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Subject	Environment Law
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Noise Pollution

Noise pollution, unwanted or excessive sound that can have deleterious effects on human health and environmental quality. Noise pollution is commonly generated inside many industrial facilities and some other workplaces, but it also comes from highway, railway, and airplane traffic and from outdoor construction activities.

Measuring And Perceiving Loudness

Sound waves are vibrations of air molecules carried from a noise source to the ear. Sound is typically described in terms of the loudness (amplitude) and the pitch (frequency) of the wave. Loudness (also called sound pressure level, or SPL) is measured in logarithmic units called decibels(dB). The normal human ear can detect sounds that range between 0 dB(hearing threshold) and about 140 dB, with sounds between 120dB and 140 dB causing pain (pain threshold). The ambient SPL in a library is about 35 dB, while that inside a moving bus or subway train is roughly 85 dB; building construction activities can generate SPLs as high as 105 dB at the source. SPLs decrease with distance from the source.

The rate at which sound energy is transmitted, called sound intensity, is proportional to the square of the SPL. Because of the logarithmic nature of the decibel scale, an increase of 10 dB represents a 10-fold increase in sound intensity, an increase of 20 dB represents a 100-fold increase in intensity, a 30-dB increase represents a 1,000-fold increase in intensity, and so on. When sound intensity is doubled, on the other hand, the SPL increases by only 3 dB. For example, if a construction drill causes a noise level of about 90 dB, then two identical drills operating side by side will cause a noise level of 93 dB. On the other hand, when two sounds that differ by more than 15 dB in SPL are combined, the weaker sound is masked (or drowned out) by the louder sound. For example, if an 80-dB drill is operating next to a 95-dB dozer at a construction site, the combined SPL of those two sources will be measured as 95 dB; the less intense sound from the compressor will not be noticeable.

Frequency of a sound wave is expressed in cycles per second (cps), but hertz (Hz) is more commonly used (1 cps = 1 Hz). The human eardrum is a very sensitive organ with a large dynamic range, being able to detect sounds at frequencies as low as 20 Hz (a very low pitch) up to about 20,000 Hz (a very high pitch). The pitch of a human voice in normal conversation occurs at frequencies between 250 Hz and 2,000 Hz.

Precise measurement and scientific description of sound levels differ from most subjective human perceptions and opinions about sound. Subjective human responses to noise depend on both pitch and loudness. People with normal hearing generally perceive high-frequency sounds to be louder than low-frequency sounds of the same amplitude. For this reason, electronic sound-level meters used to measure noise levels take into account the variations of perceived loudness with pitch. Frequency filters in the meters serve to match meter readings with the sensitivity of the human ear and the relative loudness of various sounds. The so-called A-weighted filter, for example, is commonly used for measuring ambient community noise. SPL measurements made with this filter are expressed as A-weighted decibels, or dBA. Most people perceive and describe a 6- to 10-dBA increase in an SPL reading to be a doubling of “loudness.” Another system, the C-weighted (dBC) scale, is sometimes used for impact noise levels, such as gunfire, and tends to be more accurate than dBA for the perceived loudness of sounds with low frequency components.

Noise levels generally vary with time, so noise measurement data are reported as time-averaged values to express overall noise levels. There are several ways to do this. For example, the results of a set of repeated sound-level measurements may be reported as $L_{90} = 75$ dBA, meaning that the levels were equal to or higher than 75 dBA for 90 percent of the time. Another unit, called equivalent sound levels (L_{eq}), can be used to express an average SPL over any period of interest, such as an eight-hour workday. (L_{eq} is a logarithmic average rather than arithmetic average, so loud events prevail in the overall result.) A unit called day-night sound level (DNL or L_{dn}) accounts for the fact that people are more sensitive to noise during the night, so a 10-dBA penalty is added to SPL values that are measured between 10 PM and 7 AM. DNL measurements are very useful for describing overall community exposure to aircraft noise, for example.

Dealing With the Effects of Noise

Noise is more than a mere nuisance. At certain levels and durations of exposure, it can cause physical damage to the eardrum and the sensitive hair cells of the inner ear and result in temporary or permanent hearing loss. Hearing loss does not usually occur at SPLs below 80 dBA (eight-hour exposure levels are best kept below 85 dBA), but most people repeatedly exposed to more than 105 dBA will have permanent hearing loss to some extent. In addition to causing hearing loss, excessive noise exposure can also raise blood pressure and pulse rates, cause irritability, anxiety, and mental fatigue, and interfere with sleep, recreation, and personal communication. Noise pollution control is therefore of importance in the workplace and in the community. Noise-control ordinances and laws enacted at the local, regional, and national levels can be effective in mitigating the adverse effects of noise pollution.

Environmental and industrial noise is regulated in the United States under the Occupational Safety and Health Act of 1970 and the Noise Control Act of 1972. Under these acts, the Occupational Safety and Health Administration set up industrial noise criteria in order to provide limits on the intensity of sound exposure and on the time duration for which that intensity may be allowed.

If an individual is exposed to various levels of noise for different time intervals during the day, the total exposure or dose (D) of noise is obtained from the relation $D = (C_1/T_1) + (C_2/T_2) + (C_3/T_3) + \dots$, where C is the actual time of exposure and T is the allowable time of exposure at any level. Using this formula, the maximum allowable daily noise dose will be 1, and any daily exposure over 1 is unacceptable.

Criteria for indoor noise are summarized in three sets of specifications that have been derived by collecting subjective judgments from a large sampling of people in a variety of specific situations. These have developed into the noise criteria (NC) and preferred noise criteria (PNC) curves, which provide limits on the level of noise introduced into the environment. The NC curves, developed in 1957, aim to provide a comfortable working or living environment by specifying the maximum allowable level of noise in octave bands over the entire audio spectrum. The complete set of 11 curves specifies noise criteria for a broad range of situations. The PNC curves, developed in 1971, add limits on low-frequency rumble and high-frequency hiss; hence, they are preferred over the older NC standard. Summarized in the curves, these criteria provide design goals for noise levels for a variety of different purposes. Part of the specification of a work or living environment is the appropriate PNC curve; in the event that the sound level exceeds PNC limits, sound-absorptive materials can be introduced into the environment as necessary to meet the appropriate standards.

Low levels of noise may be overcome using additional absorbing material, such as heavy drapery or sound-absorbent tiles in enclosed rooms. Where low levels of identifiable noise may be distracting or where privacy of conversations in adjacent offices and reception areas may be important, the undesirable sounds may be masked. A small white-noise source such as static or rushing air, placed in the room, can mask the sounds of conversation from adjacent rooms without being offensive or dangerous to the ears of people working nearby. This type of device is often used in offices of doctors and other professionals. Another technique for reducing personal noise levels is through the use of hearing protectors, which are held over the ears in the same manner as an earmuff. By using commercially available earmuff-type hearing protectors, a decrease in sound level can be attained ranging typically from about 10 dB at 100 Hz to more than 30 dB for frequencies above 1,000 Hz.

Outdoor noise limits are also important for human comfort. Standard house construction will provide some shielding from external sounds if the house meets minimum standards of construction and if the outside noise level falls within acceptable limits. These limits are generally specified for particular periods of the day—for example, during daylight hours, during evening hours, and at night during sleeping hours. Because of refraction in the atmosphere owing to the nighttime temperature inversion, relatively loud sounds can be introduced into an area from a rather distant highway, airport, or railroad. One interesting technique for control of highway noise is the erection of noise barriers alongside the highway, separating the highway from adjacent residential areas. The effectiveness of such barriers is limited by the diffraction of sound, which is greater at the lower frequencies that often predominate in road noise, especially from large vehicles. In order to be effective, they must be as close as possible to either the source or the observer of the noise (preferably to the source), thus maximizing the diffraction that would be necessary for the sound to reach the observer. Another requirement for this type of barrier is that it must also limit the amount of transmitted sound in order to bring about significant noise reduction.

Causes for Noise Pollution

Urban planning

Insufficient urban planning can be regarded as one main cause of noise pollution. Especially in poor countries, people often live in crowded areas in which they will be surrounded by an excessive amount of noise all the time. This may come in the form of noise from neighbors or in the home itself.

Living with big families in small houses leads to noise pollution for the whole family. The population of spaces with too many people also increases the level of aggression, leading to fights and thus to an increased level of noise. Additional examples include the fight for parking spaces or the long waiting times in hospitals, which further increases aggression levels and therefore noise.

Industrialization

Through the industrial revolution, our material wealth has been significantly increased since the production costs of goods have dropped dramatically since we can now use machines for all kinds of manufacturing processes.

However, there is also a downside to the industrialization process. The increasing use of machines leads to a higher level of noise pollution. This is both true for noise inside and also outside of factories. For example, inside factories, workers are often exposed to high level of noise, which forces them to wear earplugs or other mitigating things.

On the other hand, there are construction workers who operate machines like caterpillars or excavators which also cause an excessive amount of noise.

Public transportation

Although it is better for the environment in terms of the emission of greenhouse gases compared to the use of cars, public transport can be a great source of noise pollution. The daily use of the tube can be quite loud in many cities. Moreover, the level of noise in the public transport vehicles itself caused by other passengers phoning or also yelling on each other can be quite significant.

Noise pollution from cars

Noise pollution from the use of cars can be quite annoying. Especially on main streets, the level of noise is often that loud that people will not even be able to talk to each other. This problem is mainly due to the use of cars consuming fossil fuels instead of electricity. Electric cars are much

quieter than cars using fossil fuels and thus would be good alternatives in order to reduce noise pollution.

Construction

Construction sites also cause significant amounts of noise which impact the surrounding environment in an adverse way. The use of big machines for construction activities usually leads to high levels of noise. This is true for all kinds of construction activities, including the construction of roads, airports, dams, bridges or also mining activities.

Since our world population grows every day, it is quite logical that we need an increasing amount of construction activities in order to have enough infrastructure. However, this increase in construction also increases the overall noise pollution level.

Children

Children need plenty of room and freedom to develop a healthy personality. This is important and useful for us as a society. However, living next to schools or other childcare institutions may lead to an exposure to high levels of noise. Children naturally do not care too much about their noise levels and thus people living nearby are likely to be affected by an increased level of noise.

Events

Another source of noise pollution are social events of all sorts. This can be concerts, festivals or all other kinds of events when large numbers of people gather and having fun. Especially events with loud music can lead to noise pollution for people living in the affected area in a significant way. Moreover, people who are living nearby the festival locations will also suffer from noise pollution from the mass crowds which travel to the concert locations.

Domestic appliances

In our daily lives, we use all sorts of household appliances which cause noise pollution. This includes, among others, the use of mixers, washing machines or also our smartphones and TVs. Since we use these devices on a daily basis and thus are quite used to them, we might not even be aware of the noise pollution. However, domestic appliances have a significant impact on noise pollution and thus on our well-being.

Agriculture

Agriculture and the related processes are another significant source of noise pollution. The use of agricultural machines can cause significant noise levels which may impact people living nearby.

Moreover, agricultural processes also include the processing of grains. This is accomplished in factories and other facilities which itself usually cause some noise. Moreover, the transportation of the grain as well as of the final products cause additional noise.

Alarm systems

Although the problem of noise pollution through alarm systems is usually not quite severe, it may happen that alarm systems react in the middle of the night and thus impact the sleep of people living in nearby areas.

Military

Military interventions and also military training can cause high levels of noise pollution for its participants. There are many people which worked for the military and suffer from hearing losses in their later years.

Storms

Storms may also contribute to the problem of noise pollution. Especially when storms are quite strong, they may overturn trees and thus cause significant amounts of noise. This may be especially annoying in the night when people try to sleep but are adversely affected by this kind of noise pollution.

Rainfalls

Heavy rainfalls are an additional source for noise pollution. Although natural, heavy rainfalls can lead to a significant increase in noise levels. Similar to storms, this may lead to an adverse impact on the sleep of people.

Thunder

Another related topic is noise pollution through thunder. Thunderstorms can be quite noisy and also may frighten some people, especially children. This may lead to sleep disorders and other adverse effects.

Effects of Noise Pollution

Psychological disorders

Noise pollution can cause all sorts of psychological disorders. In conjunction with our daily lives which become busier over time, our mental system will be in addition challenged through noise pollution.

People may not be able to handle all of this stress in a healthy way which may lead to mental disorders for some groups. A prominent example of psychological disorders in our society is the problem of burnout. People are stressed in their job and also often feel social pressure. These factors alone will be enough to hurt the mental system of people.

Handling the additional factor of noise pollution will drive some people mad, since they will no longer be able to handle and process the information flow in a healthy manner and thus develop mental disorders which may lead to harmful behavior against other people.

Tinnitus

Tinnitus is also quite related to the issue of noise pollution. Tinnitus may occur due to a prolonged to loud sounds. In most of the cases, Tinnitus is accompanied by a noise-induced hearing loss. Tinnitus may go away after a few hours or may also become a permanent issue when the exposure to noise is not stopped.

Stress

Stress is a main adverse effect of noise pollution. In our society, we already suffer from all kinds of stress factors. This includes stress related to our jobs, our families and also social stress. Noise is an additional factor that harms our mental condition.

Our brain has to deal with high numbers of impressions every day. However, if we have too many impressions, we will not be able to process this information properly and thus suffer from stress symptoms. This stress may translate into diseases like burnout or other serious health conditions.

Annoyance

Another related effect is that people often get annoyed by high levels of noise pollution. After a hard day at work, people usually want to have a quiet space in which they can relax and recover. However, noise pollution may prevent this plan. If people get affected by noise pollution over a sufficient amount of time, their annoyance level is likely to increase which may also lead to mental issues and illness.

Brain damages

According to scientists, a prolonged exposure to high levels of noise can alter the behavior of our brain concerning the processing of information and also our speech processes. This may lead to speech problems or other kinds of disorders.

The effect of noise pollution on our brains is subject to extensive research. It is likely that not all effects on our brain are yet discovered. Long-term studies may reveal additional adverse effects of excessive noise exposure on our brain system.

Hearing problems

Hearing issues are main effects of sound pollution. Every noise louder than 80dB is considered harmful to our hearing system if we are exposed to it long enough. This equals the noise of a dishwasher. Thus, in our daily life, we are often exposed to noise loud enough to cause hearing problems.

Moreover, if we are exposed to quite loud noises, e.g. club music which is turned on to the maximum, this can also cause temporary or even permanent hearing issues even if we only are exposed one time. An overview of the different dB-levels is given here.

Cardiovascular diseases

Cardiovascular diseases are another adverse effect of noise pollution. In our daily lives, we are exposed to many different impressions. If we get too many impressions, our brain is unable to handle all of them properly which leads to stress. This stress can come from work, from our social lives or from strokes of fate.

Stress in turn is quite harmful to our health since it contributes to all kinds of diseases, including cardiovascular issues. The most common issue from noise pollution are heart attacks. Thus, noise pollution indirectly leads to cardiovascular issues which cause serious health threats.

Communication issues

It is quite obvious that an excessive amount of noise prevents us from communicating to each other since we simply are not able to hear what the other person says. This can often be seen in daily lives when people walk on main streets.

Sometimes, the noise level is so loud that communicating to each other is almost impossible. Moreover, this is even more true for phone calls. If we do not wear decent headsets, we are likely to miss lots of information since we do not understand the other person properly.

Sleeping issues

Noise pollution can also cause sleeping problems, both directly and indirectly. It is obvious that when you are living near highways, you will suffer from the noise of cars all day and even at night which may cause sleeping issues. Moreover, you are likely to also suffer from sleeping issues through other mental effects.

Since you are exposed to so many impressions in your daily life, you may not be able to process all of it in a healthy way. As a result, your sleep may suffer since you are worrying about many different things.

Effects on animals and plants

Noise pollution not only has serious health effects on humans, it also impacts animals in an adverse manner. Since our world population grows, we need an increasing amount of resources to meet the demand for food and housing.

This leads to deforestation and thus to an impact on the local wildlife. By invading these areas, the nearby wildlife gets exposed to the noise of our daily lives. This can cause a change in behavior of animals and can also cause animals to leave.

If animals leave their original locations, this can also lead to an impact on trees and plants since many plants need animals like birds and insects since they deliver pollen from one plant to the next and also disperse the seeds. Thus, noise pollution can have significant adverse effects, not only on humans but also on animals and plants.

Solutions for the Noise Pollution Problem

Reduce sound in your space

In order to avoid the adverse effects of noise pollution, it is crucial that we reduce the sound in our living and working spaces. This means turning down the noise of your phones or other devices. If you are working, make sure you can minimize the noise around you.

If you are working in an office, make sure that you ensure a quiet atmosphere so that everyone can work effectively and is not distracted by the sounds of each other. If you work in jobs which expose you to loud noises on a daily basis like construction, it is crucial that you wear earplugs or other mitigating things.

When you come home from work and are stressed and tired, make sure that the sound exposure is turned down to a minimum. In this way, you can relax and reload your mental batteries. For example, this can mean reading a book instead of watching TV.

Turn off electronics

Another way to mitigate the problem of noise pollution is to turn off electronics. This can include your smart phone or other electronic devices like your computer or your TV. Turning off your smart phone from time to time can be quite relaxing.

Since you have to be available during your work day all the time, it can be beneficial for your mind if you just turn your smartphone off so that the information flow is stopped for a certain time. Turning off other devices like computers or the TV can also prevent noise pollution. Instead, you can play some parlor games with your family.

In this way, you do yourself a favor by mitigating the sound pollution issue and at the same time you improve the connection to your family.

Mask noise

Another way to fight noise pollution is to mask noise. This can mean installing wind chimes or running water features in order to create a peaceful sound environment. It is quite well known

that our mind reacts quite sensitive to such measures, meaning that we can manipulate it to be able to better deal with the noise around us.

Close windows

Another quite obvious measure against noise pollution is simply to close the windows if the noise source is located outside. This is especially relevant for people living near big roads or highways. By closing the windows, the noise pollution issue can be mitigated to a certain extent.

Move to another home with low level of noise pollution

Another way, although quite drastic, is to move from a high-level noise location to a home that is located in a quiet area. This may increase the life quality of many people, especially for those who are already mentally sick from noise pollution. Living near a forest instead of next to a highway can make a huge difference since the harmful effects of noise pollutions do no longer exist.

Build a fence

If you own a house and live in a noisy area, it may benefit you if you build a fence in order to mitigate the sound pollutions. Since fences are noise barriers, installing them may be a suitable measure in order to accomplish a quieter living space.

Plant trees

The same is true for trees. Trees are natural sound barriers which could cancel noise and thus help you to make your home quieter.

Install quiet spaces

Installing quiet spaces is also a suitable measure to fight the issue of noise pollution. Since we are exposed to noise almost every minute of our day, it would be beneficial to have some quiet spaces to relax. These quiet spaces can be installed at work or also at home.

Electric cars

Since car which use fossil fuels are much louder than electric cars, a switch to electric cars would decrease noise levels significantly.

Earplugs

Another common way to quickly fight noise pollution is to wear earplugs. This may be a suitable measure against noise, especially if you live in noisy areas or near highways. By using earplugs, your sleeping quality can be increased significantly.

Headphones

Another measure against sound pollution is the use of headphones. This can be a quite effective measure which is quite easy to integrate in your daily behavior. Especially at work, headphones have the advantage that they kill noise and also make it easier to do phone calls. Thus, headphones can increase your productivity and at the same time reduce the noise level.

Government regulations

Another way to mitigate the noise pollution issue is to set government regulations. This can mean setting maximum levels of noise which are allowed for different tasks. It can also mean protecting certain areas from noise at all. For example, it is quite senseful to protect forests or other spaces where people relax from noise pollution through appropriate regulations.

Be social

Everyone of us can reduce our noise level and thus our noise pollution which we impose on others. If everyone acts like this, we can collectively reduce the noise pollution in public spaces.

Education

Education is always a main source to fight issues. This is also true for the noise pollution problem. We have to make sure people understand that noise pollution can have dramatic adverse consequences for their health and for the health of others. If people understand this, they are more likely to adjust their behavior.

Convince others

We also have the responsibility to spread knowledge and convince other in order to be able to fight the noise pollution problem in an effective way.