Production of Geographic Information System Aided Noise Maps

Abdurrahman GEYMEN and Bülent BOSTANCI, Turkey

Key Words: Noise Map, Geographical Information System (GIS), measurement and assessment of environmental noise

SUMMARY

Noise, which is defined as undesired sound is known as the source of significant environmental pollution in the field of urban housing, industry, relaxation and entertainment. Factors depending on sectors such as construction and transportation systems, industry as well as human -created factors such as loud speaking and music sound are encountered as noise pollution sources. Noise perceived as an environmental problem displeases human health in terms of physical, physiological, psychological disturbances while affecting the individual performance negatively. In this context, EU Member States are required to produce strategic noise maps for the locations with a population for more than 250000 until 30.06.2013 under the "Directive on the Assessment and Management of Environmental Noise ".

In this study, a practice has been put into at the Erciyes University Campus for the production of noise map by using the techniques of the Geographical Information Systems (GIS).

Locations of 50 points where deemed considerable in terms of the noise exposure on the main and sub routes within the limits of the campus have been determined by GPS receiver and noise levels of these areas have been measured for the day-evening-night by SVAN 949, sound level & vibration meter and analyzer. Equivalent Continuous Noise Level, LEQ, power level average for long-term averaged sound levels used to describe the overall exposure has been calculated for the correspondent areas. Locations of the areas and LEQ values calculated have been used on the campus numeric map and noise load dispersion maps have been produced.

These maps we produced will assist the city managers on the noise load mitigating and preventive projects in terms of decision-support.

Production of Geographic Information System Aided Noise Maps

Abdurrahman GEYMEN and Bülent BOSTANCI, Turkey

1. Introduction

Noise is an environmental pollution formed by undesired sound which adversely affects auditory health of human, damages the physiological and psychological balance, lessens the productivity, and changes the quality by decreasing or destroying the environmental beauty and peace (URL-1; Guzejev et al., 2000). Although the issue of noise increased in developed countries parallel to the developing technology, and affecting the life adversely, it is a noise type known very little in our country (Kalıpçı, 2007). In 20th century that the time and distance concepts have a significant importance, transportation played an important role as the most developed sector in transporting both passenger and cargo (Kurra, 2010). Noise of the land roads which is classified under transportation noise has come out based on the land road transportation developed parallel to the technology, rapidly growing unplanned urbanization has brought the noise pollution together. Therefore, traffic noise plays the most significant part among the noise sources (Şahinkaya, 2005; Aykan, 2009; Beranek, 1974; Alexandre, 1975).

Germany, France, Holland, England and Sweden are among the countries where many researches made concerning noise maps. In 1960's, in Germany, it has been started evaluating only land roads traffic noise, preparing noise maps based on measurement (Wilhelmsson, 2000). While forming the noise map of 40 cities and towns in Germany up to 1980's, this calculation has reached to 350 up to 1992. It has been evaluated the devaluation of sale prices of houses along the streets at a rate of 30% due to noise in Sweden (Wilhelmsson, 2000). In a study comprising European countries, it has been defined that 32% of overall 371 602 000 people have been affected by the noise about 55 dBA in these countries while the 13% has been affected by noise over 65 dBA by the aid of the noise maps prepared in details (Akdağ, 2002). In his study, Buratti has observed that the areas located in hot climate zone, the windows are left open and cause increasing the internal noise level due to traffic noise (Buratti, 2002). In our country, referring to the noise measurements especially in big cities such as Istanbul, Ankara, Bursa, Izmir, and Konya; it has been observed that noise has become a big distress for the people living here (Günay, 1995; Akdağ, 2002; Karadayı-2001; Aktürk et al., 2003; Dursun ve Özdemir, 1999; Kalıpçı, 2007).

In this study, it has been aimed to identify scientifically the harmful effects of noise to the human physiology and psychology and discussions about precautions against noise have begun. Upon the increasing complaints of the people exposed to noise, law-makers have given the rights required by the individuals for a healthy life by making necessary laws and directives. Such complaints against the noise, regulations and necessity of reducing the noise have rendered the noise a job, control of which requires specialty. Subject studies have been focused by different researchers in different areas on identifying the volume of the noise

pollution and the ways of preventing the noise (Şahinkaya, 2005).

Initially preparing the noise pollution maps are required in order to identify the effects of noise pollution, definition of the precautions to be taken and legal forces to be applied. It is not likely to define the precautions to be taken against the noise pollution existing in area and volume of the effects of such pollution on humans without preparing such maps. Stage after the noise map prepared is the effects of the noise on humans and the precautions to be taken against this.

"Noise Control Regulations" publicized by Official Gazette dated 11 December 1986 and No: 19308 have been issued in order to fight with the noise pollution. However, such regulations has been revoked after "Directive on Assessment and Management of Environmental Noise" publicized by Official Gazette dated 01.07.2005 and No: 25862 (URL-2; Anonym, 2004). Article 8.b of "Directive on Assessment and Management of Environmental Noise" empowers the local administrations concerning "Preparing strategic noise maps and relevant activity plans, preparing the control programs for noise controls, performing controls, notifying the responsible organizations and institutions regarding the subjects identified during controls and assessment of complaints" (Anonym, 2005a; Kalıpçı, 2007). However, as numerous local administrations in our country have not been equipped with the required know-how and staff, subject noise maps cannot be produced or prepared different products claiming noise map due to lack of knowledge (Dursun and Özdemir, 1999).

In this study, Erciyes University Campus has been selected as a pilot area for the purpose of identifying the noise, a pollution factor that has adverse effects on humans. Objective of the study is modeling the area with a noise pollution by interpolation methods. Noise levels spread through the existing roads and the land road which has a quality of inner city main artery within the campus have been measured by noise measurement device in the morning, at noon and in the evening and required precautions have been expressed to lessen and control the noise by producing the noise map of the campus center based on the values measured.

2. Area of Research

Kayseri, with its remarkable history and population around 1 Million and located in Middle Anatolia, close to Capadocia is an industry and trade city. Erciyes University, which has been selected as the study area, has been founded in 1978 and today it serves with its totally 16 faculties, 4 higher schools, 7 vocational higher schools, 7 institutes, 5 departments, 19 research centers and Gevher Nesibe Medicine Faculty Hospital with 1350 beds. In addition to the Medicine Faculty Hospital; Cardiovascular Disease Hospital, Organ Transplantation and Dialysis Hospital, Oncology Hospital, Children's Hospital and Bone Marrow Transplant and Stem Cell Treatment Center are the most important health institutions. University is located on 494 hectares of land, 59 hectares of which is closed area. In the selected campus area, there are two noise sources, one of which is the traffic noise from the roads while the other is students' density for 41.000, administrative and academic staff for 5.000 as well as the patient and visitors of the hospitals. It is observed that the traffic and human density is higher particularly, in the hospital area and bus stops.

3. Material and Method

Depending these two noise sources, approximate locations of 50 points where deemed considerable in terms of noise exposure in the main and sub routes within the limits of the campus have been determined by means of IKONOS satellite image. Points defined have been settled on the ground precisely after the examinations of land and coordinates have been registered in the system of WGS 84 by Magellan brand handy GPS. Noise levels of these areas have been measured during the morning, noon and evening hours by SVAN 949, Sound and Vibration Level Meter & Analyser.

For the purposes of this study, it has been decided to perform the measurement between 08:00-10:00 morning, 12:00-13:300 noon and 17:00-18.300 evening hours to record the highest level of noise that are the hours of highest human and traffic density within the campus.

In October 2011, for the whole 50 points, Equivalent Continuous Noise Level, LEQ has been measured for 5 minutes during the morning, noon and evening hours per each point for 5 business days. Names of the points, locations, measurement periods and LEQ values have been recorded as Excel data file. ArcGIS 9.3 program has been used for analysing noise and creating noise map (ArcGIS. 2008). Coordinates of such 50 points obtained by handy GPS have been transferred to ArcGIS software as point layer and overlaid with the satellite image (Figure 1).

Figure 1. Location of 50 noise points identified in the Campus area

4. Assessment

Data such as Equivalent Continuous Noise Level, LEQ, Maximum Sound Level (Lmax), Minimum Sound Level (Lmin) are measurable spot values that reveal the noise status of an area.

One of the most important steps during the evaluation stage of such data collected in a certain order at the noise observation stations are the expression of the data collected based on the points as spatial.

Geostatistical interpolation methods have been used to express the point data in spatial extent. Such methods calculate the values of the fields between the points based on the feature data referenced to point geometry and express the results as raster surfaces (Doğru et al., 2011). Particularly, today the geostatistical interpolation methods used to calculate the surface heights are presented to the user as a tool for many commercial Geographic Information System (GIS) software. Noise values of morning, noon and evening obtained have been assessed with "Geostatistical Analyst" module on ArcGIS. In this module, three different geostatistical interpolation methods have been used which are as follows:

- Inverse Distance Weight Method
- Ordinary Kriging (OK) Method
- Radial Basis Functions (RBF) Method

Inverse Distance Weight (IDW) method is calculation of the surface data with unknown values by using the weighted point data. In this method, weight is described as the function of the distance between the points. In this extent, the wider distance, the weaker functions effects (Doğru et al., 2011).

Kriging is one of the powerful methods for the calculation of the surfaces. Kriging techniques create surfaces that incorporate the statistical properties of the measured data (ESRI 2001). There are two categories of Kriging: linear and non-linear. Linear methods include Simple (SK), Ordinary (OK) and Universal (UK) Kriging; Non-linear methods include Indicator (IK), Probablility (PK) and Disjunctive (DK) Kriging (URL-3; ArcGIS. 2008).

RBF methods are a series of exact interpolation techniques; that is, the surface must pass through each measured sample value. RBFs are conceptually similar to fitting a rubber membrane through the measured sample values while minimizing the total curvature of the surface. The basis function to be selected determines how the rubber membrane will fit between the values (URL-3; ArcGIS. 2008).

For the purposes of researching suitable geostatistical interpolation method for noise mapping, totally 9 noise maps have been created by means of IDW, OK and RBF based on equivalent continuous noise level of morning, noon and evening. Noise maps modeled by the IDW method have been shown as an example in Figure 2-4.

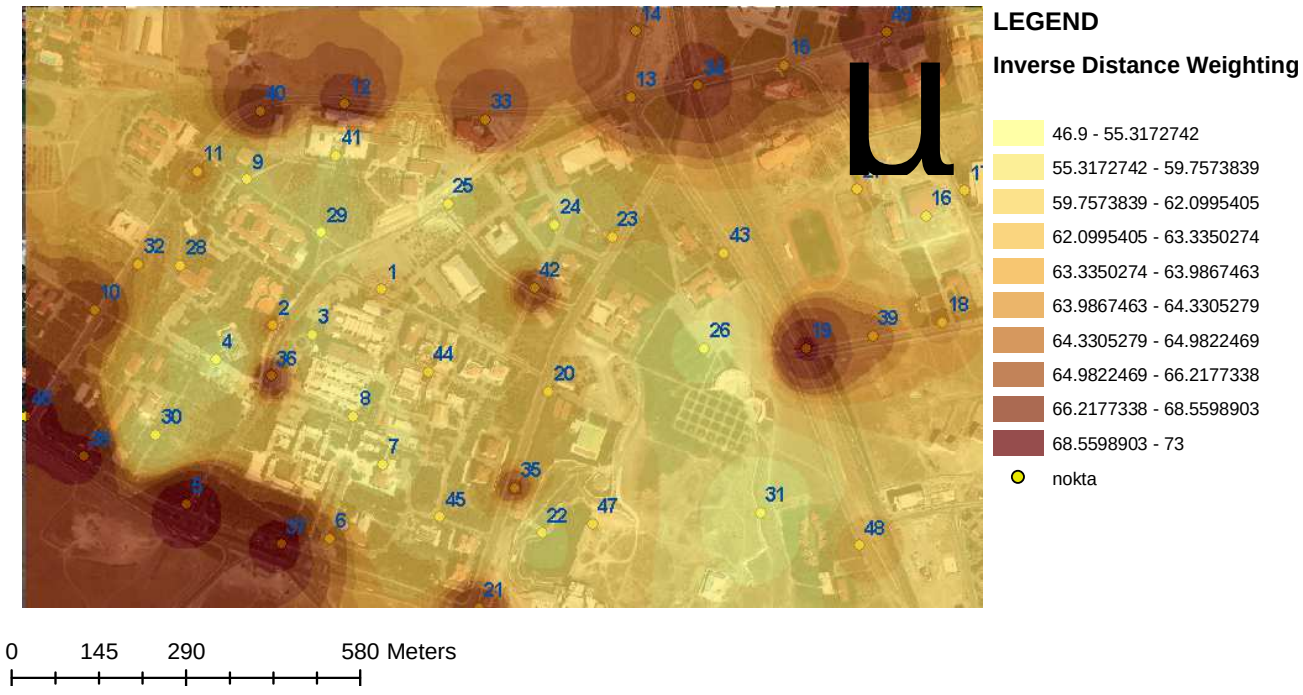

Figure 2. Morning noise map modeled by IDW method

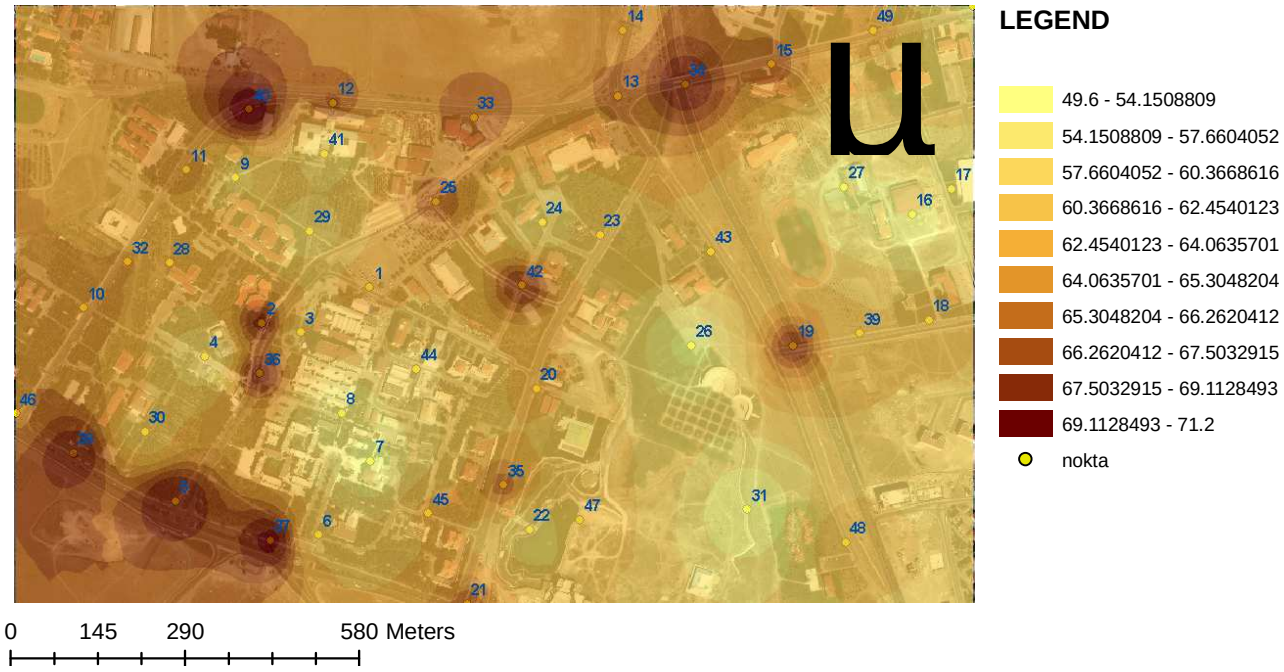

Figure 3. Noon time noise map modeled by IDW method

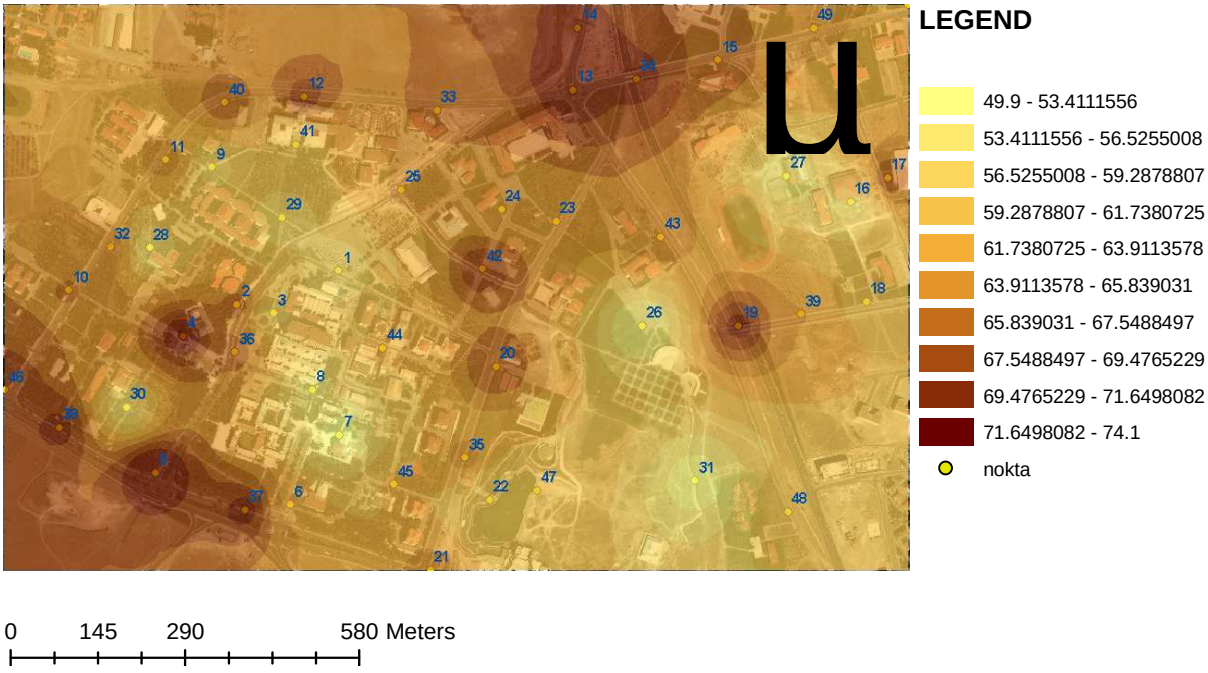

Figure 4. Evening noise map modeled by IDW method

5. Conclusion and Recommendations

This study has been performed by standard parameters of two dimension interpolation methods which are used by most of the GIS software. Accuracy of geostatistical interpolation methods depends on the dispersion of the points of noise to be measured on the study area as well as taking decision about which interpolation methods to be applied for the subject station noise values. Each of the interpolation methods create different noise maps based on the mathematics functions used. Therefore, defining the locations and density of the noise measurement stations and selecting interpolation method are important elements in terms of the assessment of the results of the study.

In order to improve the accuracy of the noise maps created by interpolation methods, increasing the number of the noise measurement stations along the roadsides in the campus is required.

When the measured equivalent continuous noise level values are examined, it is seen that the noise level is around 60-65 decibels (Figure 5). This result shows that the noise in the campus is noticeable. Furthermore, graphics of equivalent continuous noise level values measured for morning, noon and evening show similar characteristics. However, measurement stations of the evening show an increasing variability against morning and noon values. Therefore, traffic and human density at certain locations reach to maximum level in the evening time.

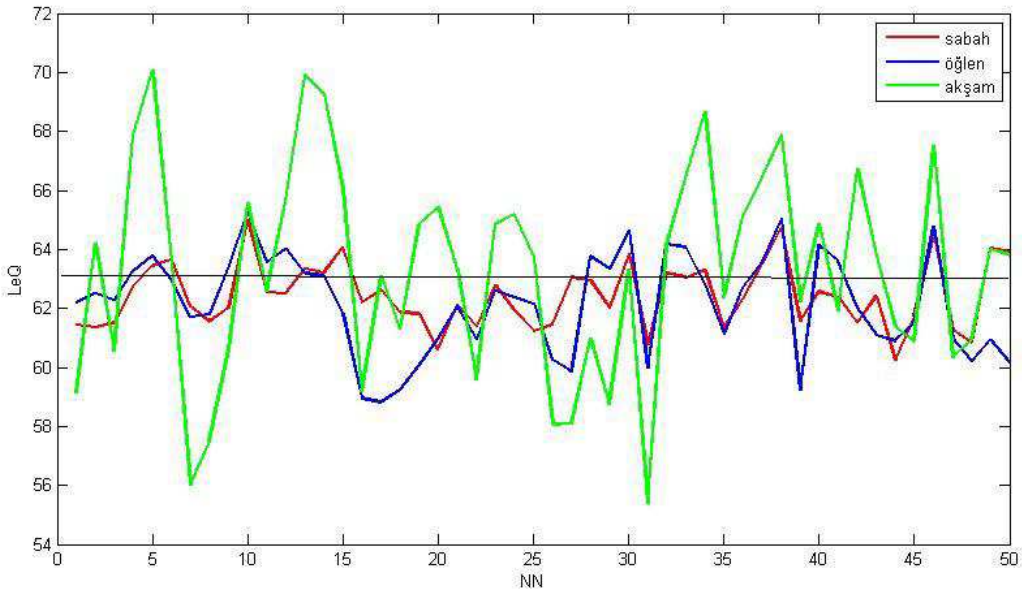

Figure 5. Graphic of variant of equivalent continuous noise levels measured by the measurement stations within the campus

While the noise maps in Figure 2-4 are examined, highest noise values have been measured especially around the entrance gates of the campus. Furthermore, Medicine Faculty bus stop within the campus, around the main street which divides the campus into two has produced quite high noise levels when measured which is over 70 decibels. According to a report of Organization for Economic Co-operation and Development (OECD) dated 1996, noise over 55 decibels will be disturbing and values over 65 decibels may have harmful results sourced by the noise.

Therefore, in areas where the noise exceeds the limit values, preventing the noise disturbance and not to damage the human health, planning the traffic to lessen the noise, increasing the soundproofing, placing noise reducing panels and forestation may be considered as the precautions to be taken for controlling the noise.

Results of the study will be helpful to the city and institutional authorities for developing projects related to preventing and lessening noise. It is planned to widen this study in a manner to make research about the optimum interpolation to be used in mapping the noise in future.

REFERENCES

Akdağ, N., 2002,'Kent Planlamada Gürültü Haritalarının Önemi: Barbaros Bulvarı Çevresi Örneği', 6. Ulusal Akustik Kongresi, Antalya.

Aktürk, N., Akdemir, O.,Üzkurt, İ., 2003, Trafik Işık Sürelerinin Neden Olduğu Çevresel Taşıt Gürültüsü, Gazi Ün..Müh.-Mim.Fak.Dergisi, Cilt 18, No.1,s.71-87, Ankara.

Alexandre, A., 1975, "Road Traffic Noise", New York-Wiley", A.B.D.

Anonim, Türk Ceza Kanunu, 12.10.2004 Tarih ve 25611 Sayılı Resmi Gazete, 2004, Ankara.

Anonim, 2005a 'Çevresel Gürültünün Değerlendirilmesi ve Yönetimi Yönetmeliği', 01.07.2005 Tarih ve 25862 Sayılı Resmi Gazete, Ankara.

ArcGIS. 2008. Using ArcGIS Desktop. *ESRI Press:* Redlands, CA.

Aykan, A. (2009). Afyonkarahisar şehir merkezi gürültü haritasının oluşturulması ve gürültünün insan sağlığı üzerindeki etkisi. Afyon Kocatepe Üniversitesi, Fen Bilimleri Enstitüsü, Afyon.

Beranek, L. L., 1974, "Noise Reduction", McGraw-Hill Bokk Co. Inc, A.B.D.

Buratti, C., 2002, Indoor Noise Reduction Index with Open Window, Applied Acoustics 63, p.431-451.

Doğru, A.Ö., Keskin, M., Özdoğu, K., İliev, N., Uluğtekin, N.N., Balçık, F.B., Göksel, Ç., Sözen, S., (2011). Meteorolojik verilerin değerlendirilmesi ve sunulması için enterpolasyon yöntemlerinin karşılaştırılması, TMMOB Coğrafi Bilgi Sistemleri Kongresi, 31 Ekim-04 Kasım, Antalya.

Dursun, Ş., Özdemir, C., 1999, 'Konya İl Merkezinde Gürültü Kirliliği Haritasının Hazırlanması', Proje No:97-081, Sayfa No:4-24, Konya.

Guzejev M.H., Vuorinens H.S., Kaprio J., Heikkila K. ve Rauhamaa H.M.2000. Self-Reported of transportation noise exposure, annoyance and noise sentitivity in relation to noise map information. Journal of Sound and Vibration 234 (2), 191-206.

Günay, E., 1995, 'Ses Kirlenmesi veya Desibel Cehennemi', Çevre ve İnsan Dergisi, Sayı No:20, Sayfa No:7-8, Ankara.

Kalıpçı, E., (2007). Measurement and map preparation of noise pollution in Giresun centre, Selcuk University Graduate School of Natural and Applied Sciences, Department of Environmental Engineering.

Karadayı, S., 2001, Bursa İlinin Trafik Kaynaklı Gürültü Haritasının Hazırlanması, Yüksek Lisans Tezi, Sakarya Üniversitesi, Sayfa No:3-38, Sakarya.

Kurra, S. 2010. Çevre Gürültüsü ve Yönetimi. Bahçeşehir Üniversitesi Yayınları, ISBN: 9789756437872.

Şahinkaya, S. (2005). Coğrafi Bilgi Sistemleri ile demiryolu gürültü kirliliğinin modellenmesi: Konya örneği. Selçuk Üniversitesi, Fen Bilimler Enstitüsü, Konya

Wilhelmsson, M., 2000, The Impact of Traffic Noise on The Values of Single-Family Houses, Journal of Environmental Planning and Management, 43 (6), p. 799-815.

URL-1. www.cevreorman.gov.tr/gurultu_00.htm.

URL-2. www.mevzuat.com.tr

URL-3. www.littleblackdoggie.com/Portfolio/Interpolation_Methods.html

BIOGRAPHICAL NOTES

Abdurrahman Geymen was born in Konya, Turkey, in 1973. He graduated with a MS degree in Geomatics Engineering from the Gebze Institute of Technology, Turkey, in 2000. He received a PhD degree from the Department of Geomatics Engineering, Karadeniz Technical University, Turkey, in 2006. He is working with the Department of Geomatics Engineering, Erciyes University as an associate professor. His research interests include Geographical Information System (GIS), Computer-aided Design, Software Development for GIS, Web based GIS and Spatial Data Structures. He has published a number of international journal and conferences article related to these areas.

Bülent Bostancı was born in Akşehir, Turkey, in 1969. He graduated from Yıldız Technical University, İstanbul, Turkey in 1992, and received MSc and PhD degrees from Yıldız Technical University, İstanbul, Turkey in 1995 and 2008. He worked at Republic of Turkey General Directorate of Highways for 5 years. He received his Assistant Professor degree in Turkey in 2010. He is now working for Erciyes University, Kayseri, Turkey as the Head of the Surveying Technical Division at the Department of Geomatics Engineering. His research interests are special engineering surveying, real estate development and risk analysis

CONTACTS

Assoc. Prof. Dr. Abdurrahman Geymen and Assist. Prof. Dr. Bülent Bostancı
Erciyes University, Faculty of Engineering, Department of Geomatics, 38039
Kayseri/TURKEY
Tel. +90 352 2076666 (ext. 32676 and 32655)
Fax +90 352 4375784
Email: ageymen@erciyes.edu.tr and bbostanci@erciyes.edu.tr
Web site: http://harita.erciyes.edu.tr/en/page/16/academic-staff.html