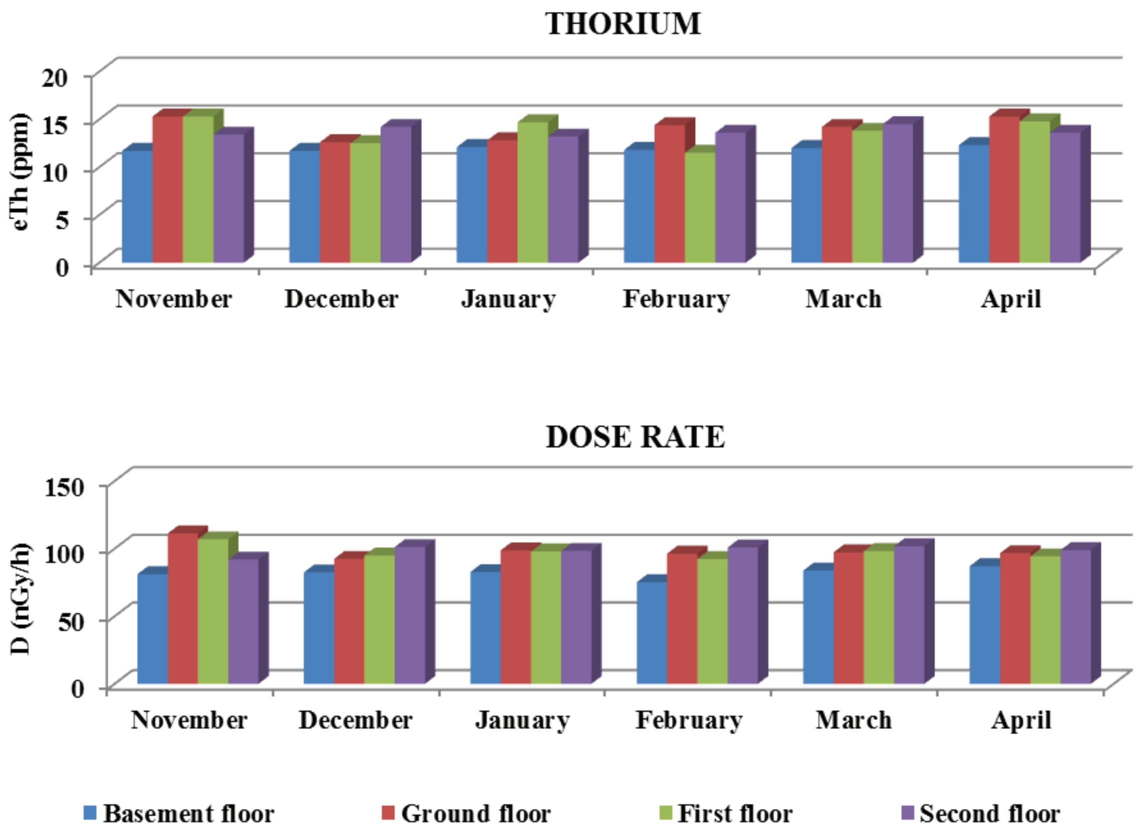
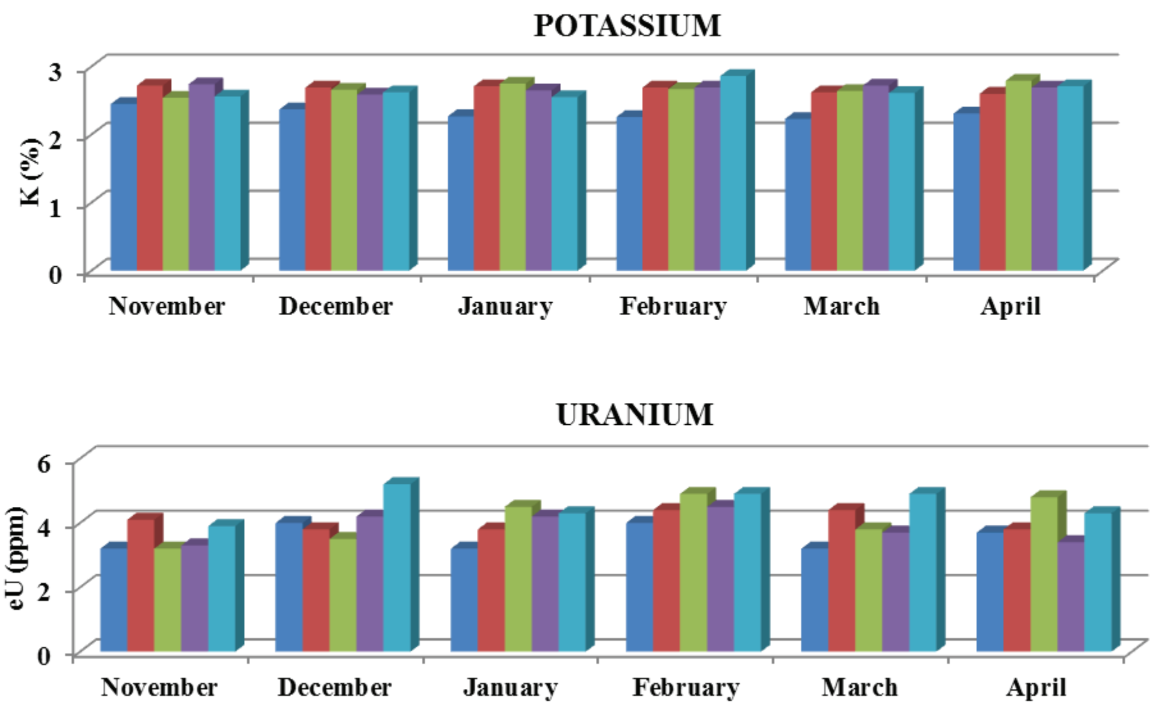


Figure 3. Distribution of ^{40}K, ^{238}U, ^{232}Th and dose rate for Geophysical Engineering building.



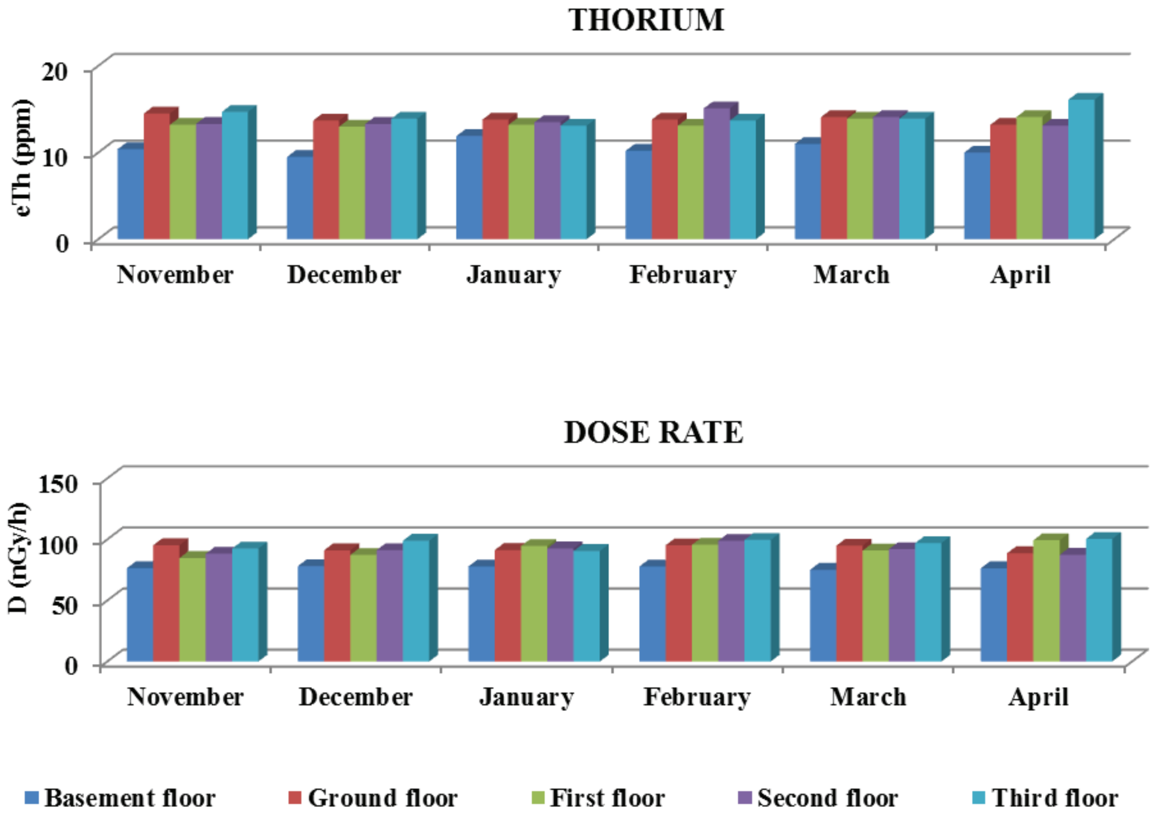
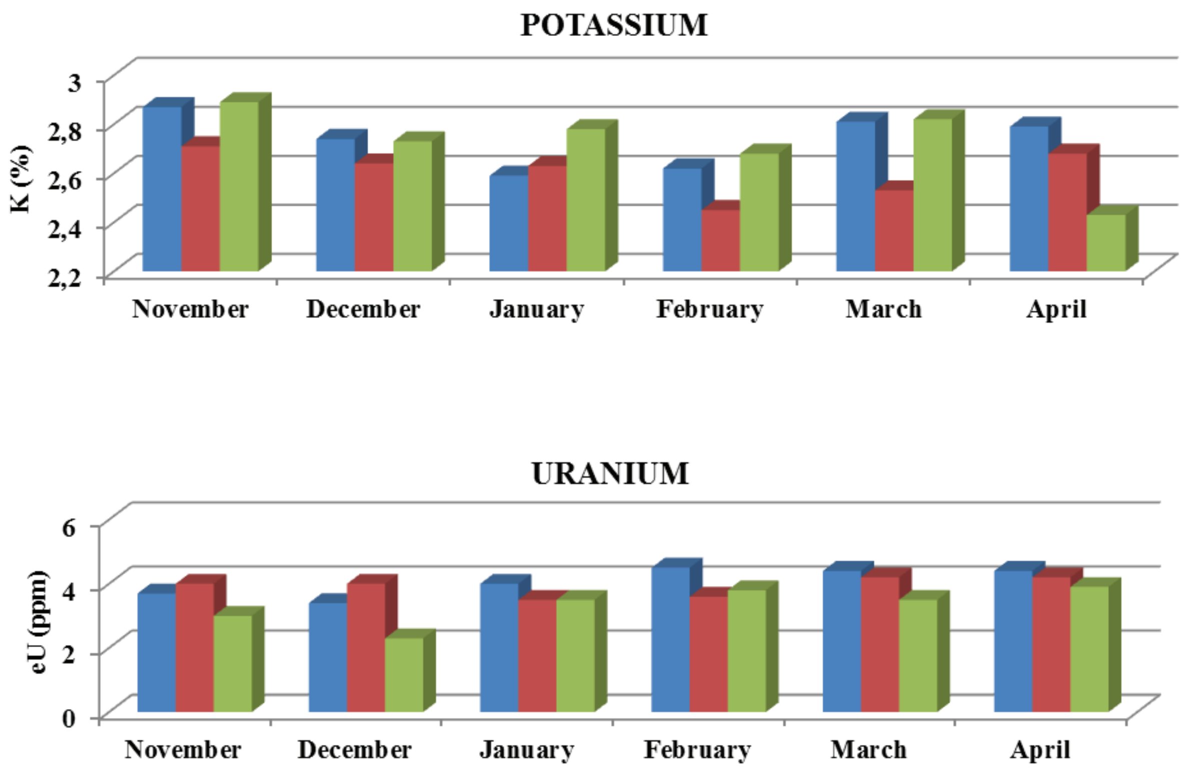


Figure 4. Distribution of ^{40}K, ^{238}U, ^{232}Th and dose rate for Geology Engineering building.



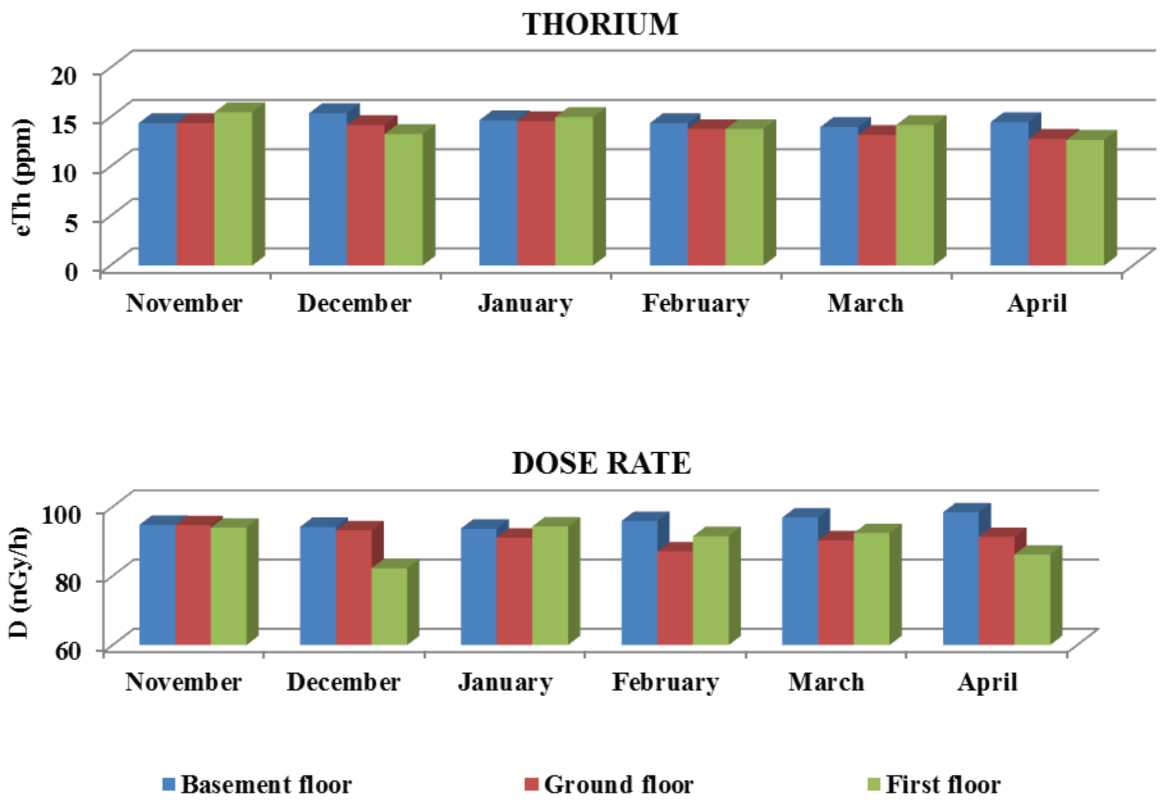


Figure 5. Distribution of ^{40}K, ^{238}U, ^{232}Th and dose rate for Geomatics Engineering building.

While higher U concentration (5.9 ppm) was observed in Geophysical Engineering building, the lowest one (2.3 ppm) was in Geomatics building. Lower and higher Th values were measured in Dean Building about 8.1 ppm, and 17.2 ppm, respectively. Higher K value (% 2.93) was measured in Geophysical Engineering building and lowest (% 1.54) was in Dean building. These higher concentration values are originated from different building materials such as sea sand and gravel used for building construction in the past. MAVI and AKKURT (2010) determined radionuclide concentrations (^{226}Ra, ^{232}Th and ^{40}K) of some building materials such as brick clay, gravel, cement and gypsum. These researchers found that all samples have higher Potassium activity concentration, and brick clay samples have also highest Potassium activity concentration. Furthermore, sea-sands have more Silicon and mafic mineral contents, and they showed high radioactivity value depending mostly on their acidic properties. DAMLA *et al.* (2012) carried out chemical analyses on sand, cement, gas concrete, tile and brick samples using energy dispersive X-ray fluorescence (EDXRF) spectrometer. These researchers found that Silicon dioxide (SiO_2) content of sand, cement and bricks samples were to be % 64.6, % 34.7 and % 57.88, respectively. Thus, it could be said that the building materials have higher Silicon content show greater radioactivity values.

On the other hand, the soils which surround the foundation of these buildings are volcanic origin. Leakage of radionuclides from the soil via to micro-cracks exist in buildings increases the measured indoor radiaton level. Furthermore, the concentrations of radionuclides in the air depend on their emanation rate from the soil, meteorological and geographical factors, and on the height above the ground surface. Even though the ventilation rate is higher in summer the higher exhalation rate of radon and thoron (daughter elements of Uranium decay) results in higher contribution to indoor gamma dose rate. The high moisture content in atmosphere, on walls and floor acts as a shield to indoor gamma radiation, which results in lower dose rate in winter (SIVAKUMAR *et al.* 2002). In this study, measurements were carried out in winter and spring, and lower indoor gamma dose rate was observed in winter, and highest one was in spring.

In UNSCEAR (2000), it is reported that median values of ^{238}U, ^{232}Th, ^{40}K activities of 35 Bq/kg, 30 Bq/kg, and 400 Bq/kg, respectively. The world population-weighted average for the indoor gamma dose rate is 89 nGy/h. The mean values of both radionuclide concentration and dose rate for each building are slightly higher than the values given by UNSCEAR (2000).

The radiological hazard parameters calculated for each building are all well below the acceptable limit. The highest absorbed dose rate in air was observed in Geophysical Engineering department, this may be attributed to the higher concentration of uranium and thorium in building materials, and the lowest in Engineering Faculty's Dean Building 112.23 and 59.69 nGy/h, respectively. The results of this study show that the average values of Ra_{eq} obtained for the all buildings are less than recommended value (370 Bq/kg) by UNSCEAR (2000), and this value does not pose a radiological hazard for people who working in these buildings. The mean annual effective dose equivalent for the indoor environment is approximately 1.5 mSv/y ICRP (1993). Our results for the average annual effective dose in all buildings are compatible with the range of worldwide acceptable value. Obtained mean value for each building is less than the acceptable value (≤1). The internal hazard index is less than 1, which means that it is safe for working people in this area.

4. Conclusion

Gamma ray spectrometry method was used to determine the natural radioactivity concentration of ^{40}K, ^{232}Th, ^{238}U and dose rate values and evaluate the natural radiation level inside the buildings. Radionuclide activity concentrations and dose rates in the buildings are higher than the median values given in the literature. The absorbed dose rates in the air, radium equivalent activities, the internal hazard indices and the annual effective dose rates were calculated from the activity concentrations, and they were compared to the corresponding world median values. All these hazard parameters are found to be lower than recommended value by UNSCEAR. It is concluded that indoor radionuclide level of studied buildings are not dangerous for human health.

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Effective annealing of ZnO thin films grown by three different SILAR processes

Harun GÜNEY[1] and M. Emrah ERTARĞIN[1]

[1] Ağrı İbrahim Çeçen University, Vocational High School, Department of Electric and Energy, Ağrı, Turkey

Abstract

In the present work, zinc oxide (ZnO) thin films have been grown three different cation solution on glass substrates by a simple and economic successive ionic layer absorption and reaction method (SILAR). One of each grown different solution films was annealed to investigate to effective annealing at 300 ^{o}C for 30 minutes. Adsorption measurements showed that the optical band-gaps of all ZnO thin films were wide and were about 3.08-3.31 eV. All films' band gap increased with annealing. Energy-Dispersive-X-Ray-Fluorescence (EDXRF) spectroscopy showed Zn in structures. Wettability of all films was analyzed using a CCD camera. It was found that without any surface modification all films show hydrophobic behavior. Thickness of the films was measured by the gravimetric weight difference method using sensitive microbalance. Thickness of the films increased with annealing. Conductivity of all films was measured by hot probe method and each film shown n-type conductivity.

Keywords: ZnO, SILAR, annealing, hydrophobic

1. Introduction

ZnO is a very important material in manufacturing thin film solar cells with hexagonal wurtzite structure and wide and direct band gap energy of 3.4 eV at room temperature (RT) (COSKUN *et al*. 2009), transparency in visible range of solar spectrum (JAMBURE *et al*. 2014). Through its typical properties it has been used in multiple applications (VARGAS-HERNANDEZ *et al*. 2008). ZnO is a promising photonic material for optoelectronic device technology by its feature. Band gap of ZnO can be changed depending on the growth conditions. In this way, ZnO becomes more useful in optoelectronic applications.

ZnO can grow different chemical methods such as SILAR (YILDIRIM and ATES 2010), Spray Pyrolysis (SP) (DE LA OLVERA *et al*. 2002), Chemical Bath Deposition (CBD) (SHINDE *et al*. 2005), Electrodeposition (COSKUN *et al*. 2009), etc. Thin films of compound semiconductors can be deposited alternately by means of the dipping substrate into the aqueous solutions of containing ions for each component via SILAR method (NICOLAU 1985). The growth of thin films during the SILAR method occurs solely heterogeneously on the solid–solution interface due to the intermediate rinsing step between the cation and anion immersions. Therefore, the thickness of the film can easily be controlled by the number of growth cycles used (GAO *et al*. 2004; YILDIRIM *et al*. 2009).

In this work the effect of annealing and different solutions optical properties of grown ZnO transparent films prepared by SILAR deposition method is investigated.

2. Experimental

On glass substrate ZnO thin films were grown there different solution procedures by the SILAR method. Firstly, substrate was cleaned subsequent 5 min. trichloroethyle 5 min. acetone and 5 min. methanol. Three different zinc cation procedures were made to obtained Zinc ammonium complex solution ($[Zn(NH_3)_4]^{2+}$). These procedures are

- 0.1 M $ZnCl_2$ and concentrated 25-28% NH_3 (1:10)
- 0.1 M $ZnSO_4$ and concentrated 29% ammonia NH_4OH (1:10)
- 0.1 M $ZnNO_4$ and concentrated 29% ammonia NH_4OH (1:10)

Each procedure is a two steps process involving subsequent immersion of cleaned substrate in cationic and near boiling DI water.

Growth procedure 1:

a. The cleaned glass substrate was immersed in the zinc complex ($[Zn(NH_3)_4]^{2+}$) solution for 14 s at room temperature so that zinc complex was adsorbed on the substrate surface.

b. The substrate was immersed in 95°C DI hot water for 6 s to form the ZnO film.

c. The substrate was hanged on in the air to drying for 50 s. 60 deposition cycles were made.

Growth procedure 2:

a. The cleaned glass substrate was immersed in the zinc complex ($[Zn(NH_3)_4]^{2+}$) solution for 2 s at room

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Corresponding author:
Harun Güney, PhD
Ağrı İbrahim Çeçen University,
Vocational High School, 04100, Ağrı, Turkey
Tel: +90-472 2161095
Fax: +90-472 2151147
E-mail: hguney@agri.edu.tr

temperature so that zinc complex was adsorbed on the substrate surface.

b. The substrate was immersed in 95°C DI hot water for 2 s to form the ZnO film. 100 deposition cycles were made.

Growth procedure 3:

a. The cleaned glass substrate was immersed in the zinc complex ($[Zn(NH_3)_4]^{2+}$) solution for 2 s at room temperature so that zinc complex was adsorbed on the substrate surface.

b. The substrates in 95°C DI hot water for 2 s to form the ZnO film. 160 deposition cycles were made.

All films were annealed at 300°C for 30 minutes. The optical properties were investigated using Shimadzu UV-1800 spectrophotometer. The EDXRF analyses have been recorded using a Skyray EDX P730. Wettability of all films was analyzed using a CCD camera. Thickness of the films was measured by weight difference method using sensitive microbalance.

3. Result and Discussion

The mechanism of three different ZnO films formation by SILAR method can be explained as follows.

- $ZnCl_2$

$$2ZnCl_2 + 4NH_3 \rightarrow 2[Zn(NH_3)_4]^{2+} + 2Cl^- \quad (1)$$

- $Zn(NO_3)_2$

$$Zn(NO_3)_2 + 2NH_4OH \rightarrow Zn(OH)_2(s) + 2NH_4^+ + 2NO_3^- \quad (2)$$

$$Zn(OH)_2(s) + 4NH_4^+ \rightarrow [Zn(NH_3)_4]^{2+} + 2H_2O + 2H^+$$
(SHINDE *et al.* 2007) (3)

- $ZnSO_4$

$$ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2 + 2NH_4 + SO_4^{2-} \quad (4)$$

$$Zn(OH)_2 + 4NH_4 \rightarrow [Zn(NH_3)_4]^{2+} + 2H_2O + 2H^+$$
(JIMÉNEZ-GARCÍA *et al.* 2014) (5)

In these reactions, when aqueous ammonia and ammonium hydroxide solution at 1:10 ratio was added to the zinc chloride, zinc sulfate and zinc nitrate solutions, the ionic product of zinc ammonium complex solution ($[Zn(NH_3)_4]^{2+}$). The detailed chemical reactions of $[Zn(NH_3)_4]^{2+}$ are given as follows:

$$[Zn(NH_3)_4]^{2+} + H_2O \rightarrow Zn^{2+} + NH^{4+} + OH^- \quad (6)$$

$$Zn^{2+} + 2OH^- \rightarrow Zn(OH)_2 \quad (7)$$

$$Zn(OH)_2 \rightarrow ZnO(s) + H_2O$$ (SURESH KUMAR *et al.* 2008) (8)

When substrate is immersed in formed these solutions, these zinc complex ions get adsorbed surface of the substrate due to attractive force between ions in the solution and surface of the substrate. These forces may be cohesive forces or Van der Waals forces or chemical attractive forces (PATHAN and LOKHANDE 2004).

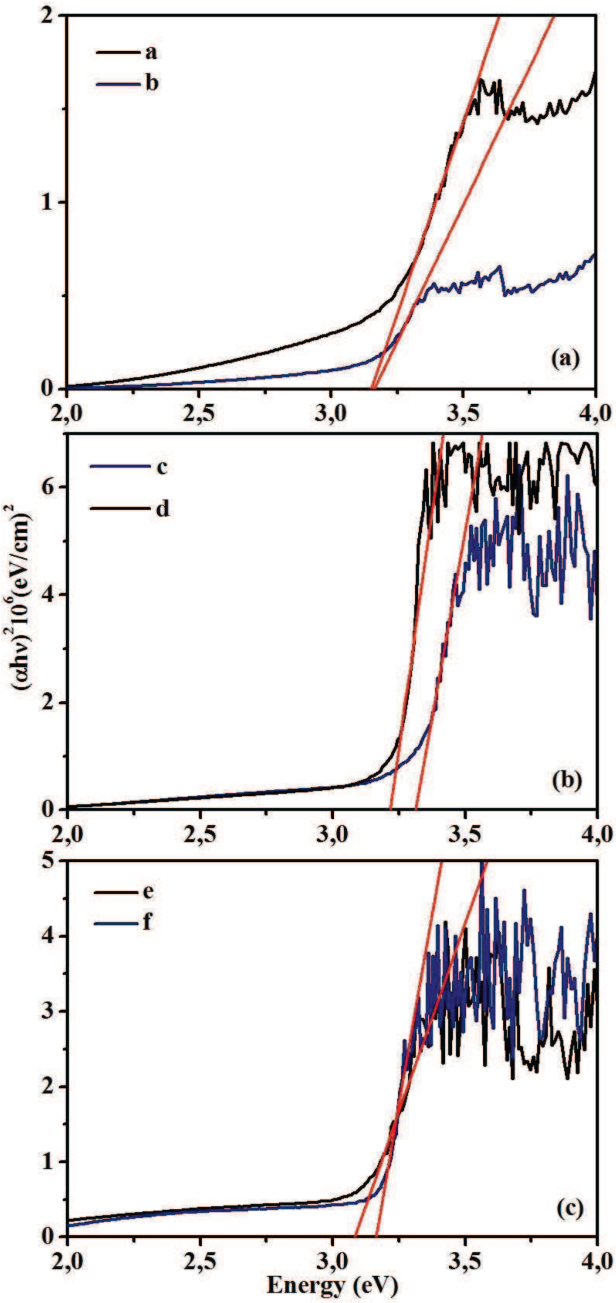

Fig. 1 (αhν)2 versus energy of respectively non-annealed and annealed prepared different solution ZnO
a) a non-annealed and b annealed with $ZnCl_2$
b) c non-annealed and d annealed with $Zn(NO_3)_2$
c) e non-annealed and f annealed with $ZnSO_4$

All samples to determine the effect of annealing were annealed at 200 degrees for 30 minutes. Thus prepared with different solutions ZnO semiconductor was observed after annealing for the change.

In order to get additional information about the effect of this particular heat treatment on the SILAR-grown ZnO thin films, we have calculated from the optical absorption of the grown structures before and after annealing.

According UV-vis absorption spectra collected of ZnO films absorption spectra measurements were converted of the absorption coefficient for observing variation optical band gap by the following equation,

$$(\alpha h\nu) = B(h\nu - E_g)^{1/2} \quad (9)$$

where α is absorption coefficient, E_g is optical band gap and B is constant (GOMEZ *et al*. 2005). Fig. 1 shows the variation of $(\alpha h\nu)^2$ versus energy. Table 1 shows varieties of band-gap of all samples. Fig.1 and Table 1. show that all films band gaps increased with annealing.

Table 1. Band gap values for ZnO thin films. (a non-annealed and b annealed with $ZnCl_2$, c non-annealed and d annealed with $Zn(NO_3)_2$, e non-annealed and f annealed with $ZnSO_4$)

Band-gap energies of same sample non-annealed and annealed (eV)			
Sample	a-b	c-d	e-f
Non-annealed	3.15	3.22	3.08
Annealed	3.17	3.31	3.16

The representative EDXRF patterns of ZnO thin films are shown in Fig. 2. The oxygen peaks isn't show because measurable elements are from sulfur to uranium of using EDXRF.

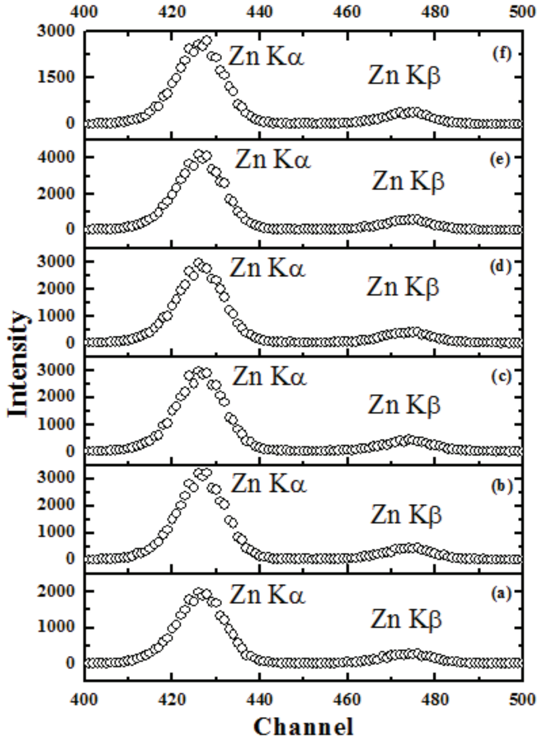

Fig. 2 EDXRF spectra of prepared different solution ZnO a) non-annealed with $ZnCl_2$ b) annealed with $ZnCl_2$ c) non-annealed with $Zn(NO_3)_2$ d) annealed with $Zn(NO_3)_2$ e) non-annealed with $ZnSO_4$ f) annealed with $ZnSO_4$

Wettability of all films was analyzed both non-annealed and annealed films. Fig. 3 and Table 2 show

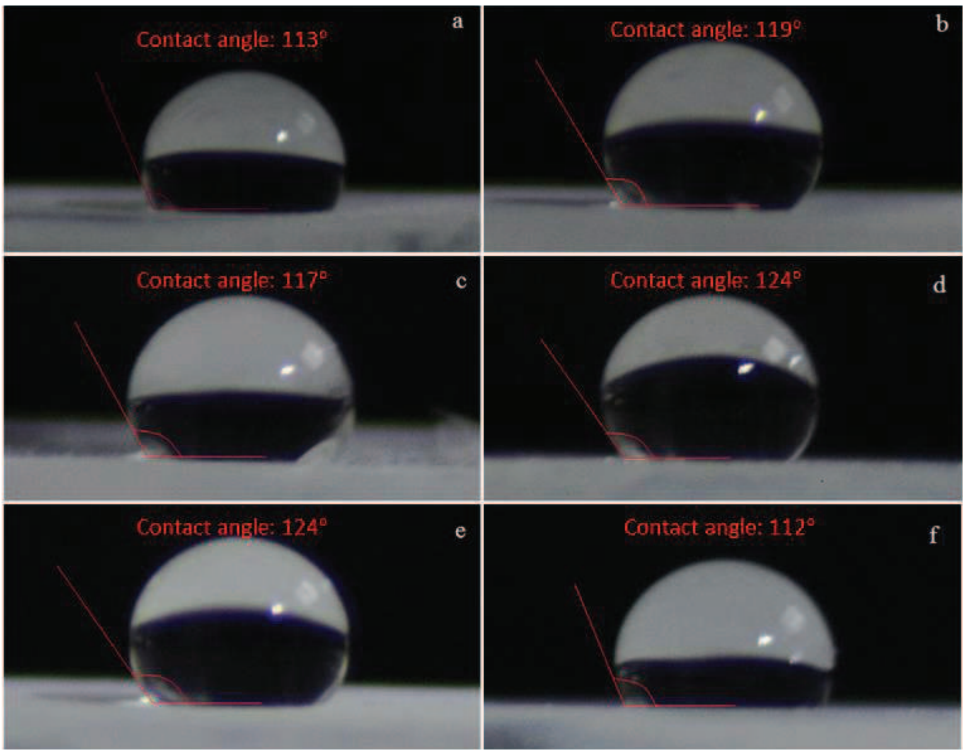

Fig. 3 Contact angles of prepared different solution ZnO a) non-annealed with $ZnCl_2$ b) annealed with $ZnCl_2$ c) non-annealed with $Zn(NO_3)_2$ d) annealed with $Zn(NO_3)_2$ e) non-annealed with $ZnSO_4$ f) annealed with $ZnSO_4$

that all films have repelling structures to water. Thus all films show hydrophobic properties. While after annealed a and c samples contact angles were increasing e sample decreasing.

Table 2. Contact angles values of ZnO films (a non-annealed and b annealed with $ZnCl_2$, c non-annealed and d annealed with $Zn(NO_3)_2$, e non-annealed and f annealed with $ZnSO_4$)

Contact angles of same sample non-annealed and annealed (degree)			
Sample	a-b	c-d	e-f
Non-annealed	113	117	124
Annealed	119	124	112

Thickness of ZnO films was calculated by the gravimetric weight difference method in terms of deposited weight of all films on the glass substrate, per unit area (g/cm^2). The thickness was calculated using formula,

$$T = \frac{M}{\rho A} \qquad (10)$$

where 'T' is film thickness, 'M' is mass of the film material in gm, 'A' is area of the film in cm^2 and ϱ is density of the film material (ϱ = 5.61 g/cm^3) (BULAKHE *et al.* 2013). Table 3 show that the thickness of all samples raised with annealed. These sources may be raising oxygen of ZnO structures as annealing.

Table 3. Thickness values of ZnO thin films a non-annealed and b annealed with $ZnCl_2$, c non-annealed and d annealed with $Zn(NO_3)_2$, e non-annealed and f annealed with $ZnSO_4$)

Thickness of same sample non-annealed and annealed (μm)			
Sample	a-b	c-d	e-f
Non-annealed	1.04	1.78	2.01
Annealed	1.11	2.01	2.15

Conductivity of all films was measured by hot probe method and each film shown n-type conductivity.

4. Conclusion

In summary, we have presented a simple SILAR method for the growth of non-annealed and annealed three different solutions ZnO nanostructure thin films on to glass substrates. Wettability property of all ZnO films was examined and clearly demonstrates the hydrophobic behavior. This SILAR method proved to be a simple and cost effective approach to prepare hydrophobic ZnO nanostructure thin films so these finds are significance for future self-cleaning application.

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Effects of some heavy metals on the activities of carbonic anhydrase enzymes from tumorous and non-tumorous human stomach

EMRAH YERLİKAYA[1], RAMAZAN DEMİRDAĞ[2], ÖMER İRFAN KÜFREVİOĞLU[3], CEMAL GÜNDOĞDU[4]

[1] Siirt University, School of Health, Siirt, Turkey
[2] Ağrı İbrahim Çeçen University, School of Health, Ağrı, Turkey
[3] Atatürk University, Science Faculty, Department of Chemistry, Erzurum, Turkey
[4] Atatürk University, Medical Faculty, Department of Medical Pathology, Erzurum, Turkey

Abstract

In this study, *in vitro* effects of certain heavy metals on the human carbonic anhydrase enzyme were examined. Inhibitory effects of metal ions (Pb^{2+}, Cu^{2+}, Fe^{2+}, Cr^{2+}, Al^{3+}, Ni^{2+}, Mn^{2+}, Cd^{2+}, Zn^{2+}, and Mg^{2+}) were observed in tumorous and non-tumorous tissue. IC_{50} values were calculated for metals. The Cu^{2+}, Zn^{2+}, Ni^{2+}, Cd^{2+} and Mg^{2+} IC_{50} values of tumorous tissue were calculated as 0.034 mM, 0.426 mM, 0.597 mM, 0.878 mM and 2.52 mM, respectively. The Cu^{2+}, Zn^{2+}, Ni^{2+}, Cd^{2+} and Mg^{2+} IC_{50} values of non-tumorous tissue were calculated as 0.067 mM, 0.991 mM, 1.065 mM, 1.724 mM and 6.13 mM, respectively. Carbonic anhydrase activity was measured as described by Wilbur and Anderson. Hydratase activity was used to determine IC_{50} values. In this study, tumorous and non-tumorous human stomach tissues were selected due to the fact that among the diseases, stomach cancer has one of the highest mortality rates. Stomach cancer, a type of cancer affecting the digestive system, is a fatal disease in living systems. The effects of metals on the CA enzyme were investigated due to the extremely important role that CA enzymes play in living beings.

Keywords: Carbonic anhydrase, heavy metals, tumorous, inhibition

1. Introduction

Gastric cancer is the fourth most common cancer in the world and the second leading reason for cancer-related death worldwide (WANG *et al*. 2011). Almost 3 million people are diagnosed with cancer in the digestive system and 2.2 million of those diagnosed die each year. Gastric cancer is the type of cancer with the highest mortality among cancers of the digestive system. Every year, more than 600.000 people die from gastric cancer (WINAVER 2005).

Carbonic anhydrase (CA: EC 4.2.1.1) is a common metaloenzyme that is found in the highest vertebrates, including humans. In the animal kingdom there are 16 isozymes of carbonic anhydrase. These include cytoplasmic isoenzymes (CA I, CA II, CA III, CA VII and CA XIII), mitochondrial (CA VA and CA VB); CA VI is found in saliva and milk, CA IV, IX, XII and XIV are membrane-bound, CA VIII, CAX and CA XI are non-catalytic. It has been clarified that there is no expression of CA XV in human beings and other primates, although it is plentiful in rodents and other higher vertebrates (WINAVER 2005; EKINCI *et al*. 2010; HILVO *et al*. 2005; EKINCI *et al*. 2007). One of the genes highly upregulated by hypoxia is that encoding CA IX. CA IX is a high activity tumor-associated membrane enzyme predominantly found in hypoxic tumor tissues being absent from most normal tissues except for a low level of expression in the gastrointestinal tract. CA IX was demonstrated to be a druggable target for the development of novel anticancer therapies and as a tumorous progression marker (OZENSOY and SUPURAN 2007). Metal ions occur naturally in the Earth's crust and are incorruptible and indestructible.

A small amount of these metals enter the body through food, drinking water and air. Trace elements such as heavy metals (eg copper, selenium, zinc) are necessary for the human body to maintain its natural metabolism. However, at higher concentrations they may be toxic (EKINCI *et al*. 2007; CEYHUN *et al*. 2011).

An important concern of environmental toxicology is the exposure to heavy metals. A large number of heavy metals are poisonous to humans, animals and plants. Humans face a significant risk of suffering from health hazards related to toxic metals as a result of bioaccumulation (HURA and HURA 2006). Human body accumulates heavy metals through the consumption of plants and this is an important pathway for the entry of toxic heavy metals into the human body. Some essential nutrients in the body can be seriously depleted by contaminated heavy metals and this is further

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Corresponding author:
Ramazan Demirdağ, PhD
Ağrı İbrahim Çeçen University,
School of Health, 04100, Ağrı, Turkey
Tel: +90-472 216 10 95
Fax: +90-472 215 11 47
E-mail: r.demirdag@hotmail.com

responsible for decreasing immunological defences, intrauterine growth retardation, impaired psychosocial faculties, disabilities associated with malnutrition and high prevalence of upper gastrointestinal cancer rates (ARORA *et al.* 2008). The objective of this study was to assess the effect of some heavy metals on carbonic anhydrase enzymes from non-tumorous and tumorous inflicted human stomach tissue.

2. Materials and methods

The homogenate was prepared according to the procedure outlined by DEMIRDAG *et al* (2012). Human gastric specimens of tumorous and remote non-tumorous locations were obtained from the Pathology Departments of the Research Hospital of Atatürk University after operation and stored at -80ºC until usage. 20 grams of thawed samples of the human gastric system were cut separately into small pieces with a knife and the fragments were homogenised with liquid nitrogen. The homogenate was taken to two volumes buffer solution (50mM Tris-HCl, pH=7.4) and 30 mL hexane was added to solution to solve the lipids. The homogenate was filtered through four layers of cheesecloth and then lipid fraction was removed from the homogenate using a Separatory Funnel. The homogenate was then centrifuged at 13.000 rpm for 1 hour and the pellet was discarded (DEMİRDAG *et al.* 2011). The homogenate was used for the determination of the effects of metals. All the purification steps were performed at 4°C.

2.1. Hydratase activity assay

Carbonic anhydrase hydratase activity was assayed by following the hydration of CO_2 according to the method described by Wilbur and Anderson (1948). CO_2-hydratase activity was calculated as an Enzyme Unit (EU) using the equation (t_0-t_c/t_c) where t_0 and t_c are the times for pH change of the non-enzymatic and the enzymatic reactions, respectively.

2.2. *In vitro* inhibition effect of heavy metals on enzyme activity

In this study, the activities of the effluents were defined by the hydratase method, in which CO_2 was used as the substrate. For Pb^{2+}, Cu^{2+}, Fe^{2+},Cr^{2+}, Al^{3+}, Ni^{2+}, Cd^{2+}, Zn^{2+}, and Mg^{2+} inhibition studies were performed using hydratase activity. All compounds were tested in triplicate at each concentration used. Different inhibitor concentrations were used. Control tube activity in the absence of inhibitor was taken as 100%. For each inhibitor an Activity%-[Inhibitor] graph was drawn. The curve-fitting algorithm allowed us to obtain the IC_{50} values (CEYHUN *et al.* 2011, DEMİRDAG *et al.* 2012). Regression analysis graphs were drawn for IC_{50} using inhibition % values by a statistical package (SPSS-for windows; version 10.0) on a computer (Student t-test; n: 3).

3. Results and Discussion

Up until this time a large number of authors have studied the effects of several substances including metals on CA enzyme activity (DEMIRDAG *et al.* 2012; SENTURK *et al.* 2012; EKINCI *et al.* 2012). The aim of this study was to determine the effects of heavy metals on the CA enzyme in tumorous and non-tumorous inflicted human stomach tissue. Enzyme activities are altered through a high level of chemical substances and drugs, which in turn affect the metabolism (EKINCI *et al.* 2012; KOZ *et al.* 2012). Chemicals are known to usually inhibit or activate certain body enzymes *in vivo* or *in vitro* and affect the metabolic pathways (CIFTCI *et al.* 2002; LUTZ *et al.* 1996).

Organic impurities and toxic heavy metals in the present era of technology found in water, air and soil contamination lead to a wide range of environmental and health problems. These impurities enter the human metabolism through the food chain and lead to bioaccumulation. Some metals such as copper, iron, manganese and zinc may be useful in small amounts for the metabolic pathways. For example, the zinc ion is an important metal for the CA of the active region. At the same time, the ion exists in some of the active sites of enzymes' such as sorbitol dehydrogenase. In addition to the well-known element iron is a vital element for the structure of haemoglobin. Conversely, if these metals in the metabolism of living creatures are found in high concentrations, the toxicological effects may be life-threatening and perhaps even fatal. In addition, some metals are not necessary for biological functions. They have toxic effects such as metals cadmium, lead and mercury (COBAN *et al.* 2007; LUTZ *et al.* 1996).

The inhibition effects of numerous substances such as medical drugs, various metals, anions and pesticides have been reported in literature. Normal enzyme activity is changed with high levels of chemicals and this affects the metabolism, particularly inhibition of specific enzymes and the effects can be both dramatic and systemic (RASPANTI *et al.* 2009; DEMIRDAG *et al.* 2011).

We report here the first study on the inhibitory effects of metal ions on tumorous and non-tumorous stomach tissue CA activity by hydratase method. The previous report by Ekinci *et al.*(2007), investigated metal ions (including Hg^{2+}, Co^{2+} and Pb^{2+}) by using esterase activity method, NPA hydrolysis assay for monitoring CA inhibition. DEMIRDAG *et al.*(2011) investigated the effects of certain metals on the activity in purified sheep liver tissue on CA II isozymes and they used both the esterase activity and hydratase activity method. K_i values for metals Zn^{2+}, Cu^{2+}, Cd^{2+} and Al^{3+} were calculated as 3.91 mM, 151 mM, 6.7 mM and 1.34 mM, respectively using the esterase activity method. IC_{50} values for metals Zn^{2+}, Cu^{2+}, Cd^{2+}, Co^{2+} and Ni^{2+} were found to be 0.058 mM, 0.00041 mM, 0.66 mM, 0.75 mM and 1.44 mM, respectively with the method of hydratase activity.

In this study, tumorous and non-tumorous homogenate human stomach tissues were prepared and the effects of certain heavy metals on the CA enzyme were examined. According to this study (Table 1), heavy metals were found to inhibit the enzyme cancerous tissue at much lower concentrations.

Heavy metals inhibition of the enzyme found that tumorous tissues have approximately two fold lower concentrations than non-tumorous tissues. When it comes to a live subject matter of the enzyme metabolism of CA and importance will be understood to have more adverse effects on heavy metals and cancer patients. This study shows that heavy metals in cancerous patients inhibit the CA enzyme at a much lower concentrations. Although it is impossible to avoid the effects from the metals in this technological age, cancer patients are recommended to stay away from heavy metals.

Table 1. Inhibition values for some metal ions of tumorous CA, non-tumorous CA, hCA I, and hCA II.

Type of metals	For tumorous tissue average values of IC_{50} (mM)	For non-tumorous tissue average values of IC_{50} (mM)	Human CA I values of K_i (mM)[a]	Human CA II values of K_i (mM)[a]
Cu^{2+}	0.034 ±0.00036*	0.067±0.0014*	0.90	0.16
Zn^{2+}	0.426±0.00042	0.991±0.023	4.41	2.78
Ni^{2+}	0.597±0.00049	1.065±0.014	-	-
Cd^{2+}	0.878±0.0015	1.724±0.029	2.18	0.24
Mg^{2+}	2.52±0.063	6.13±0.116	-	-

Mean from at least three determinations. * $P > 0.1$ vs. control, Student's *t* test. (n=3)

[a] From Ref. 23.

In this study cancerous human stomach and non-cancerous tissues were selected due to the fact that cancer has one of the highest mortality rates among diseases. Inhibitor effects of metals examined under *in vitro* conditions. For each inhibitor IC_{50} values were defined. Inhibitory effects of Cu^{2+}, Zn^{2+}, Ni^{2+}, Cd^{2+} and Mg^{2+} metals were observed in both tumorous and non-tumorous tissue. IC_{50} values were calculated for every metal. Cu^{2+}, Zn^{2+}, Ni^{2+}, Cd^{2+} and Mg^{2+} IC_{50} values of non-tumorous tissue were calculated as 0.067, 0.991, 1.065, 1.724, and 6.13 mM, respectively. Cu^{2+}, Zn^{2+}, Ni^{2+}, Cd^{2+} and Mg^{2+} IC_{50} values of tumorous tissue were calculated as 0.034, 0.426, 0.597, 0.878 and 2.52 mM, respectively. However, any inhibition effect for Pb^{2+}, Fe^{2+}, Cr^{2+} and Al^{3+} metals were not detected in both tumorous and non-tumorous tissues.

According to the data, we found that metal ions had an inhibition at a lower concentration on the enzyme CA from tumorous tissue than that of non-tumorous tissue. In this study we showed that metals had toxic effects in lower concentrations in cancerous tissues. People are constantly exposed to metals in different ways. In the present study, we can conclude that metals, especially in patients that are suffering from cancer, have negative effects on health.

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Fight of Benefit: There isn't the writers fight of benefit.

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Further instability result on the solutions of nonlinear vector differential equations of the fifth order

MELİKE KARTA[1]

[1] Ağrı İbrahim Çeçen University, Faculty of Science and Arts, Department of Mathematics, Ağrı,

Abstract

The purpose of this paper is to investigate instability of the trivial solution of non-linear vector differential equation of the fifth order of the form

$$X^{(5)} + AX^{(4)} + B\dddot{X} + \Psi(X, \dot{X}, \ddot{X}, \dddot{X}, X^{(4)})\ddot{X}$$

$$+G(X)\dot{X} + F(X, \dot{X}, \ddot{X}, \dddot{X}, X^{(4)})X = 0$$

by constructing a Lyapunov function.

Keywords: Instability, Lyapunov function, nonlinear differential equation.

1. Introduction

Instability of the trivial solution of scalar and vector differential equations of the fifth order were investigated by many authors. About the topic, we refer to the papers of (EZEILO 1978; EZEILO 1979; TIRYAKI 1987; LI and YU 1990; LI and DUAN 2000; SADEK 2003; TUNC 2004; TUNC 2005; TUNC and SELVI 2005; TUNC and KARTA 2008; KRASOVSKII 1955). In all of the papers mentioned above, authors used Krasovskii's criteria (KRASOVSKII 1955) and Lyapunov's second (or direct) method (LYAPUNOV 1966).

According to observations in the literature, firstly, for the case $n = 1$, EZEILO (1978; 1979) investigated the instability of trivial solution of the fifth order scalar non-linear differential equations, respectively,

$$x^{(5)} + a_1 x^{(4)} + a_2 \dddot{x}$$

$$+a_3 \ddot{x} + a_4 \dot{x} + f(x) = 0,$$

$$x^{(5)} + a_1 x^{(4)} + a_2 \dddot{x}$$

$$+h(\dot{x})\ddot{x} + g(x)\dot{x} + f(x) = 0,$$

$$x^{(5)} + \psi(\ddot{x})\dddot{x} + \varphi(\ddot{x}) + \theta(\dot{x}) + f(x) = 0,$$

and

$$x^{(5)} + a_1 x^{(4)} + a_2 \dddot{x} + g(\dot{x})\ddot{x}$$

$$+h(x, \dot{x}, \ddot{x}, \dddot{x}, x^{(4)})\dot{x} + f(x) = 0$$

in which a_1, a_2, a_3, a_4, are constants and f, g, h, ψ, ϕ and θ are continuous functions depending only on the arguments shown as $f(0) = \phi(0) = \theta(0) = 0$. TIRYAKI (1987) studied the instability of trivial solution of the fifth order non-linear scalar differential equation of the form

$$x^{(5)} + a_1 x^{(4)} + k(x, \dot{x}, \ddot{x}, \dddot{x}, x^{(4)})\dddot{x} + g(\dot{x})\ddot{x}$$

$$+h(x, \dot{x}, \ddot{x}, \dddot{x}, x^{(4)})\dot{x} + f(x) = 0.$$

LI and YU (1990) concerned the instability of trivial solution of the fifth order non-linear scalar differential equation

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Corresponding author:
Melike Karta, PhD
Ağrı İbrahim Çeçen University,
Department of Mathematics, 04100, Ağrı, Turkey
Tel: +90-472 215 98 94/4132
Fax: +90-472 215 65 54
E-mail: melike_karta2010@hotmail.com

$$x^{(5)} + ax^{(4)} + b\dddot{x} + \psi(x, \dot{x}, \ddot{x}, \dddot{x}, x^{(4)})\ddot{x}$$

$$+g(x)\dot{x} + f(x) = 0$$

by introducing a Lyapunov function, where a and b are some positive constant.

LI and DUAN (2000) showed the instability of trivial solution of the fifth order nonlinear scalar differential equation of the for

$$\dot{x}_i = x_{i+1}\ (i = 1,2,3,4)$$

$$\dot{x}_5 = -f_5(x_4)x_5 - f_4(x_3)x_4$$

$$-f_3(x_1, x_2, x_3, x_4, x_5)x_3 - f_2(x_2) - f_1(x_1)$$

$$(f_2(0) = f_1(0) = 0)$$

and

$$\dot{x}_i = x_{i+1}(i = 1,2,3,4)$$

$$\dot{x}_5 = -a_5x_5 - f_4(x_1, x_2, x_3, x_4, x_5)x_4$$

$$-f_3(x_2)x_3 - f_2(x_1, x_2, x_3, x_4, x_5)x_2 - f_1(x_1)$$

(1.1)

On the other hand, SADEK (2003) examined the instability of trivial solutions of the fifth order vector differential equations described as

$$X^{(5)} + \Psi(\ddot{X})\dddot{X} + \Phi(\ddot{X}) + \theta(\dot{X}) + F(X) = 0$$

and

$$X^{(5)} + AX^{(4)} + B\dddot{X} + \mathrm{H}(\dot{X})\ddot{X}$$

$$+G(X)\dot{X} + F(X) = 0.$$

In addition, respectively, TUNC (2004; 2005) investigated the instability of trivial solution of the fifth order vector differential equations of the form

$$X^{(5)} + AX^{(4)} + \Psi(X, \dot{X}, \ddot{X}, \dddot{X}, X^{(4)})\dddot{X}$$

$$+G(\dot{X})\ddot{X} + H(X, \dot{X}, \ddot{X}, \dddot{X}, X^{(4)})\dot{X} + F(X) = 0,$$

$$X^{(5)} + AX^{(4)} + B(t)(X, \dot{X}, \ddot{X}, \dddot{X}, X^{(4)})\dddot{X}$$

$$+C(t)G(\dot{X})\ddot{X} + D(t)(X, \dot{X}, \ddot{X}, \dddot{X}, X^{(4)})\dot{X}$$

$$+E(t)F(X) = 0$$

and

$$X^{(5)} + \Psi(\dot{X}, \ddot{X})\dddot{X} + \Phi(\dot{X}, \ddot{X}, \dddot{X}, X^{(4)})$$

$$+\theta(\dot{X}) + F(X) = 0.$$

TUNC and SEVLI (2005) showed a similar study for the instability of trivial solution of the fifth order vector differential equation

$$X^{(5)} + \Psi(\dot{X}, \ddot{X})\dddot{X} + \Phi(X, \dot{X}, \ddot{X})\ddot{X}$$

$$+\theta(\dot{X}) + F(X) = 0.$$

Furthermore, TUNC and KARTA (2008) analyzed sufficient conditions which ensure the trivial solution of vector differential equation

$$X^{(5)} + AX^{(4)} + B\dddot{X} + \Psi(X, \dot{X}, \ddot{X}, \dddot{X}, X^{(4)})\ddot{X}$$

$$+G(X)\dot{X} + F(X)X = 0$$

by introducing a Lyapunov function, where A and B are constant $n \times n$ −symmetric matrices; Ψ, G and F are $n \times n$ − symmetric continuous matrix functions depending, in each case, on the arguments shown.

This article is a generalized version of the study produced by TUNC and KARTA (2008). In this study, the results constituted give additional the result to those obtained by TUNC and KARTA (2008) for equation

$$X^{(5)} + AX^{(4)} + B\dddot{X} + \Psi\left(X, \dot{X}, \ddot{X}, \dddot{X}, X^{(4)}\right)\ddot{X}$$

$$+G(X)\dot{X} + F(X)X = 0 \qquad (1.2)$$

in the real Euclidean space $\mathbb{R}^n$ (with the usual norm denoted in what follows by $\|.\|$), in which $X \in \mathbb{R}^n$; A and B are constant $n \times n$-symmetric matrices; Ψ, F and G are $n \times n -$ symmetric continuous matrix functions depending, in each case, on the arguments shown. Let $J_G(X)$ display the Jacobian matrix corresponding to the function $G(X)$ that is,

$$J_G(X) = \left(\frac{\partial g_i}{\partial x_j}\right), \text{(i,j=1,2,…,n)}$$

in which $(x_1, x_2, \ldots, x_n)$ and $(g_1, g, \ldots, g_n)$ are the components of $X$and G, respectively. In addition, it is assumed, as basic throughout the paper, that Jacobian matrix $J_G(X)$ exist and is continuous and symmetric. The symbol $\langle X, Y\rangle$ corresponding to any pair X, Y in $\mathbb{R}^n$ stands for the usual scalar product $\sum_{i=1}^{n} x_i y_i$ and the matrix $A = \left(a_{ij}\right)$ is said to be positive definite if and only if the quadratic form $X^T AX$ is positive definite, where $X \in \mathbb{R}^n$ and X^T denotes the transpose of X.

Throughout this paper, we consider the following differential systems which are equivalent to the equation (1.2) which was attained as usual by setting $\dot{X} = Y, \ddot{X} = Z, \dddot{X} = W, X^{(4)} = U$ from (1.2):

$$\dot{X} = Y, \dot{Y} = Z, \dot{Z} = W, \dot{W}\dot{U} = -AU - BW$$

$$-\Psi(X, Y, Z, W, U)Z - G(X)Y -$$

$$\mathrm{F}(X, Y, Z, W, U)X. \qquad (1.3)$$

However, with respect to our observations in the literature, even though many papers have been reviewed, there are a few examples about the subject. Therefore, we give an example to indicate the importance of the topic.

2. Main result

Our main result is the following theorem.

Theorem 2.1. In addition to the basic conditions given above for coefficients A, B, Ψ, F and G of (1.2) equation, it is assumed that A and $J_G(X)$ are symmetric matrices and there are constants a, b and a positive constant k_1 such that the following conditions provide:

(i) $\lambda_i(A) > a,\ \lambda_i(B) \geq b,$

$bsgna > 0; \quad (i = 1,2, \ldots, n)$

(ii) $\lambda_i\big(F(X, Y, Z, W, U)\big)sgna$

$-\frac{1}{4|a|}\left[\lambda_i\big(\Psi(X, Y, Z, W, U)\big)\right]^2 > k_1$

$(i = 1,2, \ldots, n)$

Then trivial solution $X = 0$ of (1.2) is instability.

Now, in order to prove main result, we use the following lemma.

Lemma2.2. Let A be a real symmetric $n \times n -$matrix and

$$a^{\iota} \geq \lambda_i(A) \geq a > 0 \quad ,(i = 1,2, \ldots, n) \quad (2.1)$$

in which a^{ι}, a are constants.

Then

$$\langle X, X\rangle \geq \langle AX, X\rangle \geq a\langle X, X\rangle,$$

$$a^{\iota^2}\langle X, X\rangle \geq \langle AX, AX\rangle \geq a^2\langle X, X\rangle. \quad (2.2)$$

See HORN (1994) for proof.

Proof of Theorem 2.1. As basic tool for proof of Theorem (2.1), we will use Lyapunov function $V(X, Y, Z, W, U)$ given as

$$V = V_0(X, Y, Z, W, U)sgna \qquad (2.3)$$

in which

$$V_0 = \langle Y, W\rangle + \langle Y, AZ\rangle - \langle X, U\rangle$$

$$-\langle X, AW\rangle - \langle X, BZ\rangle - \frac{1}{2}\langle Z, Z\rangle$$

$$+\frac{1}{2}\langle BY,Y\rangle-\int_0^1\langle\sigma G(\sigma X)X,X\rangle d\sigma \quad (2.4)$$

under the conditions of Theorem 2.1, it will be indicated that the Lyapunov function $V(X,Y,Z,W,U)$ satisfies the entire KRASOVSKII (1955) criteria:

(K_1) In every neighborhood of (0,0,0,0,0), there exists a point $(\xi,\eta,\varsigma,\mu,\rho)$ such as $V\ (\xi,\eta,\varsigma,\mu,\rho)>0$.

(K_2) The time derivative $\dot{V}=(\frac{d}{dt})V(X,Y,Z,W,U)$ along solution paths of system (1.3) is positive semidefinite.

(K_3) The only solution

$$V(X,Y,Z,W,U)$$

$$=(X(t),Y(t),Z(t),W(t),U(t))$$

of system (1.3) which satisfies $\dot{V}=0\ (t\geq 0)$ is the trivial solution (0,0,0,0,0). These properties guarantee that the trivial solution of (1.2) is unstable. It is clear from (2.3) and (2.4) that V_1(0,0,0,0,0)=0. Additionally, it is easy to see that

$$V(0,\varepsilon,sgna,0,\varepsilon,0)$$

$$=\|\varepsilon\|^2+\frac{1}{2}bsgna\|\varepsilon\|^2>0$$

for all arbitrary $\varepsilon\neq 0,\varepsilon\in\mathbb{R}^n$. If this happens, it displays (K_1) feature of Krasoskii (1955). Let

$$(X,Y,Z,W,U)=$$

$$\big(X(t),Y(t),Z(t),W(t),U(t)\big)$$

be an arbitrary solution of system (1.3). Differentiating (2.3) with respect to t, along this solution, taking into account the conditions of the Theorem 2.1, we obtain

$$\dot{V}_0=\langle AZ,Z\rangle+\langle F(X,Y,Z,W,U)X,X\rangle$$

$$+\langle X,\Psi(X,Y,Z,W,U)Z\rangle. \quad (2.5)$$

It follows from (2.3) and (2.7) that

$$\dot{V}=sgna\langle Z,AZ\rangle$$

$$+\,sgna\langle X,F(X,Y,Z,W,U)X\rangle$$

$$+sgna\langle X,\Psi(X,Y,Z,W,U)Z\rangle$$

$$\geq|a|\langle Z,Z\rangle+sgna\langle X,F(X,Y,Z,W,U)X\rangle$$

$$+sgna\langle X,\Psi(X,Y,Z,W,U)Z\rangle$$

$$=|a|\left\|Z+\frac{1}{2|a|}\Psi(X,Y,Z,W,U)Xsgna\right\|^2$$

$$+\Big[sgna\langle X,F(X,Y,Z,W,U)X\rangle$$

$$-\frac{1}{4|a|}\langle\Psi(X,Y,Z,W,U)X,\Psi(X,Y,Z,W,U)X\rangle\Big]$$

$$\geq\Big[sgna\langle X,F(X,Y,Z,W,U)X\rangle$$

$$-\frac{1}{4|a|}\langle\Psi(X,Y,Z,W,U)X,\Psi(X,Y,Z,W,U)X\rangle\Big]$$

$$\geq k_1\|X\|^2 \quad (2.6)$$

by (i) and (ii).

Taking into account the conditions of the Theorem 2.1, we deduce from (2.8) that $\dot{V}(t)\geq 0$ for all $t\geq 0$, that is, $\dot{V}$ is positive semi-definite. This shows that (K_2) feature of KRASOVSKII (1955) is satisfied. Furthermore, $\dot{V}=0(t\geq 0)$ necessarily implies that $X=0$ for all $t\geq 0$, and also $,Z=\dot{Y}=0,W=\ddot{Y}=0,\dot{W}=\dddot{Y}=0,$ for all $t\geq 0$.Thus, it follows that estimates

$$X=Y=Z=W=U=0 \text{ for all } t\geq 0.$$

If this happens, it shows (K_3) feature of KRASOVSKII (1955) is satisfied. As a result, taking into account the conditions of Theorem 2.1, the function V ensures the entire the criteria of KRASOVSKII (1955). Thus, the fundamenta properties of the function $V(X,Y,Z,W,U)$,which were proved above imply that the zero solution of systen (1.3) is unstable. The system (1.3) is equivalent to the differential equation (1.2). Therefore, the proof of Theorem (2.1) is complete.

Now, we give an example for Theorem (2.1).

Example:

As special cases of system (1.3), if we take for $n = 2$,

$$A = \begin{bmatrix} 3 & 2 \\ 2 & 3 \end{bmatrix}, A = \begin{bmatrix} 2 & -1 \\ -1 & 2 \end{bmatrix},$$

$$\Psi = \begin{bmatrix} 1 & -\frac{1}{1 + {x_1}^2 + {y_1}^2} \\ -\frac{1}{1 + {x_1}^2 + {y_1}^2} & 1 \end{bmatrix}$$

$$\Psi = \begin{bmatrix} {x_1}^2 + {y_1}^2 + {z_1}^2 & 1 \\ 1 & {x_1}^2 + {y_1}^2 + {z_1}^2 \end{bmatrix},$$

$$G = \begin{bmatrix} {x_1}^2 + {x_1}^2 & {x_1}^2 \\ {x_1}^2 & {x_1}^2 + {x_1}^2 \end{bmatrix}$$

Then, respectively, we have

$$\lambda_1(A) = 1, \quad \lambda_2(A) = 5,$$

$$\lambda_1(B) = 1, \quad \lambda_2(B) = 3,$$

$$\lambda_1(\Psi) = \frac{{x_1}^2 + {y_1}^2}{\mathbf{1} + {x_1}^2 + {y_1}^2},$$

$$\lambda_2(\Psi) = \frac{2 + {x_1}^2 + {y_1}^2}{1 + {x_1}^2 + {y_1}^2}$$

$$\lambda_1(F) = {x_1}^2 + {y_1}^2 + {z_1}^2 + 3,$$

$$\lambda_1(F) = {x_1}^2 + {y_1}^2 + {z_1}^2 + 5$$

$$\lambda_1(G) = {x_1}^2, \quad \lambda_2(G) = 2{x_1}^2 + {x_2}^2$$

Hence, following inequalities are obtained:

(i) $\lambda_1(A) > 1,\ \lambda_2(B) \geq 1,\ bsgna > 0$

and

$$\lambda_1(F) - \frac{1}{4}\lambda_1(\Psi)^2$$

$$= {x_1}^2 + {y_1}^2 + {z_1}^2 + 3 - \frac{1}{4}\frac{({x_1}^2 + {y_1}^2)^2}{(1 + {x_1}^2 + {y_1}^2)^2}$$

$$= \frac{4({x_1}^2 + {y_1}^2 + {z_1}^2 + 3)(1 + {x_1}^2 + {y_1}^2)^2}{4(1 + {x_1}^2 + {y_1}^2)^2}$$

$$- \frac{({x_1}^2 + {y_1}^2)^2}{4(1 + {x_1}^2 + {y_1}^2)^2} > 0$$

$$\lambda_2(F) - \frac{1}{4}\lambda_2(\Psi)^2$$

$$= {x_1}^2 + {y_1}^2 + {z_1}^2 + 5 - \frac{1}{4}\frac{(2 + {x_1}^2 + {y_1}^2)^2}{(1 + {x_1}^2 + {y_1}^2)^2}$$

$$= \frac{4({x_1}^2 + {y_1}^2 + {z_1}^2 + 5)(1 + {x_1}^2 + {y_1}^2)^2}{4(1 + {x_1}^2 + {y_1}^2)^2}$$

$$- \frac{(2 + {x_1}^2 + {y_1}^2)^2}{4(1 + {x_1}^2 + {y_1}^2)^2} > 0$$

$$\lambda_2(G) - \frac{1}{4}\lambda_2(\theta)^2$$

$$= {x_1}^2 + {y_1}^2 + 1 - \frac{1}{4}\frac{\left(2{x_1}^2 + 2{y_1}^2\right)^2}{(1 + {x_1}^2 + {y_1}^2)^2}$$

$$= \frac{4({x_1}^2 + {y_1}^2 + 1)(1 + {x_1}^2 + {y_1}^2)^2}{4(1 + {x_1}^2 + {y_1}^2)^2}$$

$$- \frac{\left(2{x_1}^2 + 2{y_1}^2\right)^2}{4(1 + {x_1}^2 + {y_1}^2)^2} > 0$$

$$\lambda_2(G) - \frac{1}{4}\lambda_2(\theta)^2$$

$$= {x_1}^2 + {y_1}^2 + 3$$

$$- \frac{1}{4}\frac{\left(4 + 2{x_1}^2 + 2{y_1}^2\right)^2}{(1 + {x_1}^2 + {y_1}^2)^2}$$

$$= \frac{4({x_1}^2 + {y_1}^2 + 3)(1 + {x_1}^2 + {y_1}^2)^2}{4(1 + {x_1}^2 + {y_1}^2)^2}$$

$$- \frac{\left(4 + 2{x_1}^2 + 2{y_1}^2\right)^2}{4(1 + {x_1}^2 + {y_1}^2)^2} > 0$$

Clearly, these last expressions imply that

$$\lambda_i\big(F(X,Y,Z,W,U)\big)sgna$$

$$- \frac{1}{4|a|}\left[\lambda_i\big(\Psi(X,Y,Z,W,U)\big)\right]^2 > k_1$$

$$(i = 1,2)$$

Thus, it is shown that all the assumptions of theorem (2.1) are provided.

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3-People non-zero-sum games and geometric presentation on game theory

ÇİĞDEM İNCİ KUZU[1] and BÜLENT KARAKAŞ[2]

[1] Ağrı İbrahim Çeçen University, Faculty of Education, Ağrı, Turkey
[2] Yüzüncü Yıl University, Faculty of Economics and Administrative Sciences, Van, Turkey

Abstract

The game theory that provides us an optimum decision option in such a position an interaction decision is given takes place more often both in our daily life and business life. The interest in this issue is increasing when the consistency between the results of the application and application territory is seen. It will be seen that we come close to a period that theory will be used more often.

In this research it has been given fundamental concept of game theory and it has been given examples on-non sum-zero game that is for three people.

Keywords: Game theory, strategy

1. Introduction

The biggest problem that the business management encounters is the process of deciding in economic field. So, the decisions made by the businesses as producers or consumers directly affect the production or consumption types. Businesses generally aim to reach the prudential targets they have determined depending on their internal conditions in the process of deciding. The businesses, thus, choose to predict the future with the data obtained through previous periods and with the quantitative deciding techniques such as mathematical programming (Operations research), cross section data regression models, time series trend analysis in the process of deciding.

In these methods, the mutual interactions between the variables are not mostly considered or it is accepted that this is reflected in the models formed automatically. Besides, several difficulties are experienced in the addition of many socio-economic variables to the model in the results obtained from these mentioned quantitative variables (OZDIL 1998).

Game theory is a powerful managerial tool as it provides a beginning for the solution in the process of complex interactive decision making. Game theory gives the answer to the question "What should be the optimal strategy in the purpose of minimization if the loss in question, or maximization if the gain in question?" for the competitive decision-maker no matter what strategy the opponent play. In this field, the game theory can provide a good score in making economic decisions in the economic markets where competition takes place. The game theory is a mathematical approach that analyzes the deciding process considering the deciding process of the opponents in clash environments. The question "Without knowing which behavior the opponents will choose, what should be the most rational behavior to make positive move decisions" caused this theorem to be raised. Thus, the Game Theory is a mathematical approach that explains the struggle of the complex wheels (OZDIL 1998).

To meet the analysis needs of conflict situations, special mathematical techniques named as theory of games have been developed. The purpose of this theory is to analyze the most rational movement ways of the both parties which are against each other. As there are several factors, real life conflict situations are extremely complex and quiet hard to be analyzed. Hence, to make a mathematical analyzes possible, we need to remove base factors and create simplified models. These models are called games (VENTSELL 1965).

The purpose of this study is to bring a solution method to the 3-player non-zero-sum games.

2. Material and method

Geometric method which was developed by Ventsell for two-player *2x2* games was used in the development of geometric method for 3-player non-zero-sum games (VENSTELL 1965).

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Corresponding author:
Çiğdem İNCİ KUZU
Ağrı İbrahim Çeçen University,
Faculty of Education
04100, Ağrı – TURKEY
Tel: + 0472 216 20 35
Fax: + 0472 215 20 36
E-mail: cigdem253165@hotmail.com

2.1. The geometric method for 2x2 games

For the solution of a *2x2* game, a simple geometric interpretation can be given. The *2x2* game whose matrix can be seen on the side is considered and the diagram below is drawn on *xy* plane. Our strategy is shown on *x* axis. A_1 strategy is indicated with x=0 and A_2 is indicated with $x=1$. I and II perpendiculars are drawn from A_1 and A_2 points. For A_1 strategy, the gains are marked on I axis, and for A_2 strategy they are marked on II axis.

Table 2.1. B_1 and B_2 strategies.

A/B	B_1	B_2
a_1	a_{11}	a_{12}
a_2	a_{21}	a_{22}

First of all, it is accepted that our opponent uses B_1 strategy. This defines a point whose ordinate is a_{11} on I-I and a point whose ordinate is a_{21} on II.

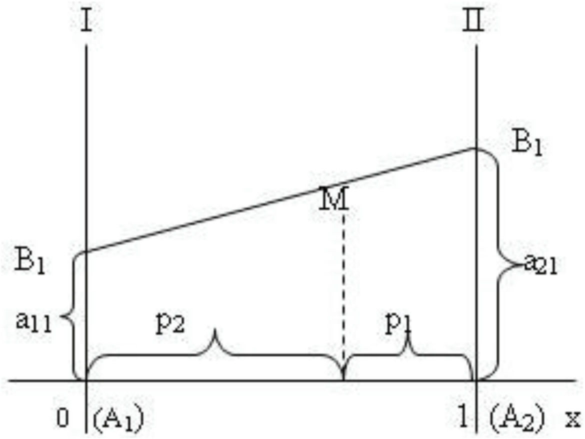

Figure 2.1. The geometric drawing for 2x2 game (VENSTELL 1965).

These points define B_1B_1 line. If we use

$$S_A = \begin{pmatrix} A_1 & A_2 \\ p_1 & p_2 \end{pmatrix}$$

the mixed strategy against our opponent's B_1 strategy

$$a_1 \, p_1 + a_2 \, p_2$$

The average gain is given with the ordinate of *M* point whose abscissa is p_2 on B_1 B_1 line. We will call B_1 B_1 line as B_1 which shows the gains for B_1 strategy. B_2 strategy is drawn completely the same.

We want to find a S_A^* optimal strategy, that is, in this strategy, minimum gain will be maximum gain for any B_1 strategy. To do this, lower bound is drawn for B_1 and

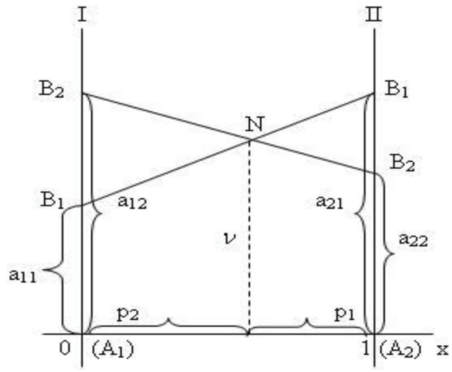

Figure 2.2. The geometric drawing for 2x2 game (VENSTELL, 1965).

B_2 strategies. This lower bound provides minimum gains for our all mixed strategies. The *N* point in which this minimum becomes maximum is the solution of the game.

The reasons of these drawing can be seen clearly from the general figure below. Here;

$$\frac{m - a_{11}}{p_2} = \frac{a_{21} - a_{11}}{p_1 + p_2}$$

or

$$m = \frac{a_{11}p_1 + a_{21}p_2}{p_1 + p_2}$$

When $p_1+p_2=1$, $m=a_{11}p_1+a_{21}p_2=v$

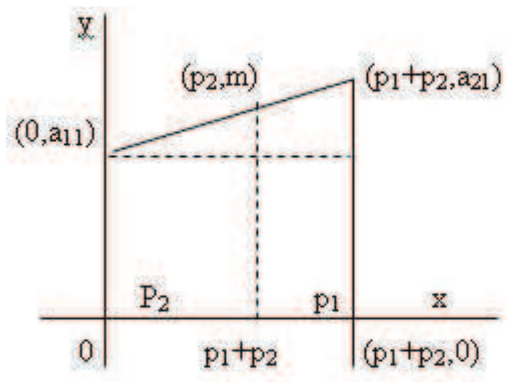

Figure 2.3. The geometric drawing for *2x2* game (VENSTELL 1965).

defines both the solution and the values. The ordinate of the *N* point is the *v* value of the game. P_2 abscissa is the fraction of A_2 strategy in our S_A^* optimal mixed strategy.

For the situation which can be seen below, it is defined with the intersection point of the solution strategies. However, the solution is not always in this point.

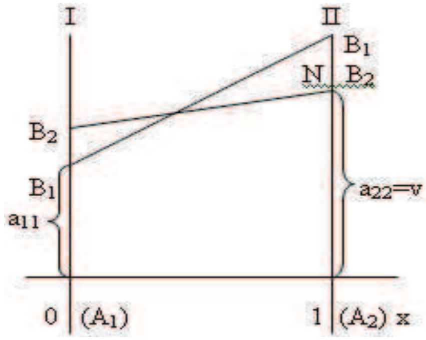

Figure 2.4. The geometric drawing for 2x2 game (VENSTELL 1965).

In the situation seen in Figure 2.4, the strategies intersect and the solution of the game is a simple strategy for each player (A_2 and B_2) and the value of the game is $v=a_{22}$. Thus, the game has a saddle point and A_2 strategy dominates A_1 strategy. No matter which strategy the opponent uses, using A_1 strategy would provide a smaller amount of gain than the A_2 strategy would provide.

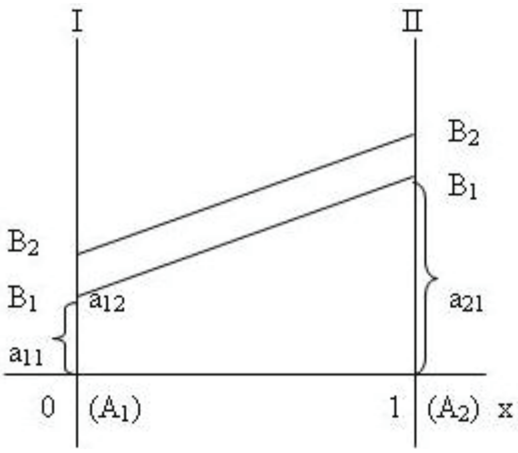

Figure 2.5. The geometric drawing for 2x2 game (VENSTELL 1965).

For the situation in which the opponent has a dominant strategy, the diagram has the figure as seen above. In this situation, lower bound is B_1 strategy which is dominant on B_2.

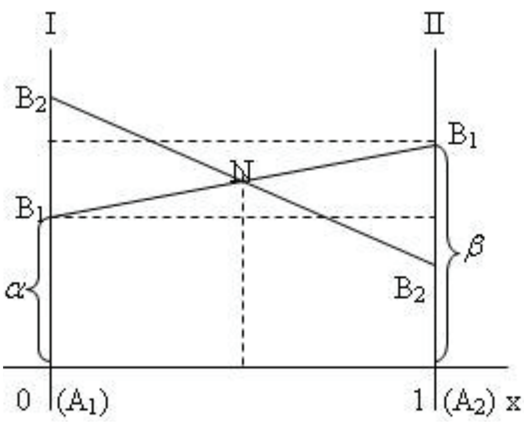

Figure 2.6. The geometric drawing for 2x2 game (VENSTELL 1965).

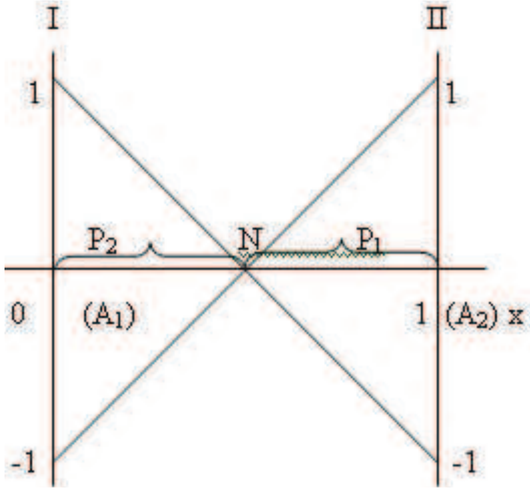

Figure 2.7. The geometric drawing for 2x2 game (VENSTELL 1965).

α lower values and *β* higher value of a game can be found from a geometric diagram.

This geometric method is further explained by giving diagrams for *2x2* games.

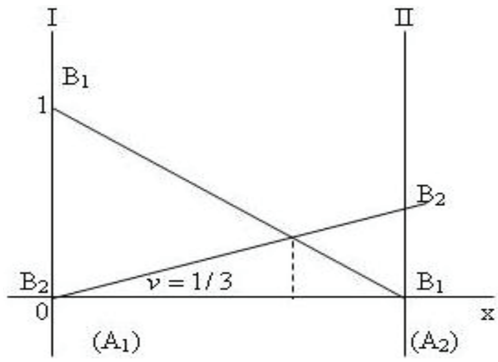

Figure 2.8. The geometric drawing for 2x2 game (VENSTELL 1965).

3. Results

3.1. 3-player non-zero-sum games and geometric presentation

We saw that any two-player game can be solved by using a simple coordinate system. We can also solve non-zero-sum games in which the number of the players becomes 3 by using the same general method by drawing it on the Cartesian coordinate system.

Let's assume that there are three sides as *A, B, C* in a non-zero-sum game. Let's consider a game in which

A's A_1, A_2 …………… A_m as *m*

B's B_1, B_2 …………… B_n as *n*

C's C_1, C_2 …………… C_k as *k*

strategies and for each strategy trinity the drawing below is drawn.

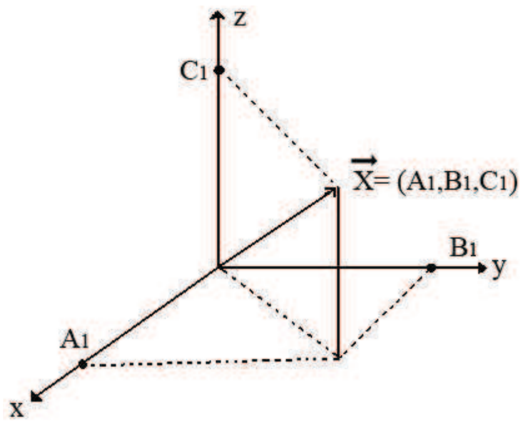

Figure 3.1. The coordinate plane for 3-player games

First of all, let's assume that A uses A_1 strategy, B uses B_1 strategy and C uses C_1 strategy.

This; for

$A = (A_1,0,0)$ $B = (0,B,0)$ $C = (0,0,C)$

can be written as. $\vec{X} = (A_1, B_1, C_1)$.

In the zero-sum games, even though the gain matrixes are always written by A, separate gains are written for each side in non-zero-sum games. The solution of the game is the strategy in which the least loss is possible for the three parts.

Now, let's analyze a 3-player conflict situation modelled example and solve it.

Example 1. When the World War I started, England was on the side of allied powers, Italy was on the side of central powers, and Greece stayed neutral. England wanted both state on its side and England promised those states İzmir and its surrounding provided that these states continued the war on England's side.

Solution:

A: England B: Greece C: Italy

A has A_1: giving İzmir and its surrounding to Italy

A_2: giving İzmir and its surrounding to Greece

B has B_1: go to war on the side of allied powers

B_2: not go to war

C has C_1: staying on the side of central powers

C_2: change its side to allied powers

two strategies as above.

The game is a 3-player *2x2x2* game. That means there are 8 possible situations.

If England gave İzmir to Italy, it would create a more powerful Italy and this could be a trouble in the future, so giving it to Greece the weaker part would be a more lucrative business. Thus;

Let's assume that while A_1 strategy brings +1 gain

A_2 strategy brings +2 gain.

B; that is, if Greece went to war in return of İzmir, it would retrain Aegean that it had longed for years; it didn't go to war and stay neutral, neither it would lost anything nor it would gain anything.

B_1: strategy brings+2

B_2: strategy brings 0.

C; for Italy, staying on the side of central powers, that is, changing its side from a powerful state like Germany to a powerful state like England would bring neither profit nor loss, but having İzmir and Aegean Island would be profitable.

C_1 brings 0

C_2 strategy brings +1.

Now, for each situation let's write down values related to strategies of all sides and draw the diagram on the coordinate plane.

***$A_1B_1C_1$*:** England gives İzmir to Italy, Italians continues to the war on the side of central powers. Greece goes to war on the side of allied powers.

A: 1
B: -1
C: -1

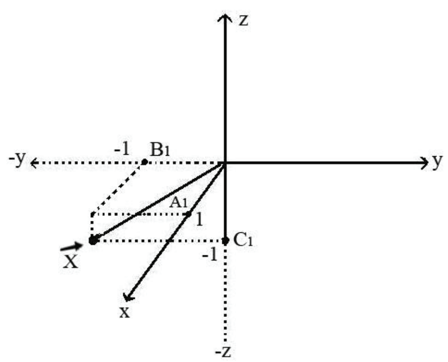

Figure 3.2. $A_1B_1C_1$ strategy.

$A_1B_1C_2$: İzmir is given to Italy, Greece joins to allied powers. Italy changes its side to allied powers.

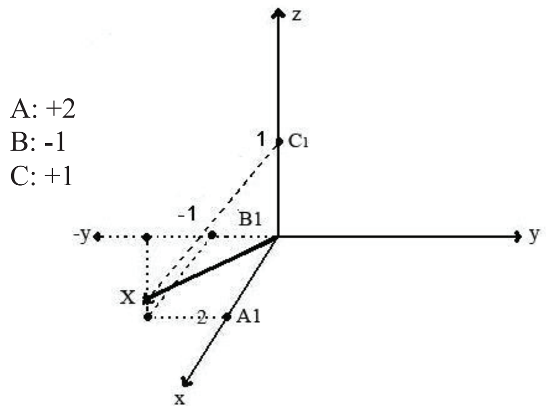

Figure 3.3. $A_1B_1C_2$ strategy.

$A_1B_2C_1$: İzmir is given to Italy, Greece does not go to war, Italy stays on the side of central powers.

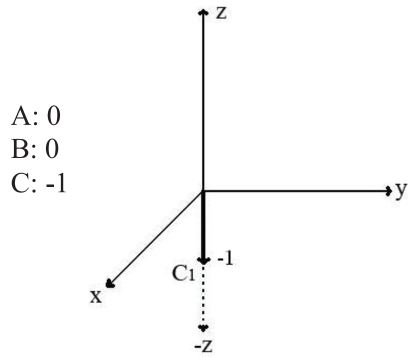

Figure 3.4. $A_1B_2C_1$ strategy.

$A_1B_2C_2$: İzmir is given to Italy, Greece does not go to war, Italy changes its sides to allied powers.

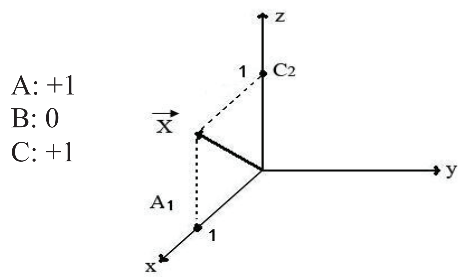

Figure 3.5. $A_2B_1C_1$ strategy.

***$A_2B_1C_1$*: -** (İzmir, is given to Greece, Greece joins allied powers, Italy joins central powers.)

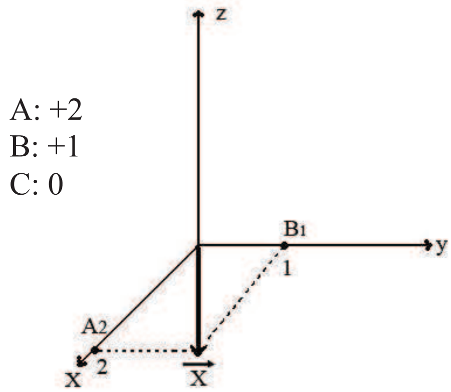

Figure 3.6. $A_2B_1C_1$ strategy.

***$A_2B_1C_2$*:** (İzmir is given to Greece, Greece joins allied powers, Italy changes its side to allied powers.)

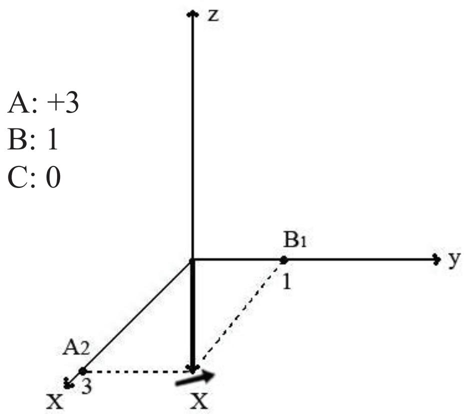

Figure 3.7. $A_2B_1C_1$ strategy.

***$A_2B_2C_1$*:** (İzmir is given to Greece, Greece does not go to war, Italy stays on the side of central powers.)

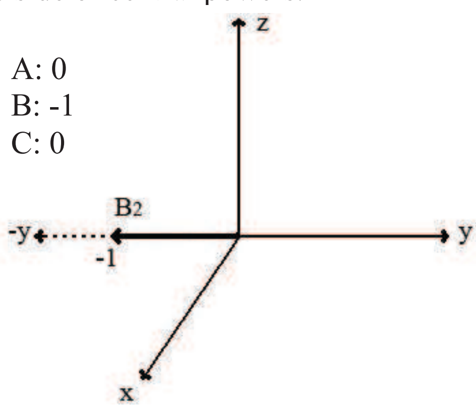

Figure 3.8. $A_2B_2C_1$ strategy.

$A_2B_2C_2$: (İzmir is given to Greece, Greece does not go to war, Italy stays on the side of central powers.)

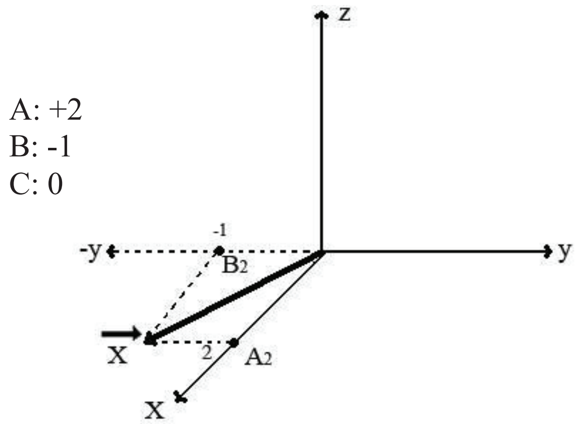

Figure 3.9. $A_2B_2C_2$ strategy.

For the solution of the game, each party should choose strategies that would provide them the least loss. In the World War I, $A_2B_1C_1$ strategy was applied and thus England was the state which benefited more from this.

In this 3-player game, the situation in which the most suitable strategies that Nash equilibrium has not unbalanced for the three party were chosen (NASH 1950).

It is not possible to talk about 3-player games for zero-sum games.

The loss of the winning party in zero-sum games is equal to the gain of the other party. In 3-player games, there are not only us and our opponent, but a third party is also in the game and the game has now become I– you– he. Even if we distribute the profit equally, my loss will be higher than the other parties' gain.

A side *x* profit

B side *x* profit

C side *x* profit

The loss of *B* is *2x*, the profits of the opponents are *x* lira. As $2x \neq x$, the game is not zero-sum.

4. Discussion and conclusion

NASH (1950) introduced his nobel-winning work - the balance of Nash Equilibrium in 2-player games and 2-player collaborationist games in his doctoral thesis. VENTSELL (1965) developed solutions for 2x2, 2xn, nx2 and mxn games in game theory. He referred solution with linear programming and found the solution for the games which is a matter of lack of adequate information. OZDEN (1989) resorted to predict the future with the data obtained through the past and with the quantitative decision making techniques. KREPS (1991) made an economic MODELLING with the game theory. MIROWSKI (1992) investigated the history of the economic policy and the emergence of the game theory. McMILLAN (1992) explained the use of game and strategy for senior management by exemplifying them within the game theory. OZDIL (1998) exemplified the place of the game theory in the solution of economic problems in financial market with an implementation. ESEN (2001) analyzed full information static games within the frame of the game theory and applied oligopoly examples. CETIN (2001) made his thesis on the game theory that offers solutions to the problems in the implementation of cooperation which protects the economic and judiciary freedom. CAGLAR (2002) analyzed the history of the game theory and created up-to-date examples. KAFADAR (2002) did his thesis on strategic foreign trade policy and technology transfer. NAEVE (2004) showed that in the game tree, every branch has a knot, a decision and so each knot can have more than one strategy. OZER (2004) applied the game theory in agriculture. ORAN (2004) exemplified the game theory with current events. GREIF (2005) made a historical analysis of the game theory for the economics. RAGHAVAN (2005) created 2-player zero-sum games. SUN and KHAN (2005) analyzed complex strategies for non-zero-sum n>2-player games and fastened them in Nash Equilibrium. CHARTWRINGHT (2009) analyzed and exemplified the balance in multiplayer games for simple strategies.

In this study, a game theory whose first foundation was laid in 1838 and then has attracted more and more interest and have been analyzed a lot was analyzed.

With the developed science and the technology as a result of this science, as the human kind is at the peak of his knowledge level, the human are aware of many more things and the need to consider all of these has made his each step in life even harder.

Now, when deciding about anything, we have to consider the variables apart from us. The game theory provides the individual a binocular evaluation by calculating the variables apart from himself that may affect himself, apart from a one-eyed evaluation by only considering their situations. If the decisions to be made, the behavior to be applied vary according to what others do or will do, the game theory provides solutions to these situations. When looking at the subject about which a decision will be made with a magnifying glass, it would be a practical tool for the individual to make a healthy and more precise decisions. As it makes the analysis of quiet complex situations easier, it is an essential knowledge for both daily life and work life.

In this study, the types of the game theory with its notions and hypotheses were mentioned, two-player zero-sum games and generally well accepted solution methods were focused on. In addition, 3-player non-zero-sum games were defined and exemplified.

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