 Ethno Med, 8(2): 127-134 (2014)

Noise Pollution and Human Health in Trabzon Parks

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KEYWORDS Traffic Noise. Plant Barriers. City Parks. Public Health

ABSTRACT Since the 1980s, rapid and unplanned urbanization has caused environmental pollution. It is accepted that noise pollution has a major impact on health, such as physical, physiological, psychological and performance-related effects, all over the world. This paper provides an evaluation of noise pollution in three urban parks in the city of Trabzon, located in the north-eastern part of Turkey. Equivalent noise point levels were measured during a 3-minute spread at each park. Measured values were compared with national legislation (Law: 60) allowed limits, and the parks were thus classified as either "acoustically polluted or unpolluted." Urban parks in Trabzon's city center, surrounded by roads with heavy traffic and intense commercial activities, do not satisfy any of the standards used. The most noise-polluted parks in Trabzon were the Meydan Park, Atapark and Fatih Park with measured Leq of dB (A) Meydan park (63.74), dB (A) Atapark (64.15) and dB (A) Fatih park (64.67). This paper examines the opportunity of using plant material (*Syringa vulgaris, Viburnum lantana* and *Acer pseudoplatanus*) to minimize noise to acceptable levels in the three urban parks located inside Trabzon's city center. At the end of this examination, it was concluded that is possible to reduce noise to acceptable levels in all three parks, by using green barriers decorated with plant material. In this way, the noise level was reduced, which will have a positive effect on human health.

INTRODUCTION

Environmental pollution becomes more severe and widespread due to population growth, urbanization and industrialization in the cities (Ralte et al. 2013). There are many factors which cause the environment to be polluted and one of those undesired and unpleasant factors is 'noise' which affects the quality of life (Haq et al. 2014). Numerous researchers have demonstrated that exposure to environmental noise may increase the risks related to personal health, such as nervous frailty, extreme irritability, muscle cramps, stress and anxiety, dizziness, headache and migraine, anger, loss of body balance. Consequently, noise pollution is one of the major problems for developing countries. There is a need to control the noise exposure levels in sensitive areas such as hospitals, schools and kindergartens (Mitra 2008; Oyedepo and Abdullahi 2009; Noori and Zand 2013; Amin et al. 2014; Marriscal-Rammires et al. 2014; Mukhola 2014).

This situation has led to protective, noise-controlling legislation, such as the Occupational Safety and Health Act, the Noise Control Act, European Directive 2002/49/EC and the Quiet Communities Act (Moudon 2009). The World Health Organization (WHO) and the US Environmental Protection Agency consider that the safe level of equivalent continuous sound (L_{Aeq}) for human health is 70 decibels (dB) (WHO 2000). However, according to this legislation, 80 million people suffer from unacceptable noise levels and 170 million experience serious annoyances during daytime in the European Union (EU) (Miedema 2007).

The urban parks, which are the main focus of this paper, stand out as important areas of social life providing access to nature and opportunities for various uses (rest, sports, relaxation, games, cultural events and sightseeing) with acoustic comfort, with a large number of studies focusing on the problem of noise pollution at urban parks (Li et al. 2002; Morillas et al. 2002; Zannin and Szermetta 2003; Lam et al. 2005; Cengiz et al. 2012; Hunashal and Patil 2012).

In addition to this there are many field surveys about the reduction of noise using plants (Beckett et al. 2000; Fang and Ling 2005; Ozer et

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al. 2008; Pathak et al. 2008; Islam et al. 2012; Vasilakopoulou et al. 2014).

In Turkey, noise is now considered as one of the main environmental problems (Kelkit 2003). The number of cars and levels of urban noise in Turkey have been increasing and reached high levels (Bekci et al. 2013). Due to the increase in population density and the process of development as a city, Trabzon cannot provide the acoustic comfort of living to its public and continues to present unhealthy living conditions. Because of insufficient communication and the huge number of cars in traffic, the noise problem has become more difficult to solve. This paper was carried out in order to determine the extent of noise levels in Trabzon's urban parks (Meydan Park, Fatih Park, Atapark). The second aim of the paper was to explore solving this problem with the use of plants.

Noise and Health

Today, noise pollution is generally defined as unwanted or loud noise or undesirable sound levels. Environmental noise may cause adverse effects for individuals as well as creating situational factors. Noise pollution is distinguished from other pollution categories due to its source and diffusion characteristics, which can adversely affect public health and environmental quality in the urban environment. The WHO recently estimated that traffic noise could conservatively account for over one million health years of life lost annually in the European Union and Western European countries. At the same time WHO recognized the following effects on the health of the population that can emanate from noise: disturbance in sleep patterns, cardio respiratory and psycho-physiological systems and hearing. It may also have negative and intervening effects on communication, productivity and social behavior (WHO 1993, 2011; Tsitsoni et al. 2005; Samara and Tsitsoni 2007).

Noise can be defined as the level of sound, which exceeds the acceptable level and creates annoyance. Frequent exposure to high level of noise can cause severe stress on the auditory and nervous system (Subramani et al. 2012). The impact of noise on human health has been studied in four aspects. These are as follows: physical effects (temporary or permanent hearing loss), physiological effects (breathing difficulties, heart disorders, high blood pressure, sleep disturbance), psychological effects (adverse emotions including anger, anxiety, depression and behavioral disorders) and performance-related effects (reduction in reading, learning and work performance, lack of concentration) (Onder and Kocbeker 2012). The effect of noise on children was also reported including findings such as increased blood pressure and annoyance reactions (Paunovic et al. 2009; Liu et al. 2014). Some studies conducted on children describe effects of noise on executive functioning (EF) (decision making, working memory and self-regulation of emotions and behaviors) and cognitive performance (Fritschi et al. 2011; Belojevic et al. 2012).

The effect of noise is the most prominent feature of the noise from the physical of inability to hear. Most studies recommend that for L_{Aeq}, exposure to 24h of less than 70dB does not lead to any permanent hearing loss. At the same time 70dB (L_{Aeq}, 24h) noise conditions can cause permanent damage to human health (King and Davis 2003). According to the Ministry of Environment and Forestry standards found in the regulation (2002/49/EC), the levels of compliance are given in Table 1.

Table 1: Standards of noise level for various areas of community (Environmental Noise Assessment Regulation)

Description of area	*Noise level dB(A)*			
	Refurbished ways		*Existing roads*	
	Day time 6.00AM-9.00PM	*Night time 9.00PM-6.00AM*	*Day time 6.00AM-9.00PM*	*Night time 9.00PM-6.00AM*
Rural area	55	45	60	50
Sensitive Areas (parks, schools, hospitals, mosques, Silence area)	60	50	65	55
Settled Area	63	53	68	58
Commercial Area	65	55	75	75
Industrial Area	75	70	75	75

Noise and Plants

Since plants, which are living organisms, can reduce noise, they are used in landscape architecture as "natural, living noise barriers." Accordingly, green natural elements found in the cities are required for health reasons as they make positive visual and psychological contributions to human health and well-being (Ozbilen and Var 1992; Bekci et al. 2012). The initial studies on the noise prevention using plants were conducted by Beck and Meyer in 1960-1970s. Some types of plants are better at performing noise reduction than others. Bernatzky (1978) state that pollution-preventing characteristic of plant materials change depending on the plant variety, that is, needle-leaf or evergreen plant, its crown diameter and the size and hardness of its leaves. Especially tree belts along roads can be used as solutions to achieve road traffic noise reduction but few quantitative data have been reported on the significance of height, density, width and length of tree belts for noise reduction (Fang and Ling 2003, 2005; Renterghem 2014). Despite the limited knowledge available plants have been used as plant barriers while trees have been used as tree belts in the landscape architecture for the purpose of noise reduction.

MATERIAL AND METHODS

Material

The study area was the city of Trabzon located on the Black Sea coast in the north-east of Turkey (N 41⁰00'00" and E 39⁰43'00"). The city of Trabzon's surface area is 4.865 km^2 and total population is 757.898. People living in the urban, the centres of districts, comprises 426.882 of this population. As the majority of the population lives in city centres, urban parks are used extensively. This paper was conducted in three urban parks in the city of Trabzon which are presented in Figure 1. The parks, Meydan Park, Fatih Park and Atapark, are located along the Tanjant Highway which is prone to traffic jam problems.

As given in Table 2, Meydan Park is located in the center of the city. It is a strictly urban park, surrounded by roads with heavy traffic. Fatih Park, which is 200 metres away from the city center, is the only park with a children's playground and is also surrounded by roads. Atapark is in 4 km of walking distance to the city center. The most important feature of this park is that it is surrounded by different architectural works such as the ancient Trabzon Castle and the city walls, historical Gülbahar Hatun Muse-

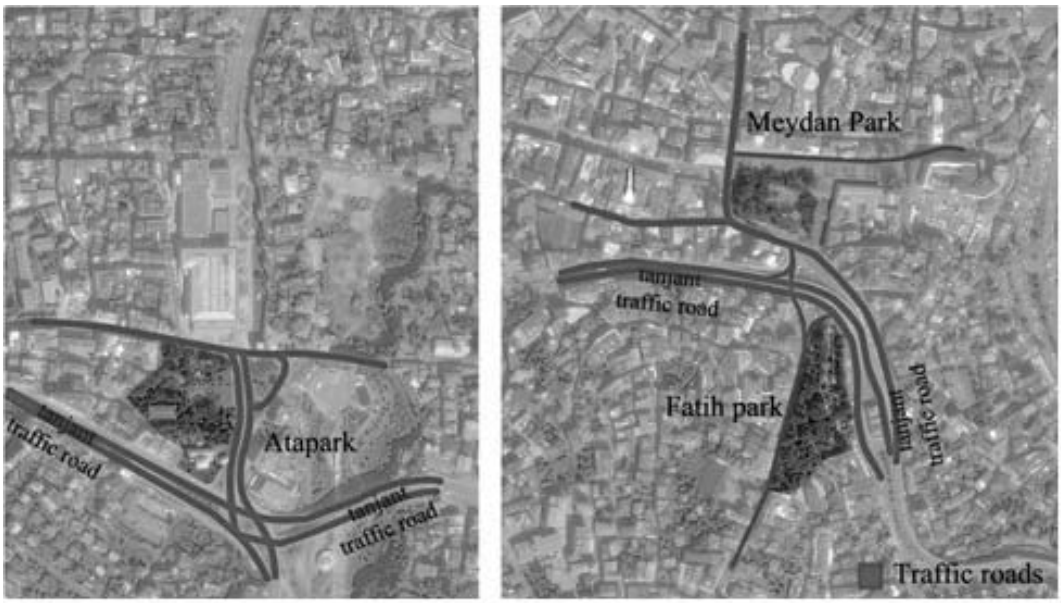

Fig. 1. Study areas

Table 2: Description of study area

Name	*Location*	*Characteristics*	*Plantation*	*Facilities*
Fatih Park				
	Distance 200m to the city center	4764 m^2 hard surface 5016 m^2 green areas 9780 m^2 total area 350 m^2 playground 155 sitting units	128 tall trees 20 medium trees 410 small trees 132 m^2 seasonal flower area	Police station Playground Wetland areas
Meydan Park	In the city center.	4270 m^2 hard surface 1500 m^2 green areas 5770 m^2 total area 184 sitting units	74 tall trees 25 medium trees 495 small trees 210 m^2 seasonal flower area	Mosque City hall Shopping center Ceremony area Wetland areas
Atapark	Neighbor to Gülbaharhatun. Distance 4 km to the city.	4939 m^2 hard surface 2115 m^2 green areas 4939 m^2 areas used by business operator on hard surface 713 m^2 playground 104 sitting units	147 tall trees 7 medium trees 341 small trees 72m^2 seasonal flower 7767 m^2 total area	Mosque Library Hospital Shopping centre Theatre Wetland areas

um, Varliba^o Shopping Mall and Trabzon Central Library. Additionally, it is subject to heavy traffic.

Methods

To detect the extent to which noise can be reduced with the help of plant elements in the urban parks with heavy traffic, measurements were made at 31 points in total in three urban parks in Trabzon (10 points in Meydan Park, 13 points in Atapark, 8 points in Fatih Park). Measurement points were decided considering the 8:00 am – 5:00 pm time interval, the working time, when traffic was heavy. Measurements were made on Mondays, the first working day of the week. Due to the proximity of the parks to the roads of heavy traffic, measurements were made at 3 minute period intervals at the corner and central points of the parks surrounded by roads. Measurements were performed at the height of 1.20 m, taking as a measurement basis the average ear height of a person in seated position. Plants chosen to prevent noise in the scope of the paper were preferred due to their capacity to absorb noise as a result of physical characteristics such as dense foliation and branching, plants with leaves or coniferous plants (adapted to the climate conditions of Trabzon), plants with strong stem structure and those that require minimal ecological conditions. In this scope, *Syringa vulgaris* (Class IV), *Viburnum*

Table 3: Suitable to the climatic conditions of Trabzon plant species

Latin name	*Class*	*Crown diameter (mt)*	*Height (mt)*
Acer negundo	Class III(4-6 dB)	6-8	10-25
Betula pendula		8-10	25-30
Lonicera japonica		dispersed	2-3
Forsythia intermedia		dispersed	1.5-2
Cornus alba		3-4	4-5
Syringa vulgaris	Class IV(6-8 dB)	4	6-7
Ilex aquifolium		3	8
Quercus robur		15-20	50
Rhododendron ponticum		dispersed	5-6
Viburnum lantana	Class V(8-10 dB)	3	3-4
Viburnum rhytidophyllum		3	3
Tilia platyphyllos		10-12	20-30
Acer pseudoplatanus	Class VI(10-12 dB)	25	20-30

lantana (Class V), and *Acer pseudoplatanus* (Class VI) plants listed in Table 3 were selected as study plants, since they could adapt to regional climate conditions to be used as plant materials in the mentioned parks with the aim to reduce noise level of studied parks down to normal dB levels. As in Beck's (1967) study, noise barriers were organized as noise-preventing green barriers in 3-component plant groups of "tree-small tree-bush," increasing at vertical axis from small to large component.

or Meydan Park, L_{Aeq}=64.67 for Fatih Park and L_{Aeq}=64.15 for Atapark. As a result of these findings, all studied urban parks were concluded to have exceeded the noise level. In order to reduce the noise down to acceptable levels and to keep these areas within the limits of Noise Control Regulations, the noise level was reduced using plant elements similar to those used by Fang and Ling (2005), Tyagi et al. (2006), Yang et al. (2011), Al-Dabbous and Kumar (2014).

Three-plant groups, which are given in Figure 2, *Syringa vulgaris* (Sv), *Viburnum lantana* (Vl), and *Acer pseudoplatanus* (Ap) were arranged in this study similar to that in Fang and Ling (2003) and Beck (1967) studies. In studies where similar plant groups were used Fang and Ling (2003) showed the noise levels to be reduced by 2.9-6 dB(A), Renterghem et al. (2012) 3-4.7 dB(A) and Rentherghem et al. (2014) by 1.1-3.6 dB(A). In this study as in Huddart (1990),

RESULTS AND DISCUSSION

Noise level measurements made in the urban parks of Trabzon city were evaluated for each park separately. Evaluation results are listed in Table 4. Measurement points were associated with the proximity of parks to roads and their surface area; thus, more measurements were made in the areas with heavy traffic.

Measurements produced the following results for the studied urban parks: L_{Aeq}=63.74 these plant groups were recorded to reduce noise by 9 dB(A). This value was calculated by averaging the noise reduction values of the studied plant groups (listed in Table 3) by using the following formula:

Sv((6+8)/2) +Vl((8+10)/2) +Ap((10+12)/2)= 7+9+11= 27/3= 9 dB(A)

New dB(A) values were calculated for each point separately on the basis of the selected plant groups. Resulting values are presented in Table 5.

According to Table 5, the noise level of Meydan Park was reduced to L_{Aeq}=54.74 while that of Fatih Park was lowered to L_{Aeq}=55.67 and for Atapark to L_{Aeq}=55.15 dB(A). These values were found to be close to the values obtained from the studies measuring noise level (Ahmad et al. 2006; Zannin et al. 2006; Ozer et al. 2008) and were approximated to the limits stipulated by the Noise Control Regulation.

Table 4: Sound levels measured in each park (between 9:00 am – 10:30 am)

Measurement points	*Urban parks*								
	Meydan Park			*Fatih Park*			*Atapark*		
	L_{AMax}	L_{AMin}	L_{Aeq}	L_{AMax}	L_{AMin}	L_{Aeq}	L_{AMax}	L_{AMin}	L_{Aeq}
1	70.1	56.2	60.7	72.3	61.8	65.4	85	65.1	71.8
2	70	56	62.6	72.2	59.6	63.6	71.7	61.1	67.1
3	70	59.9	63.7	85	59	72.5	68.8	58.9	63.9
4	73.2	63.5	66.7	66.8	55.5	60.2	74.5	60.3	67.4
5	72.7	56	64.4	73.9	55.3	65.1	70.3	57.2	63.2
6	73.7	60.5	63.8	69.2	53.5	58.4	71.1	54.9	60.9
7	69.5	58.5	64.1	71.7	54.3	62.3	70.9	50.6	58.3
8	70.8	59.4	65.8	89.6	56.6	69.9	72.9	53.7	63.8
9	72.9	58	61.6				65	53.6	57.3
10	77.2	61.4	64				67.1	56.1	61.4
11							71.9	55.7	64.7
12							80.3	62.3	69.2
13							71	57.9	65

L_{AMax}: maximum sound level, L_{Aeq}: equivalent continuous sound level, L_{AMin}: minimum sound level

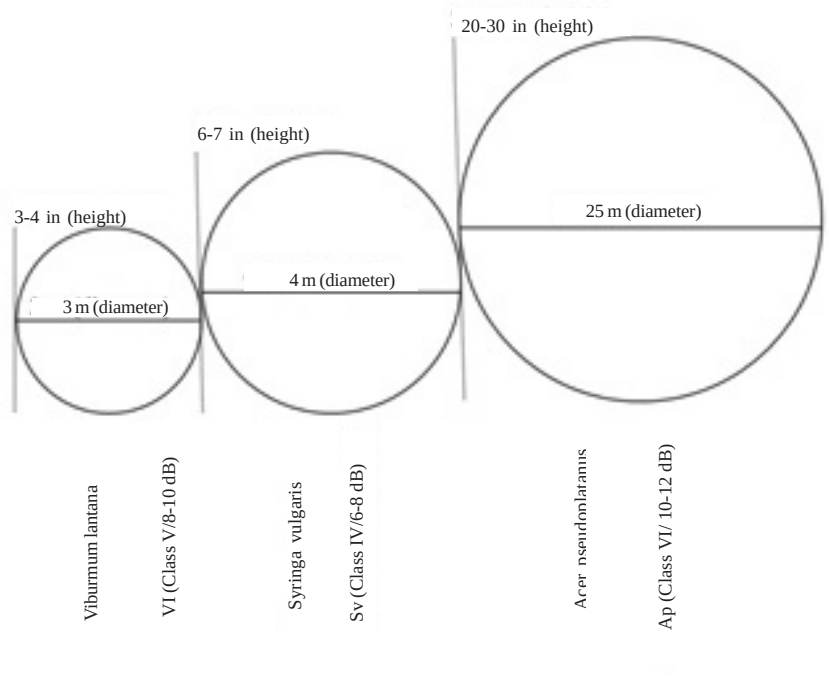

Fig. 2. The sample of group plants for the city of Trabzon

CONCLUSION

Traffic density increases in parallel with the global population growth, which affects noise pollution in urban parks. In this scope, it is possible to reduce the noise levels of park areas to normal levels by using natural or artificial landscape elements. Individual or in-group use of plant elements can reduce noise levels. Considering use density of urban parks, reduction of the noise levels of these parks down to normal noise levels will offer positive contributions

Table 5: New noise level decreases with 9dB(A)

Measurement points	*Urban parks*								
	Meydan Park			*Fatih Park*			*Atapark*		
	L_{AMax}	L_{AMin}	L_{Aeq}	L_{AMax}	L_{AMin}	L_{Aeq}	L_{AMax}	L_{AMin}	L_{Aeq}
1	61.1	47.2	51.7	63.3	52.8	56.4	76	56.1	62.8
2	61	47	53.6	63.2	60.6	54.6	62.7	52.1	58.1
3	61	50.9	54.7	76	60	63.5	59.8	49.9	54.9
4	64.2	54.5	57.7	57.8	46.5	51.2	65.5	51.3	58.4
5	63.7	47	55.4	64.9	46.3	56.1	61.3	48.2	54.2
6	64.7	51.5	54.8	60.2	44.5	49.4	62.1	45.9	51.9
7	60.5	49.5	55.1	62.7	45.3	53.3	61.9	41.6	49.3
8	61.8	50.4	56.8	80.6	47.6	60.9	63.9	44.7	54.8
9	63.9	49	52.6				56	44.6	48.3
10	68.2	52.4	55				58.1	47.1	52.4
11							62.9	46.7	55.7
12							71.3	53.3	60.2
13							62	48.9	56

L_{AMax}: maximum sound level, L_{Aeq}: equivalent continuous sound level, L_{AMin}: minimum sound level

for users in physical, physiological and performance-related terms.

The use of plant materials in especially in sensitive areas will serve as precautions for potential public health problems, specifically those concerning children.

Although noise pollution is the most frequent type of pollution in Turkey, it is also the less cared for as well as dealt least with using legal action. Even though the legal framework is suitable, the issue is not given much importance. This result reveals the necessity for the cooperation of the governmental institutions and non-governmental organizations for efforts against noise and for reduction of negative effects of noise levels.

RECOMMENDATIONS

Related public agencies and institutions should develop projects to raise public awareness for noise reduction. Since it is impossible to control the vehicle density, which increases in parallel with the population growth, the practice to reduce noise by using living plant barriers should be generalized, particularly to the urban parks, children's playgrounds and open space areas. In order to obtain the anticipated results from the use of these plant species, care should be taken with the properties of the plant material and their application principles. In order to reduce noise, increasing the distance between living areas (hospitals, parks, schools, etc.) and the heavy-traffic roads and use of plant barriers should be the priority.

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