Caspian Journal of Environmental Sciences
Online ISSN: 1735-3866
Print ISSN: 1735-3033

The effect of tree covers on reducing noise pollution load in Saravan Forest Park, Guilan Province, Iran

Mohsen Mohammadi Galangash*[1], Paknoosh Nikkhah[1], Mehrdad Nikooy[2]

1. Department of Environmental Sciences and Engineering, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Guilan, Iran
2. Department of Forestry, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Guilan, Iran

** Corresponding author's E-mail: mohammadi2g@gmail.com*

ABSTRACT
This study was carried out in the Saravan Forest Park in north of Iran. The sound level measurements were performed at 12 stations and at distances of 3, 100, 200, 400 and 1000 m from the sound source with three replicates, in the summer and in traffic hours from 10 AM to 2 PM an area without tree cover was selected as the control station. The results indicated that sound intensity at first distance (3 m) with the mean of 77.81 decibel (dB) exceeds the national standard of Iran. In this study, the first significant decrease in the sound intensity was obtained at a distance of 100 m, with the highest reduction of 26 dB for station 10, while the lowest decrease was found at station 11 with 8 dB. In an overall summary, distances less than 200 m are not suitable for tourism accommodation. The average sound intensity at distances in comparison with the permissible value indicate that the park does not currently have any noise pollution at more than 200 m in summer.

Keywords: Noise pollution, Plant cover, Distance effects, Seasonal variation.

INTRODUCTION
Road development is known one of the main parts of the urban and industrial development process. The growing trend of transport has made the roads as one of the main source of the noise pollution (Karbalaei *et al*. 2015). For many years, this has been a matter for world organizations and researchers interest (Berglund *et al.* 2000). The Increasing reports of devastative effects of noise pollution cause the related organizations to prioritize the control of this pollutant in development plans based on their economic and ecological conditions (Ozdemir *et al.* 2016; Ow & Ghosh 2017). The studies have shown that being in the exposer in excess of permissible limits for a long time can have irreparable effects on human health (Tonne *et al.* 2016; Gil-Lopez *et al.* 2017). Nowadays, for residents of neighborhoods near the roads noise-induced complications have become a big challenge in their lives (Maleki & Hosseini 2011). The issue of noise has been introduced since 1972 as a pollution by the World Health Organization. Today, with the quantitative and qualitative increase of noise pollution sources in the environment, not only this issue is addressed as a health problem for people's health in many societies, but also it has become a major environmental problem, especially in developing and industrialized countries (Gidlöf-Gunnarsson & Öhrström 2007; Sakieh *et al.* 2017). Although, attention to sound reduction in industrial processes and design of machines and cars, has been one of the priorities, due to the increased sources of sound, this pollution is still considered as one of the hazards for the health of the society (Yang *et al.* 2011). Research shows that exposure to sounds higher than 65-80 dB, in addition to being directly harmful to the human ear, can also lead to various diseases, by disrupting the mental concentration and bringing about individual stresses (Egan 2007). In different studies, the most common side effects of noise pollution were reported, including sleep disorders, anger, anxiety, exacerbation of cardiovascular diseases, increased stress and hearing system damage in humans (Weber *et al.* 2014; Gil-Lopez *et al.* 2017).

Caspian J. Environ. Sci. Vol. 18 No. 1 pp. 73~80
DOI:

Received: April 28. 2019 Accepted: Sep. 30. 2019
Article type: Research

Studies also show that noise can affect behavior and distribution patterns of wildlife (Francis *et al.* 2012; Ow & Ghosh 2017). Due to various sources of noise pollution such as: industrial activities land and air transportation and owing to its harmful effects on the human health and other living organisms, the noisy regions need to environmental quality assessment. Since a significant proportion of noise pollution pertains to road, several measures have so far been taken to create a buffer zone, to construct artificial barriers and to use vegetation to reduce road noise pollution (Kalansuriya *et al.* 2009; Margaritis & Kang 2017). Among the natural and artificial barriers for reducing noise pollution, the use of vegetation cover and in particular tree cover, in addition to having an effective role in reducing the amount of noise pollution, and also have an optimistic psychological effects on the spectator and passengers. On the other hand, the role of refining other pollutants such as gas pollutants and particulates, as well as the production of oxygen and the increase in the quality of the environment by different plant species, have always been reported (Mok *et al.* 2006; Gil-Lopez *et al.* 2017). The control of noise pollution, like air pollution, should be considered precisely at the planning stage and the preparation of comprehensive plans (Weber *et al.* 2014). For many years, trees have been used to reduce noise pollution in various industrial, urban and intersectional areas, depending on the type, height, density, position and weather conditions of the region. (Fang & Ling 2003; Tyagi *et al.* 2013). This has always been a concern due to the improvement and modification of microclimate conditions, especially in cities and parks, despite the high cost of maintenance (Pathak *et al.* 2011). Studies have shown that deciduous trees play a more effective role than the evergreen trees in reducing the sound level, and the amount of noise reduction is significantly reduced in the fall season (Van Haverbeke & Cook 1975).

Other factors of sound reduction are the size of leaf (in broadleaf trees), plant density, tree height, branches flexibility, species diversity, age of species, trunk diameter and even the amount of produced gum (Fang & Ling 2003; Maleki & Hosseini 2011). Considering that among the barriers to sound reduction, the use of vegetation has always been a priority; this study examines the effect of tree cover on reducing noise pollution in northern region of Iran. Due to average annual rainfall of 1366.64 mm in the area (Pourbabaei & Abedi 2011), maintenance costs of this park would be less than the other parts of the country. Saravan Park is located beside the Rasht City as the capital of Guilan Province, and adjacent to Rasht-Qazvin Highway, which has always attracted a large number of travelers and tourists, so attention to environmentally friendly methods for reduction of noise pollution at this recreational place is essential.

The study area attraction

Saravan Forest Park is located between the longitude 49 37’ 30" and 49 04 30" and latitude 37 05 35" and 37 37’ 12". According to Figs. 1 and 2, it is located in north of Iran and the southern part of the Caspian Sea (Limaei *et al.* 2016). The park with an area of 1487 ha has a high diversity of species. About 89.57% of the park space has tree and shrub coverings. Saravan Park is located at an altitude of 50 to 250 m above sea level. Of the total area of the park, 210 ha have been protected, while 521 ha have been devoted to extensive tourism and 756 ha to a centralized tourism. The northern and southern lengths of Saravan forest are 7600 km and its average width is 2 km in the east-west direction. One of the major tree species in this area is oak, *Quercus castaneifolia*; hornbeam, *Carpinus betulus* Linnaeus; alder, *Alnus* sp.; ash, *Fraxinus excelsior* Linnaeus; maple, *Acer velutinum*; and Persian ironwood, *Parrotia persica* (de Candolle., C.A. Meyer) (Shirzadi *et al.* 2015; Limaei *et al.* 2016).

The park is located 17 km from Rasht metropolitan capital, Guilan Province, and the Rasht-Tehran Highway, which connects these two cities to each other and is located at east of the park (Pourbabaei & Abedi 2011).

MATERIALS AND METHODS

In order to investigate the effect of tree cover on reducing noise pollution in the studied area, at first, filed surveys were implemented at three sites and suitable as well as accessible points for sampling were identified. Then the precise location of the sampling points was determined using GPSMAP 62s for 12 stations and each station at 5 distances of 3, 100, 200, 400, and 1000 m from the edge of the road were selected as noise measurement places (Kalansuriya *et al.* 2009; Ow & Ghosh 2017). The sound-level meter was calibrated and then the sound measurement operation was carried out at station 12 as a control site, then at some stations as a pre-test measurement to optimize the noise measurement conditions.

According to the results of the pre-test and the necessary modifications, final noise measurement was performed at all stations and distances. In the summer 2017, when the region had the highest traffic load and the trees had full leaf cover, the measurements were performed during traffic hours between 10 AM. and 2 PM.

Caspian J. Environ. Sci. Vol. 18 No. 1 pp. 73~80 Received: April 28. 2019 Accepted: Sep. 30. 2019
DOI: Article type: Research

The measurement time was 30 minutes and sounding operation at each station was performed with three replicates. The A-weighing unit was set on the fast-weighing mode and 50-100 dB sound density range was adjusted for a distance of 3 m from the edge of the road as a high sound density parts. The range of 32-80 dB was fixed for all other stations, while the sound level meter was about 1.5 m in height above the ground (Kalansuriya *et al.* 2009; Maleki & Hosseini 2011). A sponge protector was used to reduce the effects of airflow on the device sensor (Hosseini *et al.* 2016). In the last step, using statistical analysis of the data, the rate of sound alterations at each station, distances, compared to control stations and the standard limit were analyzed using the SPSS and Excel software.

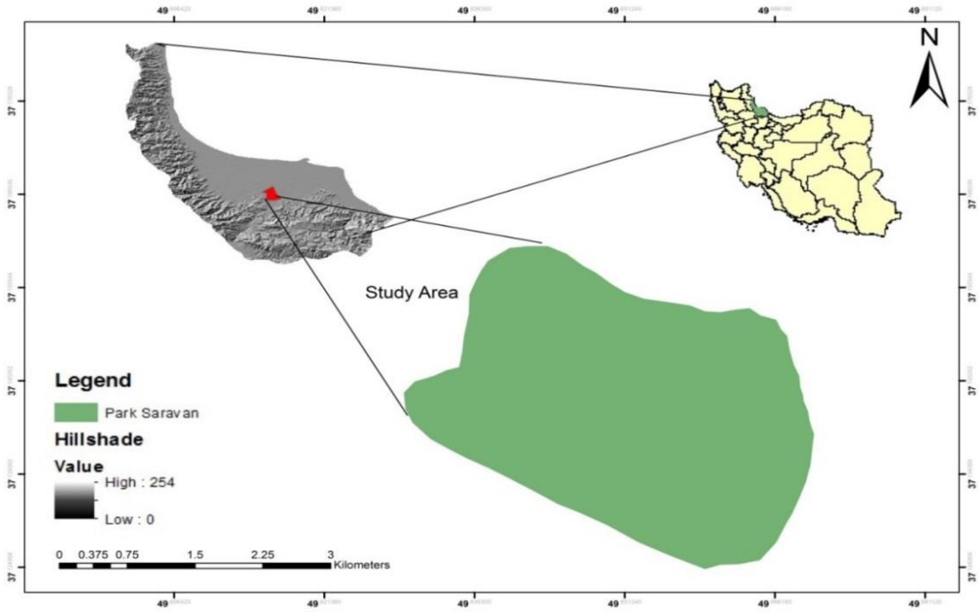

Fig. 1. The study area, Saravan Forest Park, north of Iran.

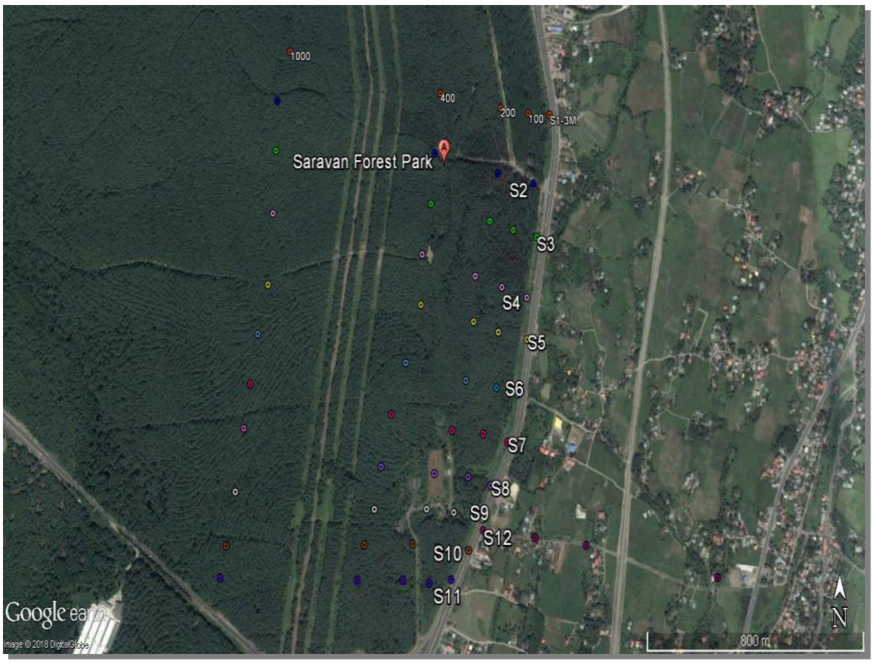

Fig. 2. Location of sampling stations in the Saravan Forest Park.

RESULTS

The results of One-Way ANOVA analysis showed a significant difference in sound intensity at different distances at all stations ($p < 0.05$) to determine the difference in sound intensity at stations and distances.

Caspian J. Environ. Sci. Vol. 18 No. 1 pp. 73~80
DOI:
Received: April 28. 2019 Accepted: Sep. 30. 2019
Article type: Research

Table 1. Analysis of variance for comparison of sound intensity at different distances in the stations.

	Sum of squares	df	Mean square	F	Sig.
Between Groups	34502.547	4	8625.637	477.323	.000
Within Groups	3162.403	175	18.071		
Total	37664.950	179			

According to Table 1, a significant difference was found between the distances at each station ($p < 0.05$) exhibiting well that vegetation at different distances have been very effective in reducing the noise pollution. Scheffe's post-hoc test was used to investigate the significant differences between different groups (each row of distances at different stations, Table 2). Since the significance level between distances in all cases was lower than 0.05, therefore, there was a significant difference between all distances of 3, 100, 200, 400 and 1000 m. As illustrated in Fig. 3, a significant difference was found between the mean of all five distances (the significant level is lower than 0.05), i.e. the mean distances of 3, 100, 200, 400 and 1000 m could not be put in one group. To compare the sound level at eleven stations with a control station (station 12), one sample T-test was used at different distances. The results exhibited that there is a significant difference between the average sound intensity at different distances of stations and sound intensity at the corresponding distance in control station ($p < 0.05$). It was also well displayed that increasing the distance from the tree cover belt, reduces noise pollution. Comparing the average sound intensity at each station by 100 m distance from the sound source indicated that the highest sound reduction belonged to station 10 with 26 dB, while the lowest to station 11 with 8 dB.

Table 2. National noise standard in Iran (Maleki & Hosseini 2011).

The type of regions	7AM-10PM Leq (30') dB (A)	10PM-7AM Leq (30') dB (A)
Residential	50	30
Residential-Commercial	60	50
Commercial	65	55
Residential-Industrial	70	60
Industrial	75	65

T-test results exhibited that there is a significant difference in the average sound intensity between 3 and 100 m distances compared to the national standard in Iran (Table 2, $p < 0.05$). These distances had a noise pollution load. Therefore, based on this type of coverage and also for tourist convenience, the services and accommodation should be built over 100 m in distance from the road.

At some stations, such as 1, 4, 6, 8, 9, 11, even at a distance of 200 m, the amount of received sound exceeds the limit. However, in a general conclusion, the average sound intensity at various distances exhibited that at distances between 400 and 1000 m from the road, there was no noise pollution at all of the stations (Fig. 3).

Caspian J. Environ. Sci. Vol. 18 No. 1 pp. 73~80
DOI:
Received: April 28. 2019 Accepted: Sep. 30. 2019
Article type: Research

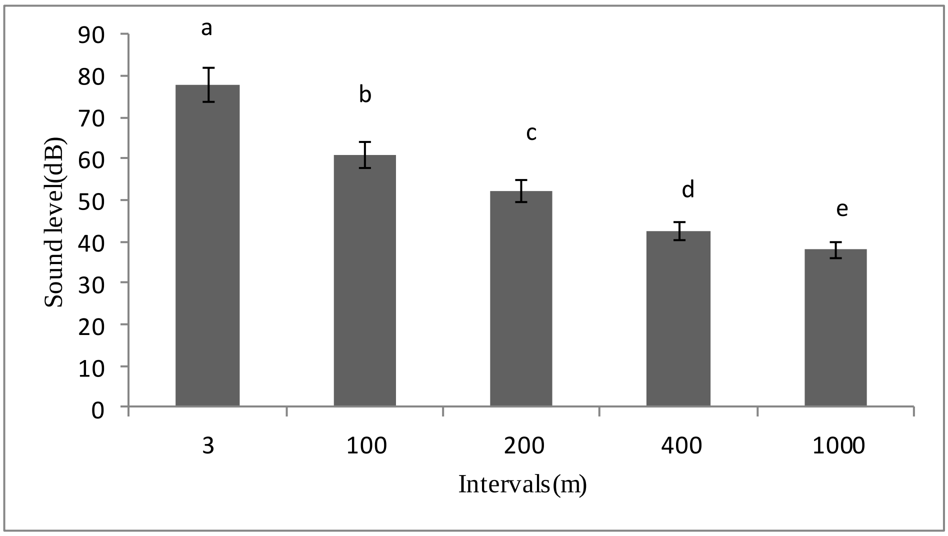

Fig. 3. The average sound intensity at sampling stations in Saravan Forest Park.
* Different letters indicate significant differences between groups ($p < 0.05$).

DISCUSSION

This study focused on the importance and significance of using trees as a group of noise barriers noise. The first studies on plant noise reduction were conducted by Beck and Mir in the 1960-1970s (Ozdemir *et al.* 2014). However, studies concerning to the effect of vegetation on the reduction of sound levels have always attracted many attentions and continued over time. Several studies have demonstrated that by increased distance from the source of noise pollution, severity of noise level was significantly decreased on the tree-covered areas (Harris 1979; Herrington 1976) similar to the results obtained at the present study. The studies have revealed that the tree belt can be effective in reducing the noise pollution to 10 dB (Cook-Patton & Bauerle 2012) and also that the tree belt with a width of 50 m has been able to reduce the intensity of the train noise to 9 dB. (Connelly & Hodgson 2008). It has also been found that stations with tree cover belt always had significant levels of noise reduction compared to the stations without covers (Fang & Ling 2005), similar to results achieved in the present study. So that, there was a significant difference of sound intensity between the control and other stations. Based on environmental conditions and species type, trees and plants have been able to reduce the intensity of sound by at least 9 and up to 26 dB (Pathak *et al.* 2008). Saravan Forest Park attracts a significant number of tourists throughout the country due to its vicinity to Rasht City, the center of Guilan Province with a population of 639,951 (according to the census, SCI 2011) and also because of vicinity to the Tehran-Rasht highway, which is one of the most important communication axes of the country and is a part of the international corridor from the north to the south of Iran (EFGR, 2017).

Therefore, the study on the indicators necessary for the convenience of passengers and tourists in this area is essential. One of the most important indicators of tourist convenience is the noise intensity. In the present study, the accommodation places for tourists were determined in the park based on the permissible limits and national standards of Iran. The average sound intensity with 77.8 dB at 3 m in distance exhibited that this locality could be introduced as the source of noise pollution. The assessment of sound intensity at 100 and 200 m distance from the road with mean sound intensity of 60.9 and 52.24 dB respectively, indicated that these distances are not suitable for tourist accommodation in terms of sound pollution. Factors such as forest fire at station 11, the main combination of leaf needles trees at station 4 and low density trees at distances less than 200 m are the most important reasons for noise pollution in the park.

The field evaluation revealed that with some restoration, the improper distances can also be added to the suitable area for recreation. At distances of 400 and 1000 m, the average sound intensity level were lower than the permissible level, hence, with the current conditions these parts are recommended as suitable areas for tourist's accommodation in the park. The results exhibited that in the case of 6.05 dB sound density, there is a difference between the tree-covered stations and control (without tree cover) at distance of 100 m, indicating the direct effect of vegetation on reducing noise pollution in this park. The results of this study, like those of other reports suggest

Caspian J. Environ. Sci. Vol. 18 No. 1 pp. 73~80 Received: April 28. 2019 Accepted: Sep. 30. 2019
DOI: Article type: Research

the effect of tree cover on the reduction of noise pollution, exhibiting a significant difference between all sampling stations at different distances. However, the rate of noise reduction was different compared to other studies which could be due to different traffic rates in the study area, vegetation type, slope, climate, and other factors (Fang & Ling 2005). Due to the high humidity of the northern part of Iran, the growth of different tree species is naturally occurring and it would be very economical compared to the other part of Iran. So, by using ecological knowledge, in order to select species, adequate density and species combination, the efficiency of tree coverage for noise reduction will be significantly increased (Herrington 1976).

REFERENCES

Berglund, B, Lindvall, T & Schwela, DH 2000, New WHO guidelines for community noise. N*oise & Vibration Worldwide*, 31: 24-29.

Connelly, M & Hodgson, M 2008, Sound transmission loss of green roofs. Proceedings of the 6th Annual Greening Rooftops for Sustainable Communities. Baltimore, MD, 607: 64-76

Cook-Patton, SC & Bauerle, TL 2012, Potential benefits of plant diversity on vegetated roofs: a literature review. *Journal of Environmental Management*, 106: 85-92.

Egan, MD 2007, Architectural acoustics. J. Ross Publishing Classics, 49-79.

EFGR 2017, Enterprise Freeway Ghazvin - Rasht.

Fang, CF & Ling, DL 2005, Guidance for noise reduction provided by tree belts. *Landscape and Urban Planning*, 71: 29-34.

Fang, CF & Ling, DL 2003, Investigation of the noise reduction provided by tree belts. *Landscape and Urban Planning*, 63: 187-195.

Francis, CD, Kleist, NJ, Ortega, CP & Cruz, A 2012, Noise pollution alters ecological services. Enhanced pollination and disrupted seed dispersal. *Proceedings of the Royal Society B: Biological Sciences*, 279: 2727-2735.

Gidlöf-Gunnarsson, A & Öhrström, E 2007, Noise and well-being in urban residential environments: The potential role of perceived availability to nearby green areas. *Landscape and Urban Planning*, 83: 115-126.

Gil-Lopez, T, Medina-Molina, M, Verdu-Vazquez, A & Martel-Rodriguez, B 2017, Acoustic and economic analysis of the use of palm tree pruning waste in noise barriers to mitigate the environmental impact of motorways. *Science of the Total Environment*, 584: 1066-1076.

Halim, H, Abdullah, R, Ali, A A A & Nor, M J M 2015, Effectiveness of existing noise barriers. Comparison between vegetation, concrete hollow block, and panel concrete. *Procedia Environmental Sciences*, 30: 217-221.

Harris, CM 1979, Sound and sound levels. Handbook of noise control. 2nd ed., New York, NY, McGraw-Hill, 1-21.

Herrington, LP 1976, Effect of vegetation on the propagation of noise in the out-of-doors. *USDA Forest Service General Technical Report, US Rocky Mountain Forest Range Experimental Station*, 25: 229-233.

Hosseini, SAO, Zandi, S, Fallah, A & Nasiri M 2016, Effects of geometric design of forest road and roadside vegetation on traffic noise reduction. *Journal of Forestry Research*, 27: 463-468.

Kalansuriya, CM, Pannila, AS & Sonnadara, DUJ 2009, Effect of roadside vegetation on the reduction of traffic noise levels. *Proceedings of the 25th Technical Sessions*, *Colombo, Sri Lanka*, 25: 1-6.

Karbalaei, SS, Karimi, E, Naji, H R, Ghasempoori, S M, Hosseini, SM, & Abdollahi, M 2015, Investigation of the traffic noise attenuation provided by roadside green belts. *Fluctuation and Noise Letters*, 14-15: 50-66.

Limaei, SM, Safari, G & Merceh, GM 2016, Recreational values of forest park using the contingent valuation method (Case study: Saravan Forest Park, north of Iran). *Journal of Forest Science*, 62: 452-462.

Maleki, K & Hosseini, SM 2011, Investigation of the effect of leaves, branches and canopies of trees on noise pollution reduction. *Annals of Environmental Science*, 5: 30-47.

Margaritis, E & Kang, J 2017, Relationship between green space-related morphology and noise pollution. *Ecological Indicators*, 72: 921-933.

Mok, JH, Landphair, HC & Naderi JR 2006, Landscape improvement impacts on roadside safety in Texas. *Landscape and Urban Planning*, 78: 263-274.

Caspian J. Environ. Sci. Vol. 18 No. 1 pp. 73~80 Received: April 28. 2019 Accepted: Sep. 30. 2019
DOI: Article type: Research

Ow, LF & Ghosh, S 2017, Urban cities and road traffic noise. Reduction through vegetation. *Applied Acoustics*, 120: 15-20.

Ozdemir, B, Bayramoglu, E & Demirel, O 2014, Noise pollution and human health in Trabzon parks. *Studies on Ethno-Medicine*, 8: 127-134.

Pathak, V, Tripathi, BD & Mishra, VK 2008, Dynamics of traffic noise in a tropical city Varanasi and its abatement through vegetation. *Environmental Monitoring and Assessment*, 146: 67-75.

Pathak, V, Tripathi, BD & Mishra, VK 2011, Evaluation of Anticipated Performance Index of some tree species for green belt development to mitigate traffic generated noise. Urban Forestry & Urban Greening, 10: 61-66.

Pourbabaei, H & Abedi, R 2011, Ecological species groups in the rural heritage museum of Guilan Province, Iran. *Caspian Journal of Environmental Sciences*, 9: 115-123.

Sakieh, Y, Jaafari, S, Ahmadi, M & Danekar, A 2017, Green and calm: Modeling the relationships between noise pollution propagation and spatial patterns of urban structures and green covers. *Urban Forestry & Urban Greening*, 24: 195-211.

Shirzadi, S, Sabouhi, Sabouni, M & Kenar, RE 2015, Sustainable management of Saravan Sylvan Park using stochastic dynamic programming. *International Journal of Agricultural Management and Development*, 5: 105-205.

SCI 2011, Implementation of the 2011 Iranian population and housing census in autumn (October 24 to November 13, 2011). Statistical Center of Iran, 456-466

Tonne, C, Halonen, JI, Beevers, SD, Dajnak, D, Gulliver, J, Kelly, FJ & Anderson HR 2016, Long-term traffic air and noise pollution in relation to mortality and hospital readmission among myocardial infarction survivors. *International Journal of Hygiene and Environmental Health*, 219: 72-78.

Tyagi, V, Kumar, K & Jain VK 2013, Road traffic noise attenuation by vegetation belts at some sites in the Tarai Region of India. *Archives of Acoustics*, 38: 389-395.

Van Haverbeke, DF & Cook, DI 1975, First report on status and progress of noise research and control programs in the federal government. USAPA, 2: 580.

Weber, N, Haase, D & Franck, U 2014, Assessing modelled outdoor traffic-induced noise and air pollution around urban structures using the concept of landscape metrics. *Landscape and Urban Planning*, 125: 105-116.

Yang, F, Bao, ZY & Zhu, ZJ 2011, An assessment of psychological noise reduction by landscape plants. *International Journal of Environmental Research and Public Health*, 8: 1032-1048.

Caspian J. Environ. Sci. Vol. 18 No. 1 pp. 73~80
DOI:

Received: April 28. 2019 Accepted: Sep. 30. 2019
Article type: Research

اثر پوشش های درختی بر کاهش آلودگی صدا در پارک جنگلی سراوان، استان گیلان، ایران

محسن محمدی گلنگش[1*]، پاکنوش نیکخواه[1]، مهرداد نیکوی[2]

۱- گروه علوم و مهندسی محیط زیست، دانشکده منابع طبیعی، دانشگاه گیلان، صومعه سرا، ایران

۲- گروه جنگلداری، دانشکده منابع طبیعی، دانشگاه گیلان، صومعه سرا، ایران

(تاریخ دریافت: ۹۸/۰۲/۰۸ تاریخ پذیرش: ۹۸/۰۷/۰۸)

چکیده

این مطالعه در پارک جنگلی سراوان در شمال ایران انجام شد. اندازه‌گیری صدا در ۱۲ ایستگاه در فواصل ۳، ۱۰۰، ۲۰۰ و ۴۰۰ متری از منبع صوتی با ۳ تکرار در فصل تابستان و در ساعات ترافیکی ۱۰ تا ۱۴ اجرا شد. یک ایستگاه بدون پوشش درختی به عنوان ایستگاه شاهد انتخاب گردید. نتایج نشان داد که شدت صوت در فاصله ۳ متری از جاده با میانگین ۷۷/۸۱ دسی بل فراتر از استاندارد ملی ایران بود. در این مطالعه اولین کاهش شدت صوت در فاصله ۱۰۰ متری با حداکثر کاهش ۲۶ دسی بل در ایستگاه ۱۰ و حداقل کاهش در ایستگاه ۱۱ با مقدار کاهش ۸ دسی بل به دست آمد. در یک جمع‌بندی کلی می‌توان گفت که فواصل کمتر از ۲۰۰ متر برای خدمات اقامتی توریستی در این پارک مناسب نمی‌باشند. میانگین شدت صوت در مقایسه با حد مجاز نشان داد که در حال حاضر در فصل تابستان آلودگی صدا در فواصل بیشتر از ۲۰۰ متر در این پارک وجود ندارند.

*مولف مسئول

Bibliographic information of this paper for citing:

Mohammadi Galangash, M, Nikkhah, P, Nikooy, M 2020, The effect of tree covers on reducing noise pollution load in Saravan Forest Park, Guilan Province, Iran. Caspian Journal of Environmental Sciences, 18: 73-80

Caspian J. Environ. Sci. Vol. 18 No. 1 pp. 73~80
DOI:
Received: April 28. 2019 Accepted: Sep. 30. 2019
Article type: Research