616. Measurements of noise at crossroads and on transportations, its effects and possible measures to take

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Abstract. Noise has some effects which can be explained under the titles as 'psychological', 'physical', 'physiological', and 'related to performance'.

The psychological effects are general feeling of annoyance, boredom, bad-temper, and behavioural disorders; the physiological effects are the increase in blood pressure, faster breathing and pulsation, changes in body activities, disorders in blood circulation and sudden reflexes. The physical effects are temporary or permanent hearing damage. The effects on performance are associated with difficulty in concentration, lack of movement, and decrease in efficiency at work. It may not be possible to keep noise at normal levels in every condition but it may be possible to keep its effects under control by various arrangements and preventions. The measurement and definition of the noise, desired to be kept under control, by accurate methods and systems is a determinative factor in prevention of noise. For this aim the noise measurements were applied in Kadikoy, on the Anatolian Side of the city of Istanbul. In the research the measurements were made on five major crossroads and on mass transportations and the results were analyzed. The time of the measurements was randomly selected within working hours on weekdays. The data were obtained at certain periods of time from different spots and the results were presented.

Key Words: noise, traffic, city noise, noise measurement.

1. Introduction

1.1. Voice

The intensity of the sound, which is one in a million atmospheres pressure is expressed as microbar. "Bell" is a measure which determines the intensity of sound. In practice, decibel (one-tenth of a bell) is used. Our ears detect sounds between 0 and 140 decibels. This hits another audio format is dependent on power supply. A sound power source, a reference value to define the precise terms are needed. This value is "PICOWATT" [1]:

$$Sound \quad power \quad level = 10\log_{10}\frac{W}{W_0}dB, \tag{1}$$

W_0 = 10-12 picowatt.

In the above equation, the coefficient 10 to provide an integration with daily life Bell was used in order to convert to decibels.

Physiologically healthy young ear can hear the lowest dB sound pressure and it is known as hearing threshold. This threshold is "zero" dB. Difference between two sounds that can be distinguished by ear is called as decibel [1].

Table 1. The decibel values denominated in various audio elements

dB VALUES	SOUND TYPES
0	Dead silence
10	Desert Silence
20	Whispering
30	Quiet rural
40	Quiet apartment
50	Normal voice
60	High human voice
70	Normal traffic flow
80	Heavy traffic flow
90	Upcoming underground train
100	Large orchestra
110	Lawn mower
120	Motorcycle racing, extreme forced motor
130	Aircraft engine turbine

1.1.1. Frequency

Frequency is the number of vibrations per second, and the unit of frequency is hertz (Hz) [2]. Voice varies in the range of 500-2000 Hz. Healthy human ear hears sounds between 20 and 20000 Hz. This region is called “audible frequency range”. Sound below this limit is called infrasound, and sound above this limit is called ultrasound. Sounds that are outside the audible limit are heard, but they have harmful effects, for example, sickness, unrest, headache. Infrasound that is most commonly induced in motor vehicle usually occurs depending on the technology. According to international standards, higher noise level that damages hearing system is 100-10000 MHz, and is above 85 dB [3].

A sound of 1000 Hz is heard about 20 mPa by a young and healthy human ear and this value is called the human ear hearing threshold. Human ear pain threshold is sound pressure level about 100 Pa [4]. The pain threshold is able to vary according to the person. The noise threshold for pain intensity 120-140 dB (A) varies according to people.

Frequency defines the height of the sound. A certain density of low-frequency is likely to lead to hearing loss. In addition, it is used as tone quality of sound, that indicates softness and hardness of sound, and “timbre” - term that can be called as color of sound.

1.1.2. Timbre of the Sound

Timber of sound is called as the perception of sound [5]. It is the color difference between the sounds. If the number of periods per second forming frequency is higher, sound is

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treble; if it is lower, sound is bass. Sound, this unique color, carrier of a vibration (prime wave) on the "rate" as the side of vibration (harmonic of) the complex formed by the thousand as a result of gains as a result of vibrations.

1.1.3. Pure, mixed, complex sounds

If the change in sound pressure is periodic, the fundamental frequency of sound is the number of repetitions per second of sound pressure. These types of sounds, i.e. consisting of a single frequency, are called pure tones. All the sounds found in nature are a mixture of pure tones.

1.2. Vibration

Vibration is the mechanical oscillation around an equilibrium point [1]. These oscillations may be periodic like a pendulum movement or they may be random such as wheel movement on a gravel road. Sound and vibration studies are linked with each other quite closely. Sound is created by vibrating structures such as the pressure waves or vocal cords. In addition, pressure waves cause to vibrate structures such as eardrum. Therefore, efforts to reduce noise are often related to reduction of vibrations [1].

2. What is the noise

Noise is unwanted sound. In this respect the noise is defined with relation to sound and vibration. The noise which has a random spectrum is defined as unwanted sound. Listening to loud music at home could mean for us, such as loud music, but neighbors could hear it as noise. Noises not only disturb people but also create physiological and psychological problems that may severely threaten human health.

Scientific findings indicate that noise adversely affects organic, neural and psychological structure of humans. These adverse effects depend on several factors. These are:

- Noise frequency,
- Duration of exposure to noise during the day,
- This time exposure to noise during the day according to the distribution,
- The average noise value,
- Exposure to noise during the working life of the total time.

Individual's age, sensitivity and the environment can be listed as trained [6].

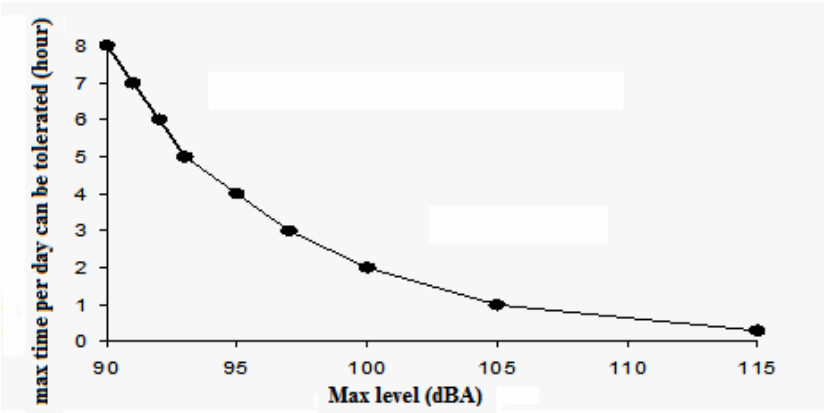

Fig. 1. Noise-time curve exposed during the day [6]

Intensity of noise emitted in the atmosphere is known to decrease with distance. Besides distance, some factors such as environment viscosity, temperature differences, air vortex play an important role in spreading of noise in the atmosphere. Environment viscosity reduces the frequency of noise and changes the direction of propagation. The spreading of noise present in the environment is important in terms of absorption and the reflection of sound waves. The natural obstacles (forest, vegetation, etc.) have significantly absorbed capacity on earth. These obstacles are preventing the spread by reducing intensity. Especially high-frequency noise level is thereby decreased to a greater extent. In addition, the type of material plays an important role in noise reduction. For example, short grass is lower in sound-absorbing capability. In addition, noise was determined to be reduced by high grasses or corn cultivated fields each 100 meters by the 20 dB. Part of a noise factor to the surface by the material is absorbed, a portion is transmitted and some is reflected back to. The materials which are described as hard in terms of acoustic properties reflect a large amount of sound back. In this case, those materials create a negative environment for those living in it. Rough and heavy materials are used for noise control by preventing sound reflection. The settlements are classified in Ministry of Environmental Noise Reports, which were prepared by dr. Çağatay Güler and Zeki Çobanoğlu. According to this classification it is addressed and noise rates Istanbul district of Kadikoy Anadolu Yakası III. Region City center residential areas, main roads, business locations (traffic flow at a distance of 20 m) category in the framework of assessment is deemed to be eligible. Region an average of 65 dB of common noise level is indicated [7].

Noise levels indicated in this report are as presented in Table 2.

Table 2. Noise levels

Day Time	Time	Level
Daytime	(06.00 - 19.00)	45-35 dB
Evening	(19.00 - 22.00)	40-30 dB
Night	(22.00 - 06.00)	35-25 dB

2.1. Transportation noise

Noise control is very important with respect to the amount of traffic noise. Traffic noise according to the conditions in the land, air, sea and ground transportation noise caused by the impact creates a separate one. According to place within the city of urban fabric and settle, while air and sea noise do not carry any significance for some regions, it can be very effective for some regions. But road traffic noise in urban transportation is everywhere due to widespread roads. However, activity is not the same everywhere.

Road Traffic Noise

Road traffic noise is a kind of noise that people are exposed the most. The cause of the noise in road traffic can be classified in terms of motor vehicles accents, consisting of the speed of the vehicle, road quality and traffic density [8]. Diesel-driven vehicles are generally more noisy than gasoline ones [7].

With the road surface friction wheel vehicles as a result of the traffic noise which represents another important source of noise. Because, according to research if the speed of a car exceeds 60 km/h, noise due to friction is more than the engine noise [7] .

Railway Traffic Noise

Although trains usually generate low-frequency noise, nowadays various differences can be observed in noise level due to engine type, machinery equipment and railway condition. Especially fast train passes through the bridge causing increased noise among the detected data. Train that reaches a speed of 200 km/h has been observed to increase rate of high-frequency noise energy. This problem is particularly significant in Japan due to widespread use of high-speed trains [10]. In addition, people who live in places close to train line are affected by ground vibrations induced by passing trains [9].

2.2. Sensory Hearing, the Noise and Effects

Noise arises from changes in air pressure and these are waves with density differences. Human ear perceives atmospheric pressure fluctuations that can be transmitted to the brain via electrical message. In addition, the inner ear structure has mechanism that provides body's physical balance.

Effects of Noise

Changes created by the noise in the inner ear can lead to the temporary or permanent hearing loss. The inner ear includes both the cochlea hearing organ and the vestibulum balancing organ. Cochlea is the end of perioheral hearing and it conserves hair cells the cornerstones of hearing in a structure called the corti. In response to sound stimuli occurring fluctuations in the hair cells, these cells are associated with the received by the auditory nerve fibers of the brain that are submitted to the center. Effects of noise in the inner ear occur in the form of damaging hair cell. Acoustic trauma occurs as a result of exposure to a very high intensity blast-type noise. In acoustic trauma, volume forces mechanic nerves of structures in the inner ear and even corti organ can be divided from cochlea by rending. Membrane and middle ear ossicle of the people exposed to high intensity sudden noise can be damaged also. In inner ear, the first and most obvious effect on the behaviour of physiological damage is hearing loss in other words threshold decreasing that it is obtained with high frequencies as 4000 Hz. Longer duration of exposure to noise, frequencies include 80% of speech sounds (3000, 2000, 1000 and even 500 Hz) can also affect these losses [6]. Therefore, the longer the duration of exposure to noise, the effects on hearing damage in the inner ear reach to level that will affect communication [11].

2.2.1. Difficulty in timely prevention of noise-induced hazards

The question is, for example, why noise and vibration rates in public transport and traffic are not detected as noise. What is the influence on our health? There are many descriptions of this problem. But the answer to this question consists only in the pain of our perception of danger signal. There is no pain receptors in cochlea, so cochlea does not suffer, damage in cochlea does not cause pain. Therefore, noise is not perceived as danger and exposure to noise may continue. The pain is felt at sudden explosions over 130 dB, but hearing loss due to noise occurs in long-term exposure at much lower level. A second reason is the lack of information and data on this issue [11].

2.2.2. Effects of noise on humans

Human health problems due to noise effects:
- Psychological effects: behavioral disorders, anger, general ill feeling, tired.

- Physical effects: temporary or permanent hearing damage.
- Physiological effects: changes in bodily activity, blood pressure increase, circulation disorders, accelerated breathing and heart rate, sudden reflexes.
- Performance effects: reduction in work productivity, concentration disorders, the prevention of movements, fatigue [11].

Noise levels can also be classified with respect to degree of induced negative effects (Table 3).

Table 3. Physiological effects of noise level

1. Degree	30-65 dB	discomfort, anger, sleep disorders and concentration disorders
2. Degree	65-90 dB	physiological reactions: increase in blood pressure, heart rate and breathing, brain fluid pressure decrease, sudden reflexes
3. Degree	90-120 dB	increased physiological reactions, headaches
4. Degree	120-135 dB	permanent inner ear damage, impairment of balance
5. Degree	140 dB	severe brain damage

3. Methods

Sound level meter that was used for noise measurement is a handheld two-sound level meter SL 4001 (IEC 651, International Electrotechnical Commission). The meter is CE certified. It is suitable for measurement according to standard ISO 1996-1.2003. All measurements were conducted with this device.

Safety rules for noise measurement:
- Before measurement, measurement of noise sources in the environment, reflective surfaces and the measurement location should be processed on a sketch.
- Measuring the brand of hardware items, type and serial numbers should be recorded. Also, the microphone used for measurement or characteristic features should be known.
- Sound level meter should be kept without moving arm's length away from the person making measurement. The effect of the measured sound field so that the body will be kept to a minimum level.
- The microphone should be 1.5 meters high from the ground, away from reflective surfaces.
- Sound level meter should be kept away from dusty environments, from magnetic fields and high temperatures.
- Determination of measurement location should be performed following measurement standards and regulations.
- Rainy and 5 m/sec high speed wind field measurements cannot be made. Even light wind conditions may affect measurements. While taking measurements in the open air and in the air flow, special housing of microphone must be inserted.
- Sound level meter has to be mounted on a stand, the floor should be absent of vibrations.
- Background noise in the environment must be controlled. If the measured difference between background noise levels is less than 10 dB, decibel levels measured by subtraction of the background noise is necessary to purify. When the difference is less than 3 dB it is not possible to make reliable measurements.

Noise assessment was submitted for Industrial Noise and Air Vehicle, Road Traffic and Railway Noise and other resources for the preparation of strategic noise maps. In this study, noise calculation and measurement paths used here, the date and 25862nd Official Gazette dated 01.07.2005 published in "Environmental Noise Assessment and Management Regulations" in Annex II shall be made within the specified standards.

4. Results

The sampling frequency was determined the accuracy of for measuring the average level, which could not reach very high values. Also measurements that can be performed on single-point at the same time has remained dependent on the overall time.

4.1. Mass transport vehicles and transportation

The biggest registered noise in our study was the traffic noise of public transportation. The people that live in apartments or work on the streets are the most affected by this noise, which results in stress and fatigue. High noise levels are observed in different public transport: rail transport and old buses. Shipping noise level is lower when compared to others. Traffic noise is the significant portion of the inner-city noises. Measurements have been made at some of the busiest intersections of the Kadıkoy district center and have been made in a public transport in the inner city.

4.1.1. Noise of the Public Transportation

Noise measurements were conducted in relation to sounds generated by buses, minibuses and commuter trains.

Commuter trains

Measurements have been made in Sogutluçeşme train station and in Haydarpaşa-Gebze commuter train. Commuter train interior noise ratios are shown in Figure 2.

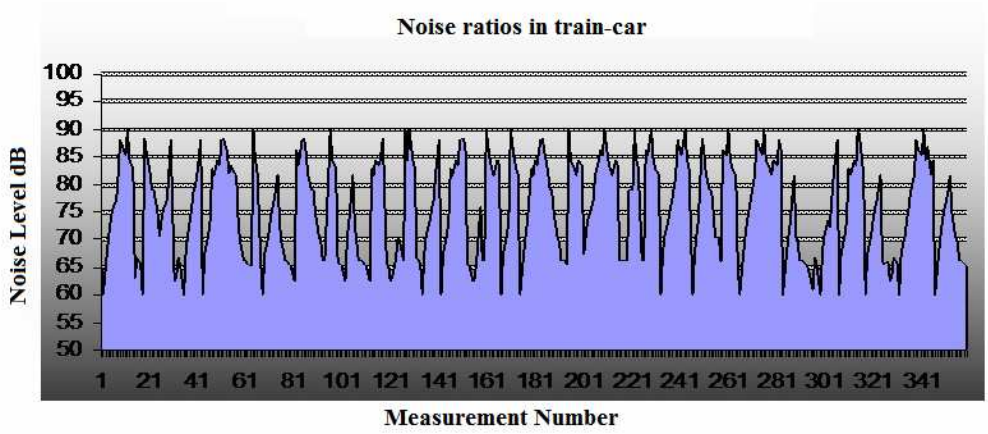

Fig. 2. Physiological effects of noise level

The average noise level in the presented graph is equal to 75.74 dB. Noise level of commuter train in motion can reach up to 90 dB(A). Although an average of measurement made for an hour and five-minute during the line is 75-74 dB(A), quickest way between two stops receiving noise is deemed to be 85-90 dB(A). The maximum noise level is 70 dB in the wagon needs to be in the noise report of Environment ministries [7]. The noise level of the wagon in the functioning system has been exceeded. The noise measurement results of train transition at the train station are given in Figure 3. The amount of noise is 70.05 dB when measured during train transition.

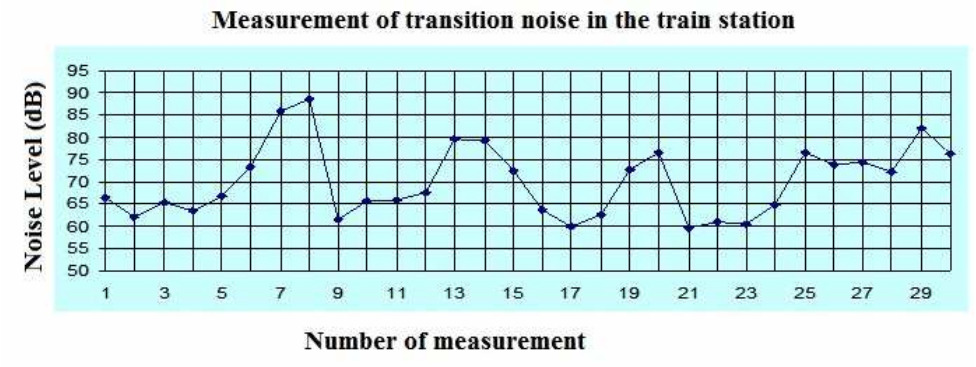

Fig. 3. Physiological effects of noise level

According to the Ministry of Environment, railway noise should be reported maximum at 65dB during daytime, while at night it should be 25 dB [7]. Findings concerning the measurements at the train station are also shown in Figure 4. The average noise value is measured at 70.52 dB. Noise level when the train enters the platform can reach up to 90 dB(A).

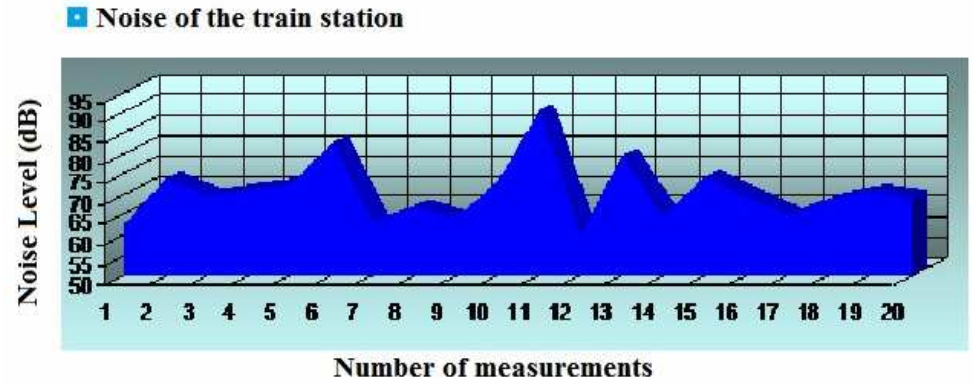

Fig. 4. Physiological effects of noise level

The highest noise at station has been measured in train that uses diesel locomotives. 91.3 dB average noise value was registered. The sound source can be seen to produce higher frequency noise.

Buses

Buses were evaluated using two measurements: public buses and municipal buses. Measurements started on 14 May 2008 at 13.00 in Kadıkoy-Pendik line. The results of measurements are provided in Figure 5, which indicate that the average noise value is 73.83 dB in the public buses and 74.57 dB in the municipal buses. Public and municipal buses were responsible for generating on average the same level of noise. The interior of the bus is normal crowded and there are no standing passengers at two measurements. Traffic is dense in the average course and smooth handle.

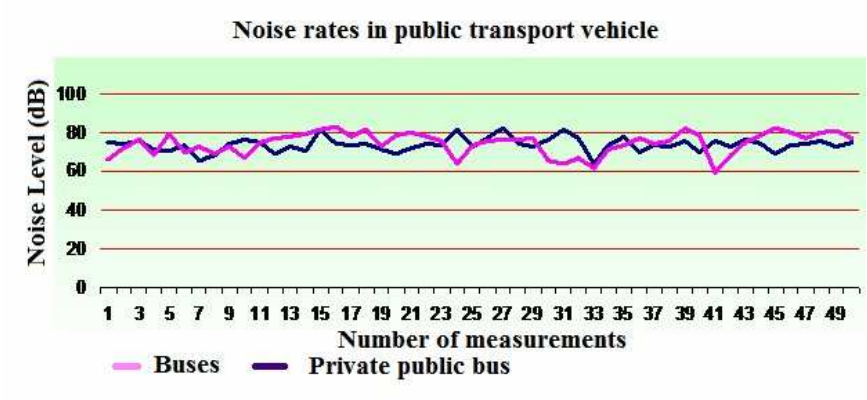

Fig. 5. Physiological effects of noise level

The maximum permissible noise level in the buses (urban) is 85 dB as indicated in noise report of Environment Ministry [7]. If it is considered to expose people to noise during this journey and is considered to be long for the average value of inner city transport, it is considered that it has a negative impact on passengers.

4.2. Junction noise of Anatolian side Kadikoy center

The last measurement was performed at center junction in Kadikoy. Noise measurement values were registered during 2 minutes (on 08.04.2008 at 10.00).

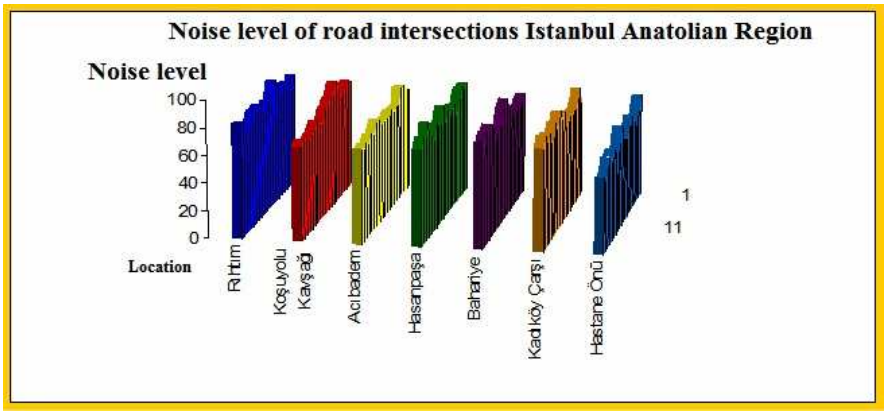

Fig. 6. Physiological effects of noise level

The results of noise measurements in different junctions are given in Figure 6 at Kadikoy region of Anatolian side in Istanbul. While Kadikoy-Rıhtım junction has the highest noise level (78.99 dB), in front of Hospital can be seen to be the lowest noise level (62.20 dB).

We can also state that ferries passing from Haydarpaşa port are a very important factor in terms of high noise at the coast.

Table 4. The average noise level in the junction

RIHTIM	KOŞUYOLU	ACIBADEM	HASANPAŞA	BAHARİYE	ÇARŞI	H. ÖNÜ
78,995	75,46	71,55	73,98	73,76	74,275	62,20

The average values of noise measurements in junction are listed in Table 4. Measurement is mainly in the regions: commercial businesses, educational institutions, places of worship, recreational areas, social places, entertainment places, etc. (i.e. mainly places where people spend their time). It can be said to be coming from Haydarpaşa to Kadikoy has high noise because of active using. According to results, the noise level detected in the traffic junction is damaging to health of the inhabitants.

Fig. 7. Measurement points of noise level in junction

5. Suggestions

1. The most appropriate way for reducing transportation noise is implementation of noise barriers. For example, the forestation can be done to reduce railway noise along railway line.
2. Periodic maintenance of technical condition of public transport leads to reduction of generated noise. In addition, new vehicles cause less noise. Replacement of old vehicles with new ones will contribute positively to reduction of traffic noise.

3. Commuter trains on the move generate 85 dB(A) noise to the passenger compartment. This is a level harmful to human health hearing. Sound insulation measures should be used in order to reduce the noise propagating from the wheel section to the cabin section of commuter train.
4. In addition, appropriate maintenance of railways and rail transport could contribute to reduction of generated noise. Development of noise regulations, and related organizations intensify control of activities needs to be strengthened.
- Adhere to the Health Directorate for Combating Noise Ankara.
- Ministry of Environment (Provincial Directorates of the Provincial Environment).
- Provincial Health Directorates.
- Municipalities.
- Universities.

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