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Study of Noise Map and its Features in an Indoor Work Environment through GIS-Based Software

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A B S T R A C T

Background: Noise mapping in industry can be useful to assess the risks of harmful noise, or to monitor noise in machine rooms. Using GIS -based software for plotting noise maps in an indoor noisy work environment can be helpful for occupational hygienists to monitor noise pollution.
Methods: This study was carried out in a noisy packaging unit of a food industry in Ghazvin industrial zone, to evaluate noise levels by GIS technique. For this reason the floor of packaging unit was divided into squares of 2×2 meters and the center of each square was marked as a measurement station based on NIOSH method. The sound pressure level in each station was measured and then the measurement values were imported into Arc GIS software to plot noise map.
Results: Unlike the current method, the noise maps generated by GIS technique are consistent with the nature of sound propagation.
Conclusion: This study showed that for an indoor work environment, the application of GIS technology rendering the assessment of noise levels in the form of noise maps, is more realistic and more accurate than the routine method which is now being used by the occupational hygienists.

1. Introduction

Unwanted sound waves that are emitted from different sources and can be unpleasant to hear are called noise or noise pollution [1]. Various research shows that long time exposure to noise levels greater than 90 dB can be damaging to hearing cells [1]. Noise as well as other environmental pollutants, reduces life quality and causes health hazards, e.g. the people who live along the highways, may have higher blood pressure levels [1].

Unwanted noise can cause insomnia, impatience, nervousness, awakening and finally the risk of mental illness [1]. The noise problem is more highlighted in the industries, e.g. NIOSH reported that four million workers go to work each day in damaging noise [2]. Ten million people in the U.S have a noise-related hearing loss [2] and twenty-two million workers are exposed to potentially damaging noise each year.

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In 2007, approximately 23,000 cases of occupational hearing problems were reported that were great enough to cause hearing impairment [2].

Reported cases of hearing loss accounted for 14% of occupational illness es in 2007. In 2007, approximately 82% of the cases concerning occupational hearing loss were reported among workers in the manufacturing sector [2].

In general it is proved that the hearing loss in industry workers is higher than the other people [3]. Thus, due to the importance of noise monitoring in industry, it is necessary to use more accurate and more clarifying technique to this purpose. This technique is Geographic Information System (GIS) which is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. GIS applications are tools that allow users to create interactive queries, analyze spatial information, create maps, and present the results of all these operations [4].

Lately a few studies have used GIS as a high tech method for noise monitoring, e.g. Guarnaccia et al., plotted a room's noise map by using GIS method in an industrial settlement acoustic noise impact study [5]. In another study carried out by Cho et al., the noise maps for both indoor and outdoor spaces without GPS data were plotted [6].

In order to expand the use of GIS technology in the noise monitoring, especially for occupational hygienists who work in health centers, the present study has demonstrated an evaluation of sound pressure levels in the noisy parts of a food industry by GIS method. The following is the detail of GIS -based software application for sound pressure levels monitoring in an indoor area and the description of obtained results using this method.

2. Materials and Method

Sound pressure levels were measured in the packaging unit of a food industry in Ghazvin industrial zone, Iran. In this unit the floor was divided into squares of 2×2 m, and the center of each square was marked as measurement station based on NIOSH guideline.

The selected points which were placed on the devices, were considered as the blind spots and consequently deleted from measurement stations list. After the location of measurement stations list. After the location of measurement stations were determined, the Sound Pressure Levels (SPL) were measured in each station by using a calibrated sound level meter, testo 815(Testo GmbH & Co., Lenzkirch, Germany). According to the NIOSH guideline, all sound pressure levels measured in a network and slow response and the minimum distance of sound level meter microphone from the reflective surfaces, walls and floor, were kept 1 and 1.5 meter respectively. Also the Arc map software was utilized for the plot of sound pressure level contours.

The database in the Arc map software directly imports measured data and then these data are exported to the noise mapping program. This way, in the first step the plan of the packaging unit was drawn and in the second step the measured sound pressure level values for all stations were entered into the software table. Finally, by using the software menu, the contours of sound pressure levels, in the height of measurement, were plotted for packaging unit.

3. Results

By using the above- described method of station determination, the number of stations in the packaging unit, except blind spots stations, was 158. In table 1 the SPL values for all stations are shown.

Also in Fig. 1 the lay-out of devices and the location of each measurement station in packaging unit are shown.

After importing measurement data to the database of Arc map software and then exporting them to the mapping program, the by software which is shown in Fig. 2.

As depicted in Fig. 2, the distribution of sound pressure level values in the noise maps are shown by 10 areas with 10 colors, that make it easy to recognize noisy areas. As depicted in Fig. 2, the maximum sound pressure levels were placed in the centre of packaging unit. It is possible to plot the noise map with 3 colors for allowable, caution and unallowable areas that were defined as below:

1- Green color for allowable area (SPL<65 dB A)
2- Yellow color for caution area (65<SPL≤85 dB A)
3- Red color for unallowable area (SPL>85 dB A)

In Fig. 3, the noise map has plotted by 3 colors that show clearly the three above mentioned areas. Also Fig. 3 shows the contour of sound pressure levels that have separated the areas with different SPL values.

Table 1: sound pressure level (dB) measurement data in each station.

Station No.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
SPL(db)	70.0	70.3	70.5	69.6	67.5	69.9	73.5	81.3	80.5	81.5
Station No.	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
SPL(db)	78.5	82.1	78.8	82.3	80.1	81.9	81.2	79.1	79.5	69.7
Station No.	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
SPL(db)	70.2	70.0	67.1	67.1	69.6	69.9	67.5	65	68.9	70.7
Station No.	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
SPL(db)	71.1	72.6	72.3	82.0	82.2	78.2	82.2	83.5	84.2	86.7
Station No.	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**
SPL(db)	82.9	82.2	85.8	85.8	81.1	80.5	82.5	83.5	87.0	89.1
Station No.	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**
SPL(db)	85.7	80.9	81.0	79.9	80.8	80.3	77.2	73.4	72.8	82.7
Station No.	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**
SPL(db)	82.5	82.6	82.0	82.9	86.7	72.9	73.3	74.4	71.1	78.2
Station No.	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**
SPL(db)	78.8	80.4	79.9	80.7	80	76.6	78	78.1	78.2	77.3
Station No.	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**
SPL(db)	79.7	78.5	78.3	78.5	77.9	76.3	71.6	74.5	75	76.5
Station No.	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**
SPL(db)	76.8	71.1	74.2	78.2	77.5	76.5	73.2	77.3	78	78.5
Station No.	**100**	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**
SPL(db)	75.7	76.2	75.6	73.1	74.7	74.9	74.1	73	72.5	72.8
Station No.	**110**	**111**	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**
SPL(db)	73	72.5	73.4	72.8	72.7	73.9	73.9	75.7	74.2	77.2
Station No.	**120**	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**
SPL(db)	76.5	76.6	77.5	78	77.6	77.7	78.8	80.7	75.2	75.8
Station No.	**130**	**131**	**132**	**133**	**134**	**135**	**136**	**137**	**138**	**139**
SPL(db)	76.7	75.4	75.8	75.6	75.8	78	75.6	75.5	75.2	73.3
Station No.	**140**	**141**	**142**	**143**	**144**	**145**	**146**	**147**	**148**	**149**
SPL(db)	73.7	72.6	72.5	72.2	70.9	72.5	73	71.8	71.5	74.1
Station No.	**150**	**151**	**152**	**153**	**154**	**155**	**156**	**157**	**158**	
SPL(db)	75.1	76	75.5	76.6	76.4	76.8	76.4	76.3	75.9	

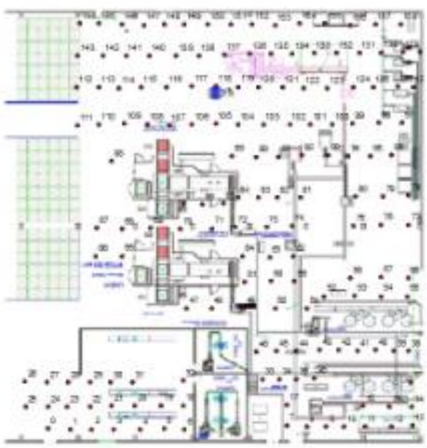

Fig. 1: Lay-out of the plant and the number of measuring point's placement in the package unit.

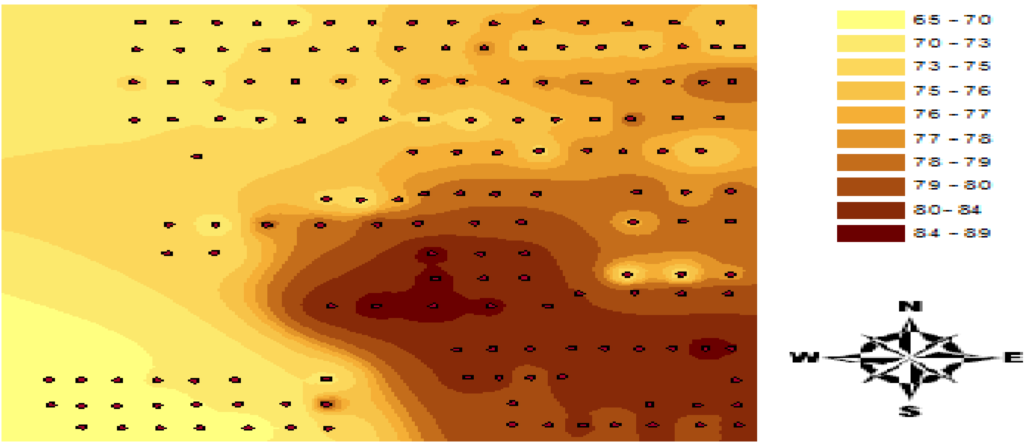

Fig. 2: Noise map for measured sound pressure levels in each station.

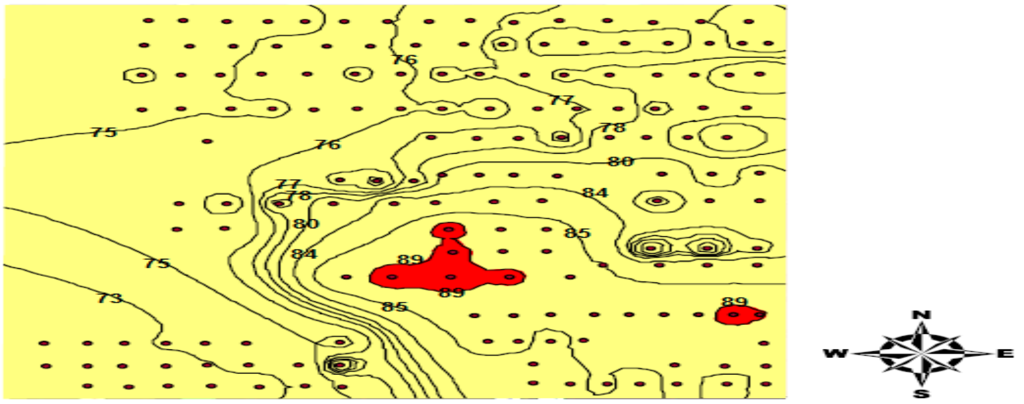

Fig. 3: Contours of sound pressure level in packaging unit at the height of measurements by GIS -based software**.**

These SPL contours have complex shapes all of which are closed curves. It should be noted that none of the curves has intersected each other because otherwise one point will have two values simultaneously.

4. Discussion and Conclusion

Noise is a hazardous physical agent in a large number of workplaces and its proper monitoring can play a main role in preventing hearing loss in the workers who are exposed to unallowable noise levels. Naturally, the results of monitoring are important, because analyses of results are completely dependent on the method of monitoring. At present, the occupational hygienists use the routine method in order to plot the workplace noise maps, where the floor areas are divided into equal squares and the measured SPLs will be recorded in the center of related squares. Then by coloring of each square, the noise map will be obtained. In Fig. 4 one sample of this routine noise map is shown.

As depicted in Fig. 4, the border lines between two adjacent areas are straight which separate these two areas with different SPLs. It is clear that in real situations the border of all adjacent areas could not be a straight line, so this noise monitoring method cannot be correct.

However, recently in cases involving the study of industrial noise indoors, the GIS -based software has been used. For instance in a study of noise control of steel industry GIS method is used [7]. Also the software for indoor noise mapping in industries provided by companies in the noise control engineering, GIS method is used for noise mapping in indoor areas [8]. In the present study, we have attempted to plot the noise mapping in packaging unit of a food industry by GIS -based software. The results showed that the boundaries in plotted noise map by GIS, unlike the routine

Method that is currently used by occupational hygienists, has lots of twists and turns lines between two adjacent areas that should really exist in the real situations, due to the nature of sound propagation. For instance Fig. 4 shows the SPLs in border of two different areas immediately change from caution area to unallowable area or conversely, that cannot be reasonable. As depicted in Fig. 3 the SPL in the center of packaging unit is in the level of unallowable (SPL>85 dB), that is the result is absolutely correct, because the higher SPLs in this area are caused by noisy devices, e.g. chamber and conveyer. Also in Fig. 3 there is no green area that shows there is no allowable area in the packaging unit. By comparison the proposed method and the routine method for noise monitoring in the indoor areas, it is clear that the proposed GIS based method is more realistic and more accurate than the routine method.

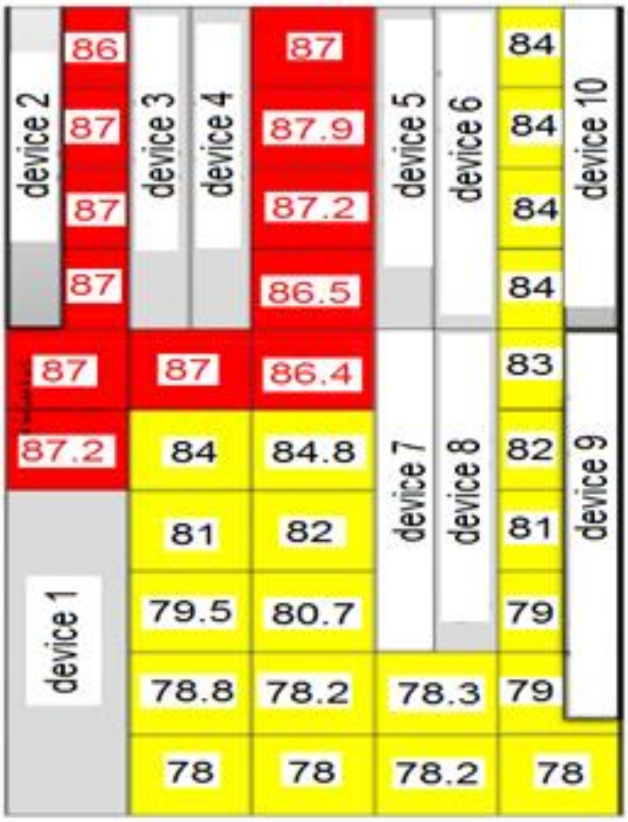

Fig. 4: A sample of sound pressure level contours at the height of measurements depicted by routine method. (Courtesy Green Territory Accountants Co).

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