NOISE POLLUTION MODELLING AND VISUALISATION – THE CASE STUDY FOR THE CITY OF SKOPJE

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Abstract: *Noise pollution modelling can be used to provide information about growing noise pollution from the urban traffic. Various methods have been developed that aim at minimizing the noise pollution and improving the environment. Geographic Information System (GIS) can be adapted to gather, analyse and present noise information. The results in this paper demonstrated that most of regions surrounding the main streets are suffering from the noise pollution. As a main contribution of this paper, the first this-kind of study for the city of Skopje, practicing GIS capabilities for presenting noise information, we have produced a general picture of the traffic-induced noise pollution on annual level. The assessment showed that the used method in visualization can provide reliable information about noise pollution in any city or urban region. In this paper, we were focused, as a case study, for the city of Skopje.*

Keywords: TRAFFIC NOISE, URBAN AREA, ENVIRONMENTAL MODELLING, VISUALIZATION

1. Introduction

In the last years the number of motor vehicles increases in Republic of Macedonia and together with this the noise pollution as well. Noise is a big environmental health problem. Researchers show that noise can have serious health effects for learning and task-motivation effects in children and adults exposed to constant noise. Ac-cording to the World Health Organization [1] the most important repercussions regarding extensive noise are: hearing loss, physiological effects, work-related stress and increased risk of accidents. About 120 million people in the European Union are disturbed by road traffic noise levels above 55 dBA, and more than 50 million people are exposed to noise levels above 65 dBA. The same fact was elaborated in the re-port published in US by Federal Highway Administration (FHWA) [2]. A high fraction of citizens is exposed to high levels of road traffic noise in and around their homes, population can start to migrate out of cities, because people prefer to live in a quiet and safety environment. However, traffic noise starts also to affect property values and community atmosphere.

Noise pollution model can be used to provide information regarding the noise pollution from the urban traffic. Various methods have been developed that aimed at modelling the noise pollution and improving the environment. In most of the cases, the Geographic Information System (GIS) has been adapted to gather, analyse and present noise information. Geographic Information System (GIS) have been used effectively in the gathering, weighting, analysing and presenting spatial and attribute information to facilitate the management of environmental pollutions [3, 4]. GIS provides various tools to incorporate new models for decision making process [5, 6]. This study aimed at quantifying temporal and spatial dynamics of urban traffic-induced noise pollution in the districted of Skopje as well as assessing noise levels based on national and international criteria. By practicing GIS tools for presenting noise information, the results of interpolation applied in the process of visualization were evaluated. In this study we measured urban traffic noise levels in Skopje city, then visualized and assess the results using the inverse distance weighting (IDW) interpolation. A refinement of IDW was performed according the procedure given in [6]. Measurements were done at different time of the day, during two successive months.

Numerous traffic noise prediction models have been developed, some of which are highly specific and solve a reduced class of problems. The more popular ones include the CRTN model in the UK, the FHWA-TNM model in the US, the RLS90 model in Germany, the OAL model in Austria, the EMPA model in Switzerland, and the ASJ model in Japan. FHWA-TNM is arguably the most widely used noise model. The FHWA-TNM (Federal Highway Administration Traffic Noise Model) is a computerized model used for predicting noise impacts in the vicinity of highways. It uses advances in acoustics and computer technology to improve the accuracy and ease of modelling highway traffic noise, including the design of efficient, cost-effective high-way noise barriers [7]. Also often used prediction model is Nordic Prediction Method published by the Nordic Council of Ministers [8]. The Nordic prediction method can be used to design computer programs for calculation of noise. One of the most important introductory information found in Nordic prediction is the fact that the calculation can be performed only up to 300m from the road. They assume that after this distance, a normal traffic noise is not disturbing anymore.

The paper is organized as follows: In Section 2 we present the methods and the materials that we use to gather the necessary data, while in Section 3 we present the noise pollution model and the results from the model for the city Skopje. In section 4 we conclude the paper and we give direction for future work.

2. Methods and materials

In order to determine the noise caused by road traffic on busy roads in the city of Skopje, the Environmental laboratory 'PHARMACHEM" from the Department for environmental protection and nature of the City of Skopje did periodic measurements on the level of noise. Locations where monitoring was conducted and periodical measuring of noise was done to match area of 3th degree of protection under the Rules of noise for locations of measurement stations and measuring points (Gazette of RM 20/2008). The measurement points were located in areas where it is necessary to provide protection from noise caused by road traffic, affecting human health and the environment, and also to obtain data that will serve the development of strategic action plans and maps of the City Skopje.

The selection of roads included frequent roads located in the downtown area, as well as side streets of the downtown area connected to the main roads. Also, two main thoroughfares were chosen on the entrance/exit of the City of Skopje located on the west and on the east side of the town – boulevard Gjorche Petrov and boulevard "Alexander the Great". The following factors affected on the selection of the roads:

- dominance of road traffic noise compared to other sources of noise (chirring up and other human activities)
- distance from intersections
- representativeness of the segment of the thoroughfare
- presence / absence of reflective surfaces
- space openness
- safety equipment

We have used several instruments in order to obtain the noise pollution data. The instrument Cirrus CR: 171B was used by the Environmental laboratory Pharmachem. This instrument provides functions and features according to the standards IEC 60651: 1979, IEC 60804: 2001, IEC 61260: 1995, IEC 60942: 1997, IEC 61252: 1993 and IEC61672-1: 2002nd. The experts from the Department for environmental protection and nature of the City of Skopje used the instrument Bruel&Kjaer Hand-Held Analysers Types 2250 which provides features and performance standards IEC61672-1, ISO 7196: 1995, ANSI / ASA S1.4, S1.42 and S1.43. After the data was collected, we have used several methods. NordTest Meth-od NT ACOU 039 Road Traffic: Measurement of noise emission-engineering method and MKC ISO 1996: 2/2007 Acoustics-Description measurement assessment of environmental noise.

3. Noise pollution model of city Skopje

After we have collected and processed the data using these methods, the results of the monitoring and periodical measuring of the level of noise in the busy city locations in Skopje are loaded with ArcMap. Figure 1 shows the measuring points where periodical measuring of noise is performed.

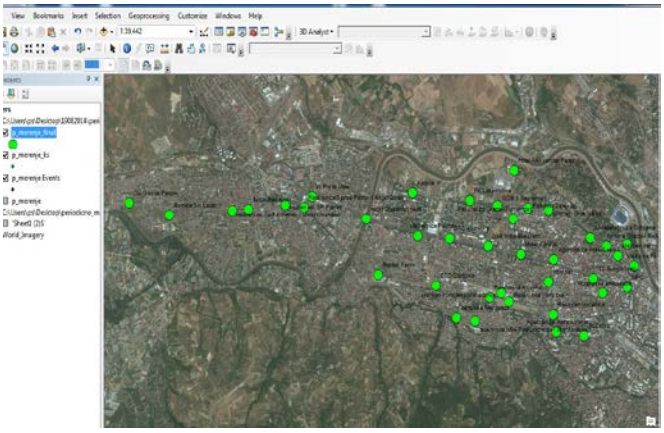

Fig. 1 *The measuring points where periodical measurement of noise is performed.*

Before to make an interpolation with IDW method we review the barriers options. It is used to specify the location of linear features known to interrupt the surface continuity. Barriers limit the selected set of the input sample points used to interpolate output z-values to those samples on the same side of the barrier as the current pro-cessing cell. Separation by a barrier is determined by line-of-sight analysis between each pair of points. Barriers can be used for predicting of the interpolated surface that we are expecting.

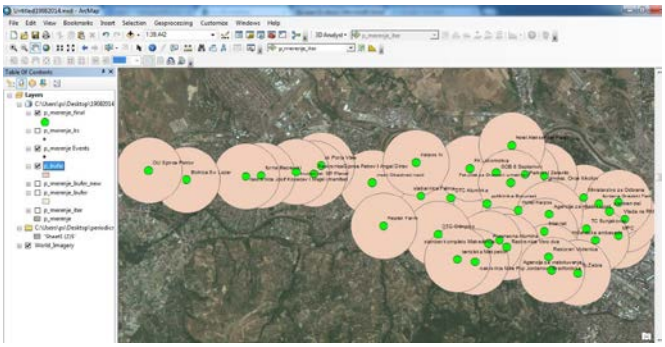

Fig. *2 Buffering input point.*

It allows easier to make a decision of limiting the number of input points or to eliminate input points far away from the cell location. In our case, we set the distance around the input features that will be buffered to 700 meters. It is shown on Figure 2. In our study, we used IDW interpolation determines cell values using a linearly weighted combination of a set of sample points. The weight is a function of inverse distance. This method assumes that the variable being mapped decreases in influence with distance from its sampled location.

The output value for a cell using IDW is limited to the range of the values used to interpolate. Because IDW is a weighted distance average, the average cannot be greater than the highest or less than the lowest input. The best results from IDW are obtained when sampling is sufficiently dense with regard to the local variation that we are attempting to simulate. If the sampling of input points is sparse or uneven, the results may not sufficiently represent the desired surface. On Figure 3, the measure-ment points are presented with green colour, while the highest level of measured noise level is given with white colour. The lower noise levels are marked with darker colours. The number of colours depends from the selected number of intervals in the process of generation of IDW interpolation.

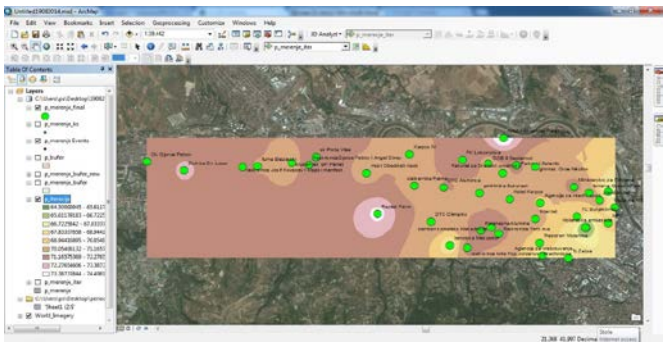

Fig. 3. *The results of visualized noise levels for the city of Skopje*

From the Figure 3, we can conclude that the highest level of noise was measured at the measured points of “Hotel Alexander Palace” and Pharmacy Company “Replek Farm”. It can be also observed that the majority of measurement points were concentrated in the city centre because we expected higher level of noise in this area. The measured levels are generally beyond the aloud limits given in EU directives [9, 10].

4. Conclusion

In this paper, we produced the general picture of the traffic-induced noise pollution on annual level for the city of Skopje. The assessment showed that the used method in visualization can provide reliable information about noise pollution for any city or urban region. We were focused, as a case study, for the city of Skopje. For more precise visualization, it is necessary to take more measurement points and to cover uniformly the area of the city. This is important in building a good traffic noise pollution model. The idea with this kind of system is to raise the public awareness and to help the city planners and regulatory institutions to get information about traffic-induced noise pollution. In the future, we plan to provide a general traffic noise pollution model and according to the input data from different measurement points and sensors to provide more precise and complete data for any city and larger region around the city.

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