NOISE CONTROL IN MECHANICAL SYSTEMS

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Week: 5

Lecture: 22

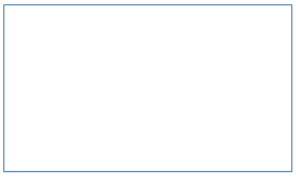
Lecture 22: Noise regulations and guidelines: 1

Hello and welcome to Lecture 22 in this course on noise control in mechanical systems. So, here we will start the last series of lectures in the module on human response to noise. So, here we have noise regulations and guidelines, part 1. So, to summarize, we have been discussing the human response to noise, which is hearing, and then the impact that noise has on human health. And then how to evaluate the noise-induced hearing loss, and the standard process of audiometry has been used to evaluate it.

Summary of previous lecture

- Human response to Noise: Hearing
- Impact of Noise on Human Health
- Noise Induced Hearing Loss

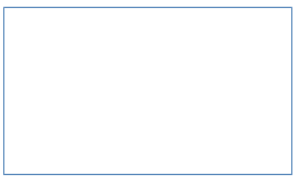
Audiometry



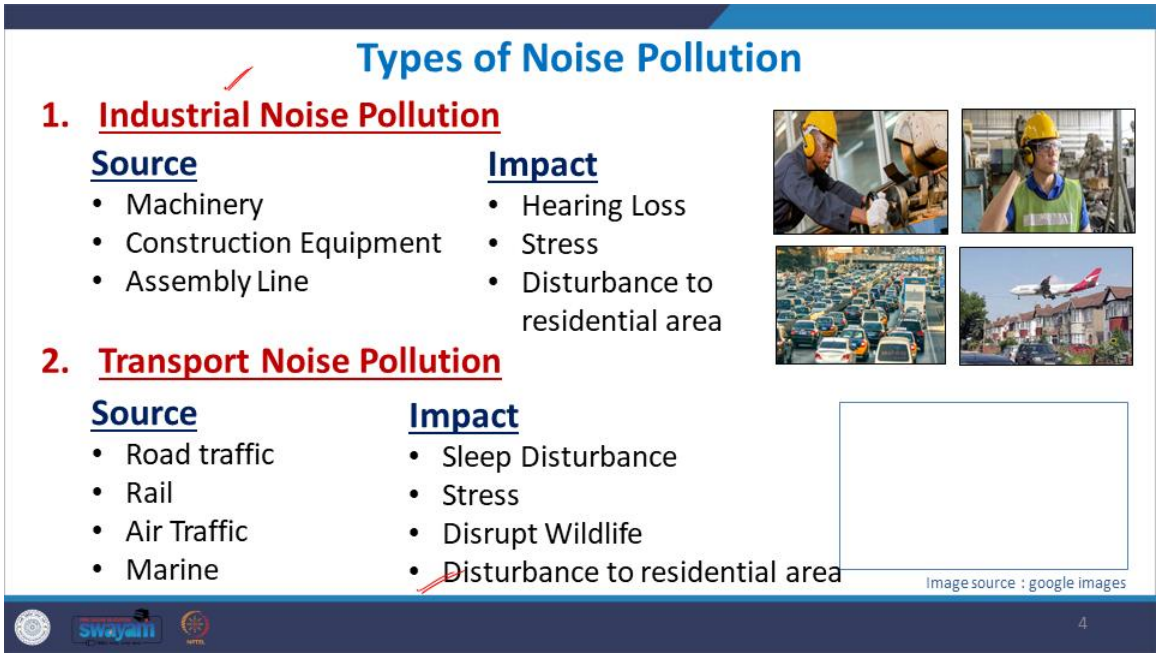
In this particular lecture, we will study and get an overview of noise pollution worldwide, its effects, and after this quick overview, we will see the need for noise regulations, and then what the noise regulations are worldwide and in India, and some guidelines and recommendations for the same.

Outline

- Overview of Noise Pollution
- Noise regulations worldwide and in India
- Guidelines / recommendations for noise pollution

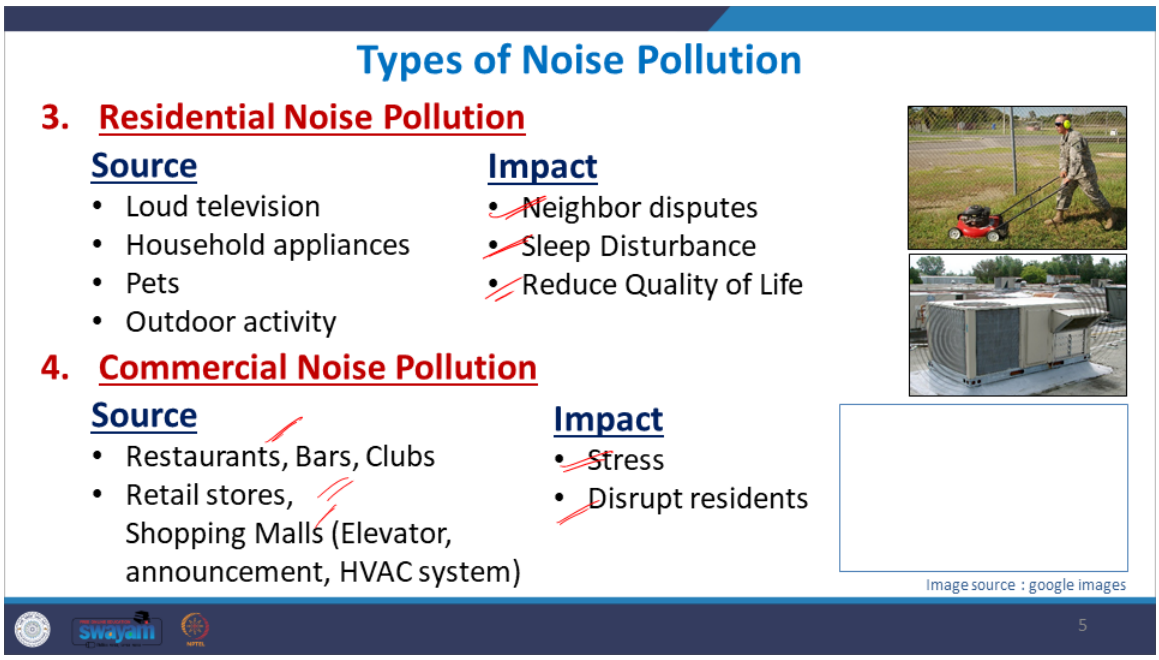


So, to sum up, noise pollution is a health hazard. It is everywhere, be it in the industry, where we have industrial noise pollution from various sources such as machinery, construction equipment, assembly lines, and a lot of other things. The impact it has on workers is that it leads to hearing loss, stress, and even disturbance to people living nearby. In the same way, we have transport noise pollution. Again, various sources are there. You have road traffic, railways, air traffic, and the marine transportation system. And they are also impacting sleep disturbance. So, even if you are living near these highways, for example, very busy roads, etc., then sleep disturbance is caused. Stress can be there, and when these transportation systems are being made, they are usually made by deforestation and cutting of places, affecting the wildlife living nearby. Sometimes, you know, the transportation routes could be through the jungles and the wildlife. They are also disrupting the wildlife. And also disturbance to the nearby people.



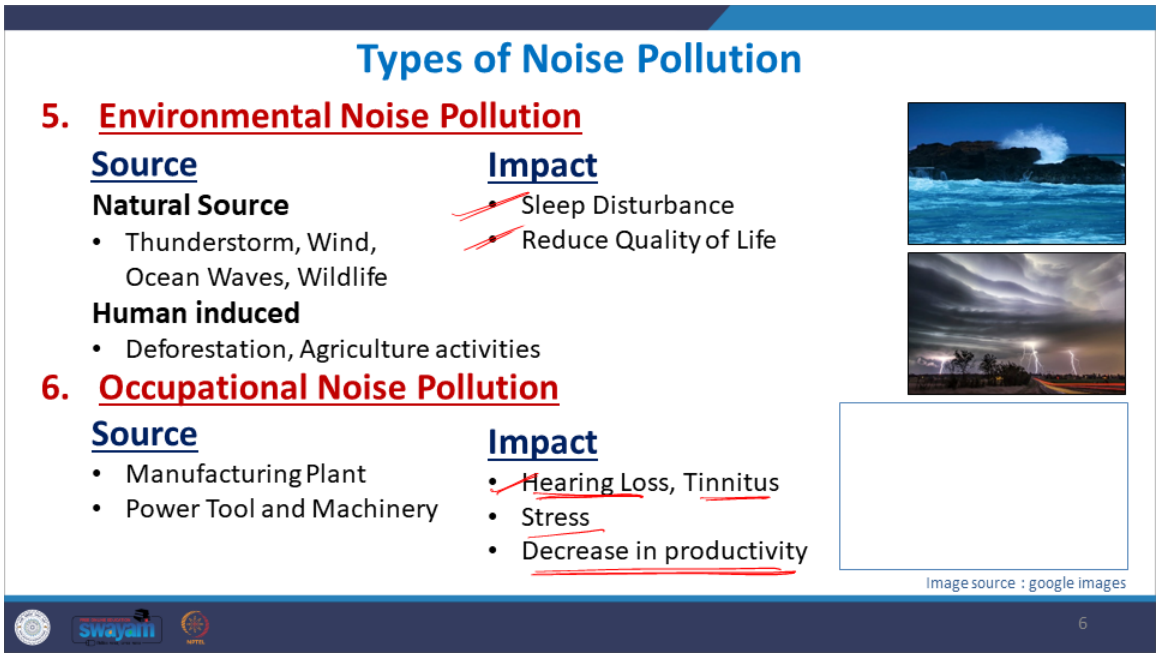
You also have residential noise pollution due to, you know, loud television, household appliances, the pets, and various other outdoor activities. You can have, you know, certain noisy neighbors who don't have the civic sense, and they You know, play the loud television music and use various kinds of noisy appliances and equipment and make a lot

of noise in general. And it can lead to, you know, neighbor disputes, disturbance in sleep. If, suppose, some neighbor has a habit of playing loud music or television or shouting at the Sleep disturbance can be caused overall, you know. It can reduce the quality of life because you are living with that person forever. Then commercial noise pollution also takes place where you have, you know, noise pollution due to various commercial areas like restaurants, bars, clubs, then various kinds of retail stores, shopping malls. They themselves have got these elevators, announcements, HVAC systems, and the hustle and bustle of the people in general. They can also lead to stress and disrupt the residents.



Noise pollution can also manifest as environmental noise pollution, which is caused by natural sources: thunderstorms, wind, ocean waves, the wildlife, and also human-induced activities like deforestation, agricultural activities. Again, they might not be, you know, they might not be as profound as the previous ones, but once in high intensity, they can also lead to sleep disturbance and reduce your quality of life. Occupational noise pollution, again, you know, in the occupational noise, you have this manufacturing plant, power tools, machinery, and various other things that might be used, you know, and all of that leads to hearing loss. We already, you know, discussed in depth about occupational

noise exposure And the NIOSH guidelines for the occupational noise exposure and the noise-induced hearing loss. So, this noise-induced hearing loss can happen, tinnitus can happen, stress, and the decrease in the productivity of the worker because they need quiet environments to work properly, do the cognitive tasks as well.



Then social noise pollution is yet another form of noise pollution where, you know, especially in a country like India, which is a country of celebrations, we have a lot of festivals, parades, political rallies, sports events, and concerts, and just playing of the loudspeakers in the public spaces, in the social gatherings. And they can impact sleep, you know, they can cause annoyance and headaches, and they can disturb cognitive tasks. I remember that when I used to study, and whenever there would be some kind of festival or some kind of marriage function, that whole night and day would be ruined. You cannot study, and you cannot do any mental task that day. Then you have the impulse noise pollution due to these, you know, impulsive sources. Though the frequency of occurrence of the impulse noise is not that much, you don't have explosions or gunshots or fireworks every day. They are very, you know, occasional, but occasionally these things can also lead to hearing loss and ear pain.

Types of Noise Pollution

7. Social Noise Pollution

Source

- Festival, Parades.
- Political rallies
- Sport events and Concerts
- Loudspeaker in public space

Impact

- Sleep disturbance
- Annoyance
- Headache
- Disturbance in cognitive tasks

8. Impulse Noise Pollution

Source

- Explosions,
- Gunshots and fireworks.
- Sirens and alarms

Impact

- Hearing loss, Ear pain

Image source : google images

So, you know, noise pollution is there everywhere. It manifests in these various forms that we saw. And according to the ISE Acoustics of Australia, the world's noisiest cities are, you know, Dhaka, Muradabad, Islamabad, Rajshahi, and Ho Chi Minh City. Some of these highest you know, cities, and the maximum noise levels recorded in these cities, as you can see, are above 100 dB. It's an extremely dangerous and loud noise. So, in general, what we can say is that with increasing urbanization and increasing modernization, we are getting a lot of benefits, but it's also leading to the world becoming an overall noisy place.

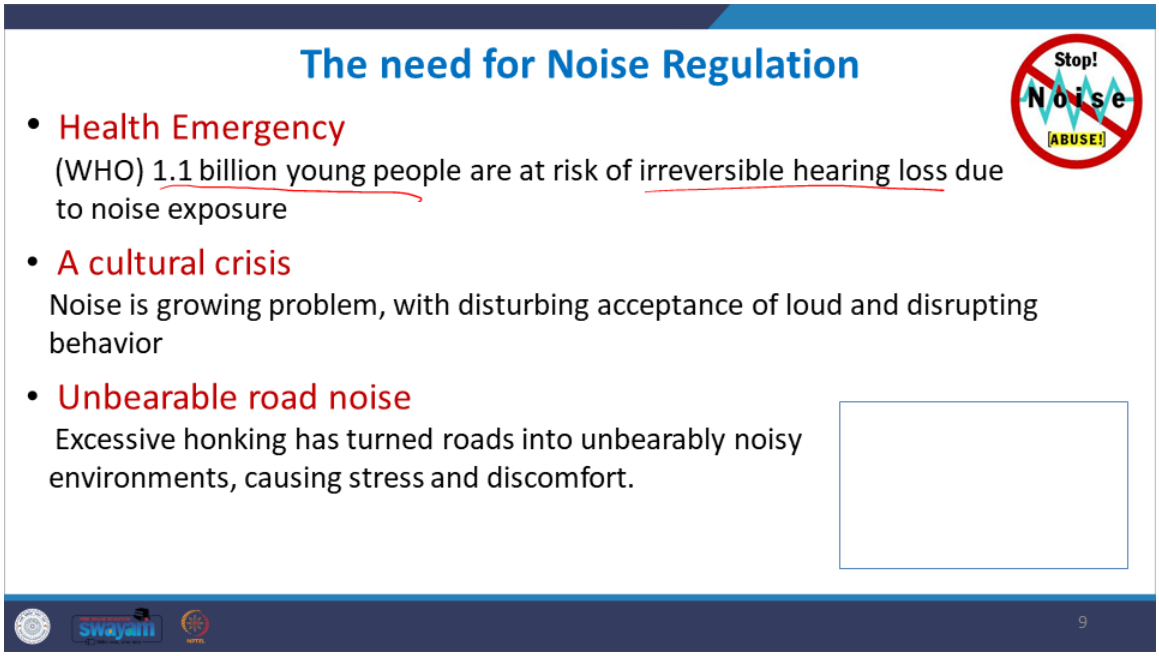
Noise Pollution

- World Noisiest Cities

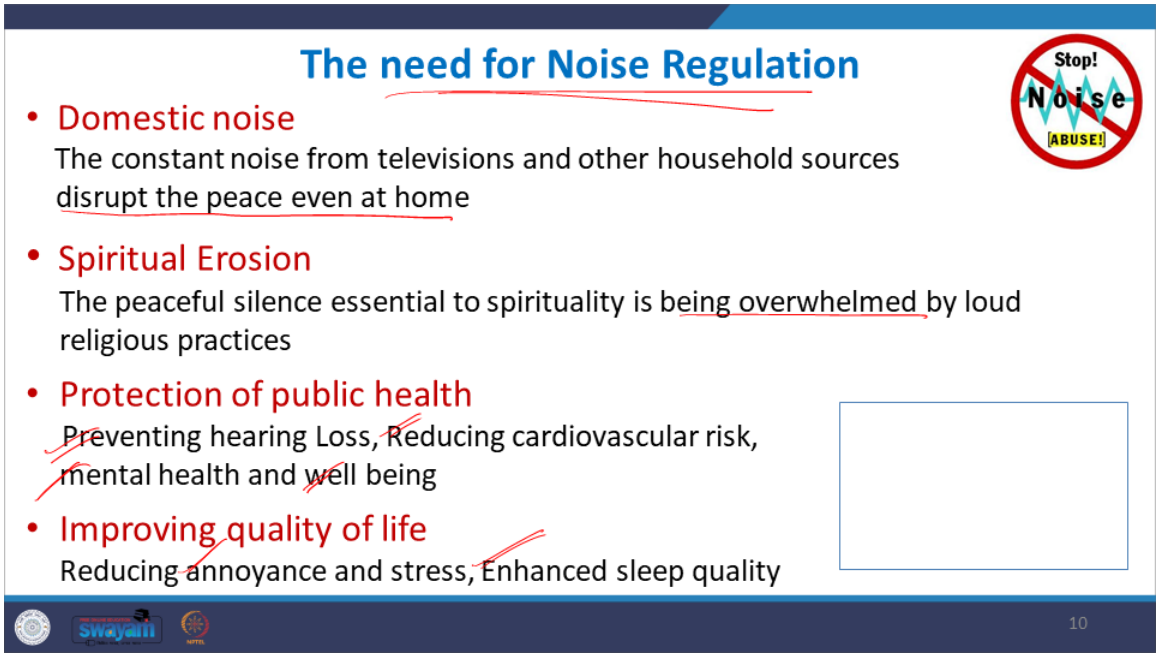
Cities	Country	Noise Level (Max)
Dhaka	Bangladesh	119 dB
Moradabad	India	114 dB
Islamabad	Pakistan	105 dB
Rajshahi	Bangladesh	103 dB
Ho Chi Minh City	Viet Nam	103 dB

Source: IAC acoustics, Australia

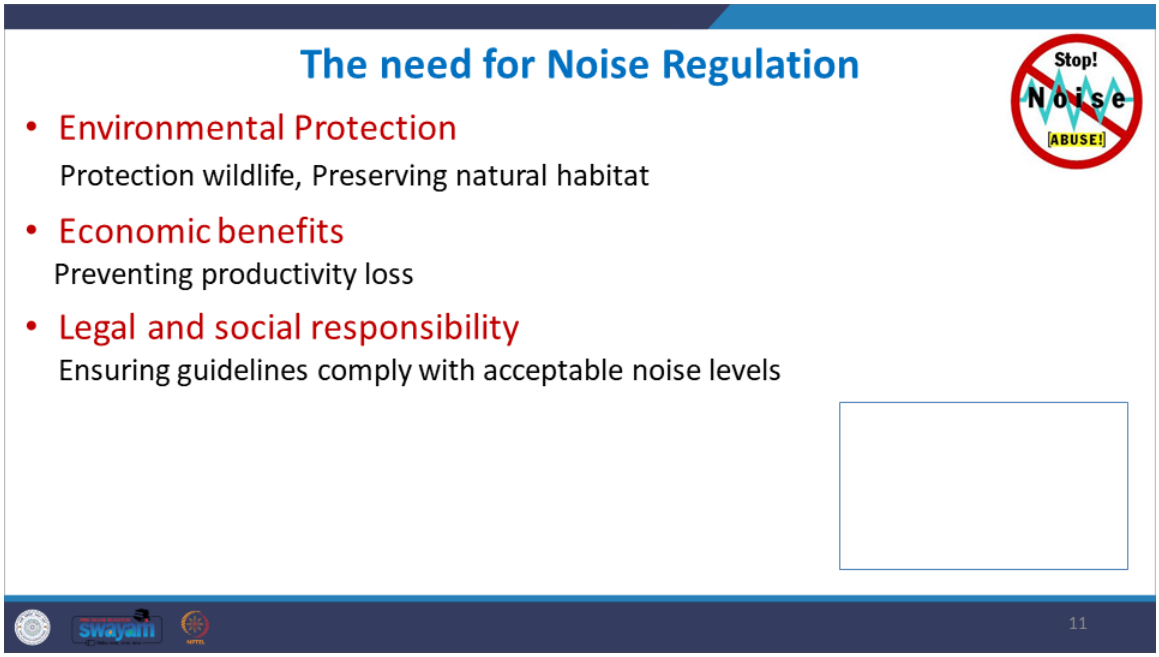
So we definitely need some regulations or policy-making to keep this thing in check, okay? Why? Because obviously, it's a health emergency. WHO has classified this as a health emergency. You know, 1.1 billion young people have been found to be at risk of irreversible hearing loss due to this noise exposure. It also comes as a cultural crisis, you know, noise being a growing problem with the disturbing acceptance of loud and disruptive behavior. As I said in the previous lecture, you know, shouting, being noisy, yelling, and screaming are being normalized. It's not normal. It's a noisy behavior. It's not normal, and it's leading to a cultural crisis that we are facing in modern society. Then, unbearable road noise, definitely excessive honking, is happening on the roads, and these unbearable noisy environments are causing stress and discomfort. Especially, you know, if you see a busy road or a street with jams and people, and there's just noise from a lot of vehicles surrounding you. And on top of that, you have these excessive honking. It just leads to the stress of the driver. And how does the driver respond to this stress? They just shout and increase the noise levels even further in response to already excessive noise.



Then there can be domestic noise, you know, constant noise from televisions and other household sources. They are disturbing the peace even at home. So there is no relief even at home and in various households. We are facing, you know, because of this increasing noisy environment, a spiritual erosion because, you know, spirituality needs peaceful silence. It is very essential to spirituality. However, that is difficult to achieve when people are being overwhelmed by loud religious practices which are very noisy and essentially not spiritual in nature. The protection of public health is definitely becoming a necessity. You know, public health and noise are essential parts of human health. You have to prevent hearing loss. You have to reduce the cardiovascular risk that it induces on people. Various mental health and well-being aspects have to be protected, and hence noise needs to be regulated. Similarly, improving the quality of life is very essential in the modern world and modern society, and this also necessitates the need for noise pollution regulation. So, we need to reduce annoyance and stress, enhance our sleep quality, which is very much essential to improve our quality of life, all necessitating the need for noise regulation.

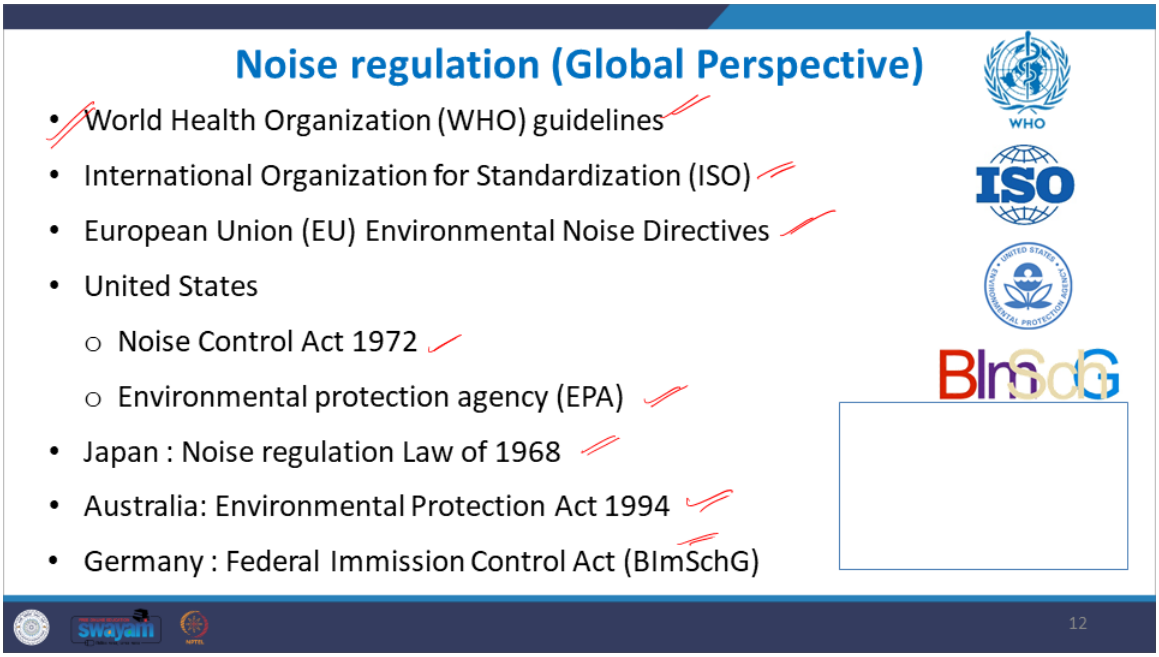


In the same way, you know, Environmental protection is also very important for the protection of wildlife that might be suffering from a noisy environment and the preservation of natural habitats. Noise also has, you know, economic benefits if you reduce or regulate it because, you know, in any occupational environment, especially a factory floor, industrial setup, or office cubicle. In all of these, you know, noise can actually disturb people from the tasks they are doing. So, if you are in an office cubicle and you have a noisy neighbor or some kind of drilling going on or some construction happening in the next-door building. Then you will not be able to perform the task that you could do in two hours. Now, because of that excessive noise nearby, you are able to do it in six or seven hours. It's taking your time to concentrate, focus, and finish your work. And hence, it's decreasing the productivity of the workers and employees. So there is a loss in the economy as well. So, legally and above all, we have a legal and social responsibility, and we should ensure that guidelines are in place where we can comply with acceptable noise levels so that we stop causing discomfort to ourselves and to nearby human beings.

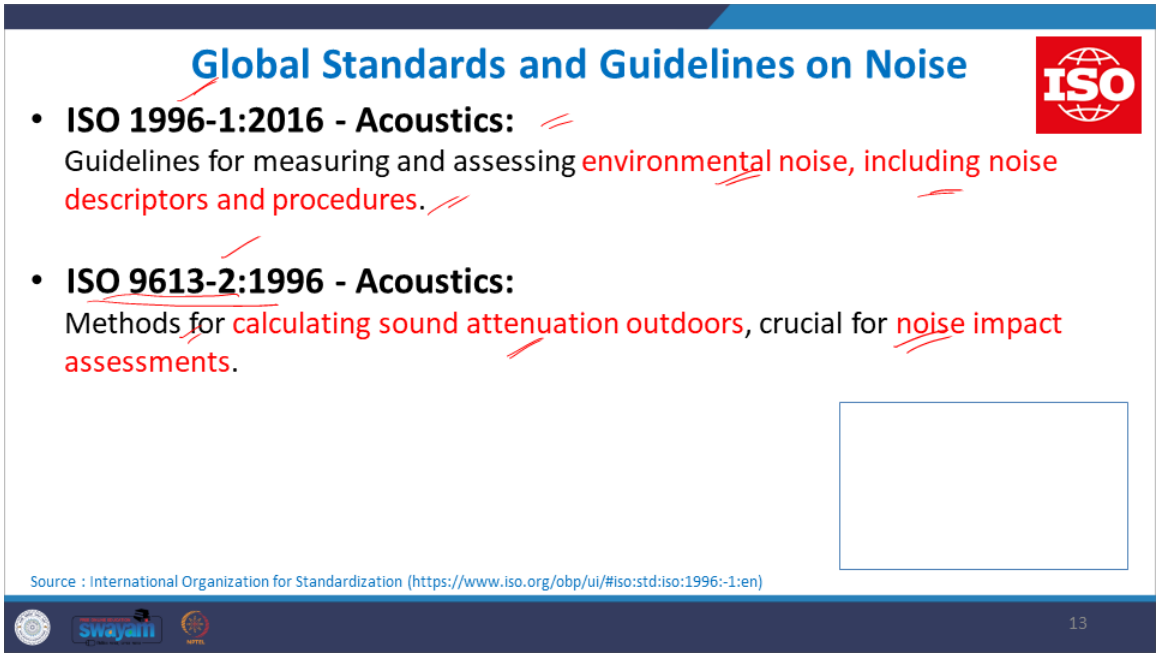


So, that is why you need to regulate the noise. And if you just have a quick global perspective of noise regulation, you can see that steps and measures have been taken for a long time in various forms. For example, WHO, from time to time, issues guidelines, and as the years pass by, these guidelines are also amended to suit modern needs. So, guidelines and amendments are in place in WHO. Then again, the International Organization for Standardization, or ISO, issues various guidelines or standards on how to monitor noise, what metrics can be used, how you should measure the noise of machinery, and evaluate environmental noise. In line with WHO guidelines, the European Union also provides its environmental noise directives, which people ought to follow. In the United States, we have the Noise Control Act of 1972, which was a pioneer act in this field. Then you have a special agency called the Environmental Protection Agency, and noise pollution also comes as one of the special areas within this Environmental Protection Agency. In Japan, you have the Noise Regulation Law of 1968, another pioneer law in noise regulation. In Australia, you have the Environmental Protection Act of 1994, which includes various recommendations and guidelines for noise levels. In Germany, you have the Federal Emission Control Act, or BImSchG, which also specifies noise as one of its special areas and how it should be regulated. So, here I would like to take a step back and tell you that various directives and guidelines are in place.

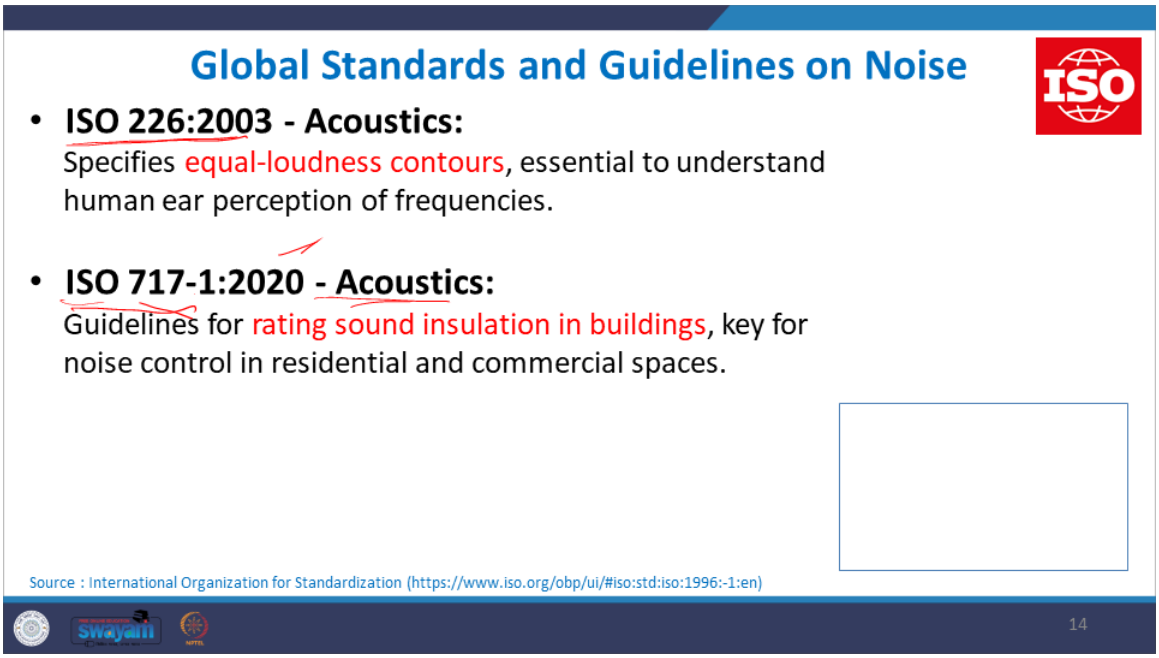
But these are just guidelines. They are not law per se. So, you know, based on that, people can file complaints. They can put a case to stop the noise. But again, it's not a hard and fast law. These are guidelines or directives given to people in general. It ultimately boils down to the people how much they follow it.



Okay, so if you think about it, the ISO has given up their various standards, you know, and guidelines on how to measure and assess the noise. Okay, the ISO 1996-1, ISO 96132, and so on. So, this standard is a guideline for measuring and assessing the environmental noise, including the noise descriptors and procedures to be followed. This particular standard by ISO is used to calculate the sound attenuation outdoors, which is a very crucial part for assessing the impact of noise in the outdoor areas.

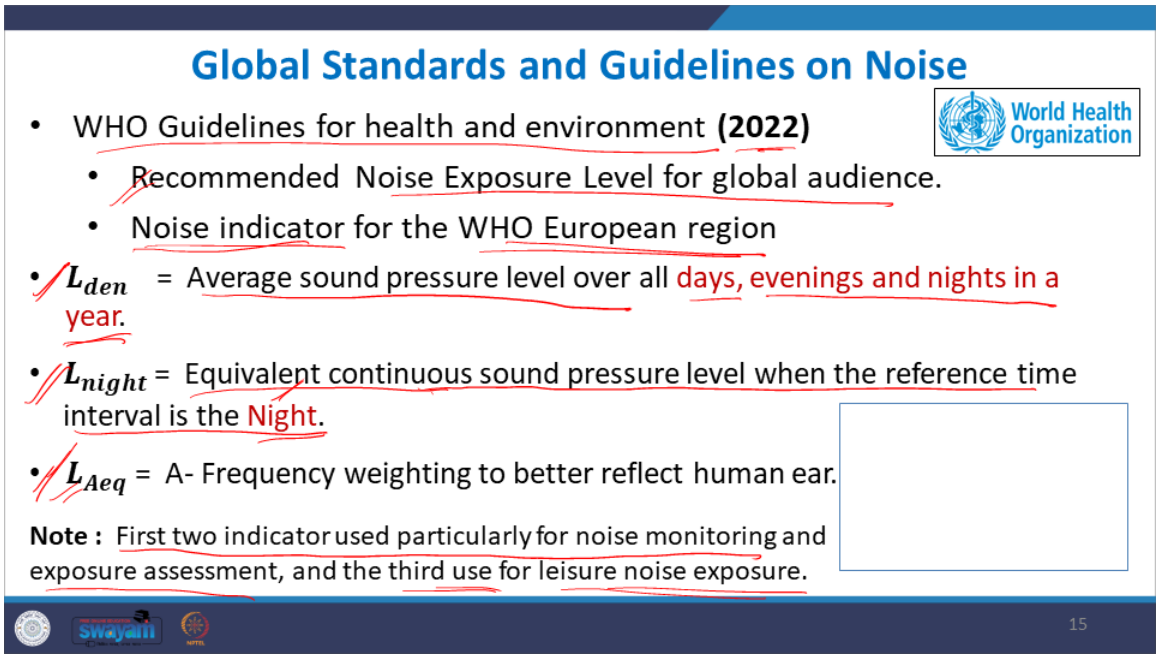


Some other standards by ISO are ISO 226-2003. It specifies the equal loudness contours and essentially from this standard, we are able to incorporate the human ear perception and use it for evaluating or monitoring the noise. Then the ISO 717-1, this particular standard, which is the latest standard out of the discussed. These are the guidelines for rating the sound insulation in buildings. Again, this is very key in order to evaluate noise control in residential and commercial places. How to give the ratings to the various sound insulation that is installed in buildings, these guidelines are available there.



Then, if you look at the efforts done by WHO. So, they have issued various guidelines for health and the environment. In this as part of this, what they have done is that they have recommended noise exposure levels for a global audience. They have also recommended and given that the following noise indicators should be used while evaluating the noise exposure. So, the key indicators that WHO recommends are these. You can use an indicator called L_{10}. So, L, obviously, throughout this course, when I refer to L, it means that it is the SPL or the sound pressure level. So, when it is the sound pressure level den, which means d for day, e for evening, and n for night. So, this is the level day, evening, night, which means the average sound pressure level over all days, evenings, and nights. So, a 24-hour average you can say for a year. So, this is usually used for environmental noise monitoring. You have a particular environmental area, be it a traffic, transportation, commercial, industrial, or residential area. You can use this measure. Over a year, you monitor the noise levels at different parts of the day, evenings, and nights, and you prepare a yearly average, which is L_{den}. Then you have just an average for the nighttime, and Lnight has to be lower than L_{den} because people are sleeping at night, so we need lower levels at night. So, this is the equivalent continuous sound pressure level when the reference time interval is at night. Nighttime recordings are done, and the average is taken over a period of time.

$L_{Aequivalent}$ is again calculated as the continuous sound pressure levels. In previous lectures, we have seen how to calculate an $L_{equivalent}$, which is the continuous sound pressure levels over a long period of time. When you apply the A-weighting filter to it to convert it into the A levels, then that same thing becomes $L_{Aequivalent}$. So, here the first two indicators are particularly used for noise monitoring and exposure assessment, and the third one is usually used for leisure noise exposure.



So, as per the WHO guidelines, the noise sources are recommended to never exceed certain levels. They should not exceed the following sound pressure levels so that they are helpful for the people residing nearby. So, for road traffic noise, the L_{10} should be less than 53 dB, and the night noise exposure should be less than 45. This is for the comfort of the people living nearby. Similarly, for railway noise, these are the levels. Aircraft noise, again this is the level, and the wind turbine noise, we have less than 45 dB, which is an overall yearly average for the noise levels at these areas taken at different parts of the day, evening, and night.

Global Standards and Guidelines on Noise

- The noise sources are recommended to not exceed the following sound pressure levels for people residing nearby

World Health Organization

Noise Sources	Sound Pressure Level: Average (L_{den})	Sound Pressure Level: Night Noise Exposure (L_{night})
Road traffic noise	< 53 dB	< 45 dB
Railway noise	< 54 dB	< 44 dB
Aircraft noise	< 45 dB	< 40 dB
Wind turbine noise	< 45 dB	--

Okay, for the leisure sources, also, some SPLs have been recommended. So, by recommended, you mean that this is the upper limit. Okay, that does not mean that they have to have this level. It means that it should not exceed that level. So, for the leisure sources, the yearly average should always be within 70 dB for an $L_{Aequivalent}$ measured over a 24-hour time. Weekly average up to less than or equal to 80 dB, such as through your personal music system, your loudspeakers, or your outdoor gaming activities. Then, short-term average from the occasional source. Can still be not beyond 100 if it is an occasional source, like, for example, once or twice a year you are having some kind of party or some kind of orchestra or something, then you can go up to 100 dB. So, these are the recommendations done by the WHO.

Global Standards and Guidelines on Noise

- For noise exposure from leisure source, the following sound pressure levels are recommended.

Leisure source noises	Sound Pressure Level
• yearly average	≤ 70 dB $L_{Aeq,24hr}$
• weekly average	≤ 80 dB L_{Aeq} (personal listening devices)
• short-term average from occasional source	≤ 100 dB $L_{Aeq,15min}$

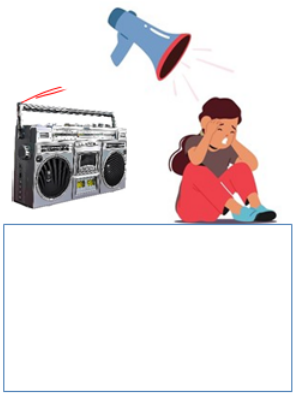
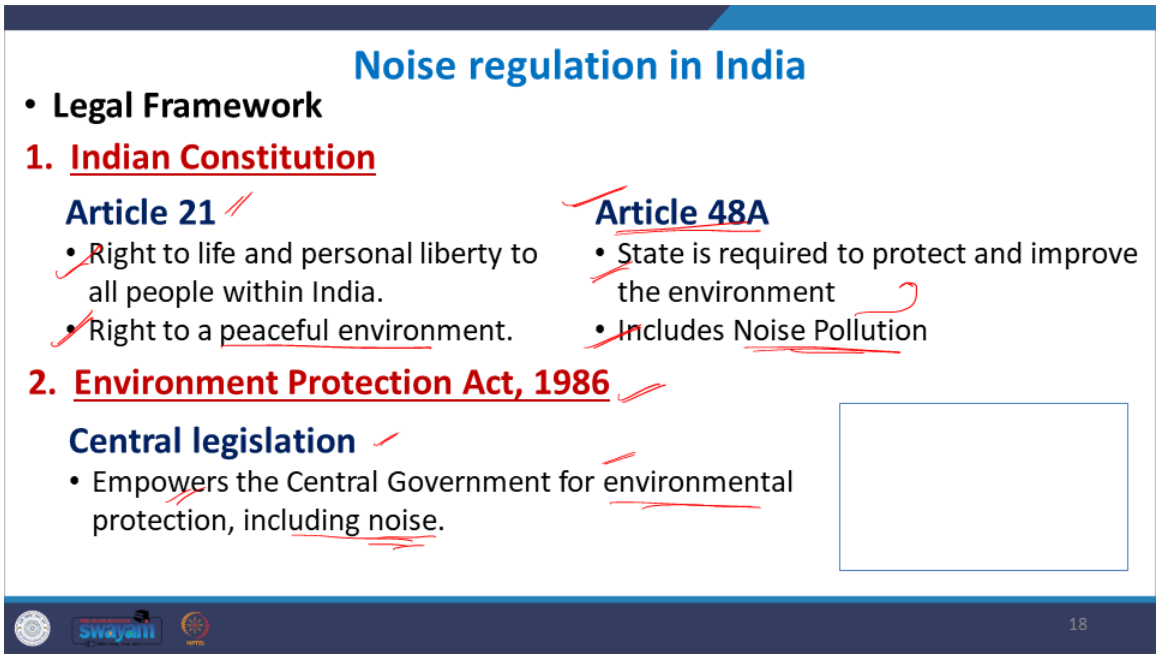
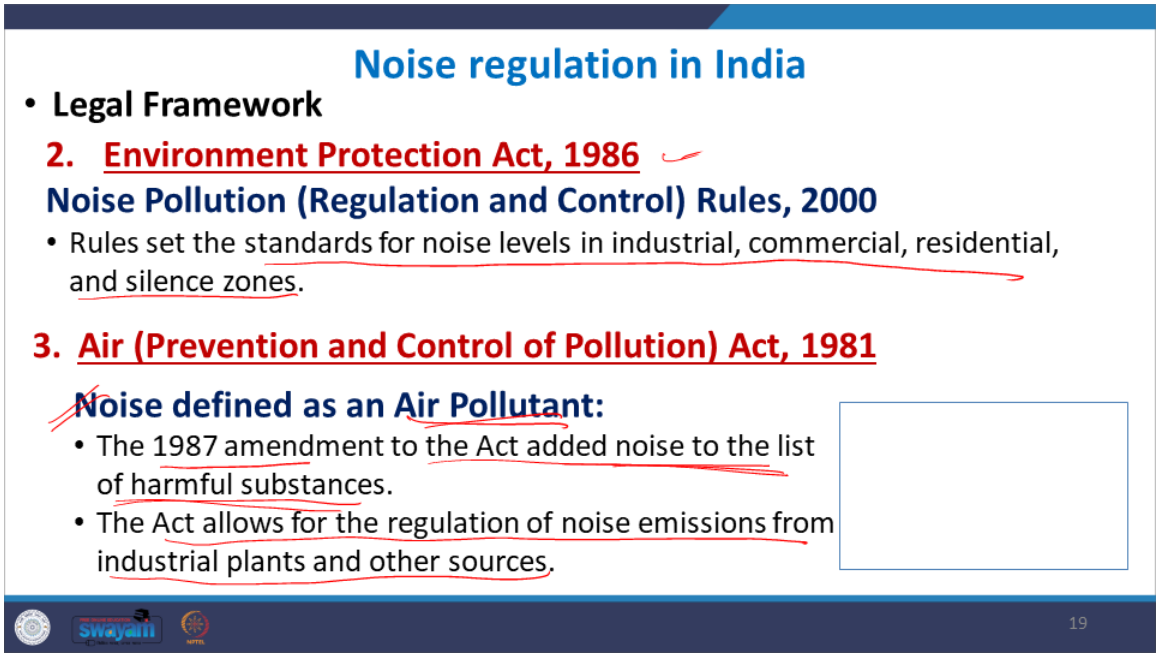


Image source: Shutterstock.com, https://colombia.yaxa.co/products

Now, let us see what this is, just a quick global perspective. Let us see specifically in the context of India, what is the legal framework we have with respect to regulating the noise. So, in the Indian constitution, in Article 21, it gives that the people have the right to life and personal liberty to all the people within India and the right to a peaceful environment. So, on the basis of Article 21, a person can claim the right for a peaceful environment, and if you think that there is some kind of If there is an event or some kind of source that is continuously disturbing your peaceful environment, then you have the right to demand the regulation of that particular noisy source. In the same way, you have Article 48A. Here, the state is required to protect and improve the environment, and this also includes the protection of the environment, just like we have air pollution, land pollution, and even noise pollution included within this protection. The other legal framework is the Environment Protection Act of 1986. Within this act, the central legislation empowers the central government to enforce environmental protection, and within that, it also includes noise because the protection of the environment includes all forms of pollution, be it land, air, or noise.

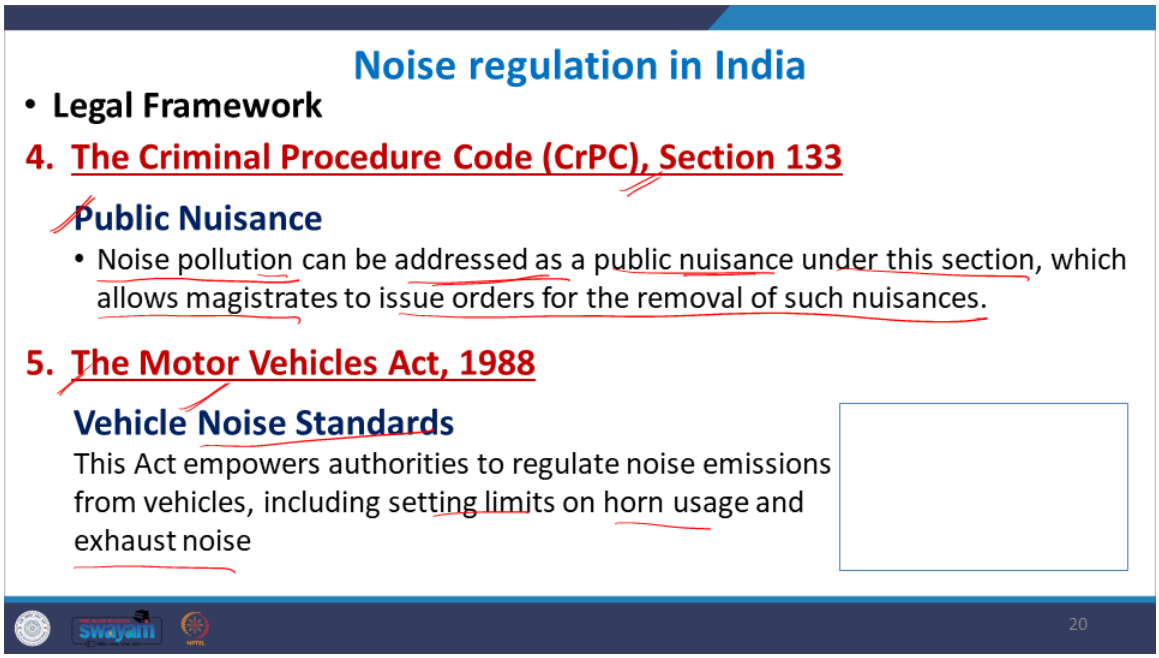


Within the same act, we also have the Noise Pollution Regulation and Control Rules that were added in the year 2000 because of growing noise concerns, and these rules set the standards for noise levels in industrial, commercial, residential, and silent zone areas. Then, the third kind of framework is the Air Act, which is also called the Air Prevention and Control of Pollution Act 1981. Here, within this act, noise is also defined as an air pollutant. Just like you assess the air quality and see what kind of particulates are there, such as smoke or dust particles. In the same way, even the noise present in the air has been included as one form of air pollutant. So, once noise is defined as an air pollutant, then the Air Act will be responsible and can be used for controlling and regulating this noise. So, in the 1987 amendment, the act added noise to the list of harmful substances in the air, and the act allows for the regulation of noise emissions from industrial plants and various other sources in order to monitor and control air quality.



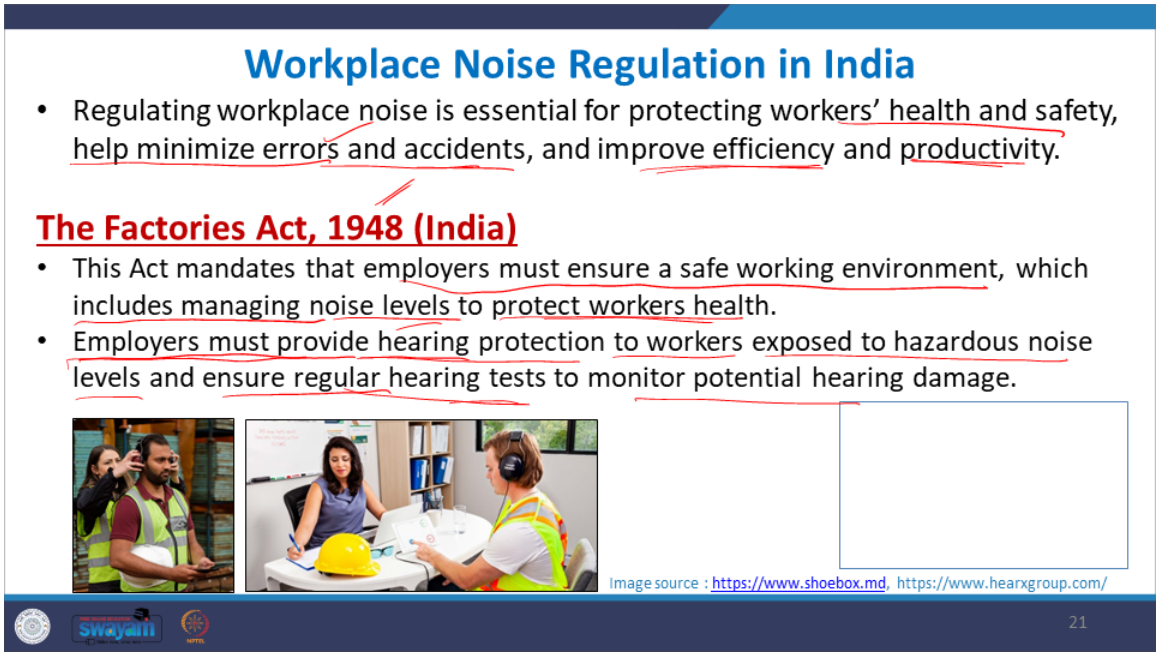
We also have the Criminal Procedure Code, Section 133, and here, Section 133 is about public nuisance, what can be termed as a public nuisance, and action can be taken against that public nuisance. So, here noise pollution is one such public nuisance. Which has been added as one of the public nuisances under this section. And this allows the magistrates at the district level to issue orders for the removal of such nuisances. So, if you think, you know, if you are a citizen and you think that there is some noisy source or something which is creating a lot of noise and disturbing your peace, you can first request the owner of this noise source to keep it down. And if they don't abide by it despite your repetition, after even your repetitive requests and pleas, you can actually approach the district magistrate and, within this section, you can actually book for controlling and regulating the noise and removing that noise source. We have the very famous Motor Vehicles Act of 1988, which laid down the various standards for vehicles, and amongst the various standards that the vehicles need to comply with, there were also some noise standards that the vehicles need to comply with. So, this act empowers the authorities to regulate what should be the noise emissions from the vehicles and set up the limits on the horn usage and the exhaust noise. So, just like you know, the vehicles now are coming with some kind of, you know, some limits set to the amount of emissions that they need

to make, in the same way, the limits have also been set on the amount of noise emissions that the vehicles need to make.

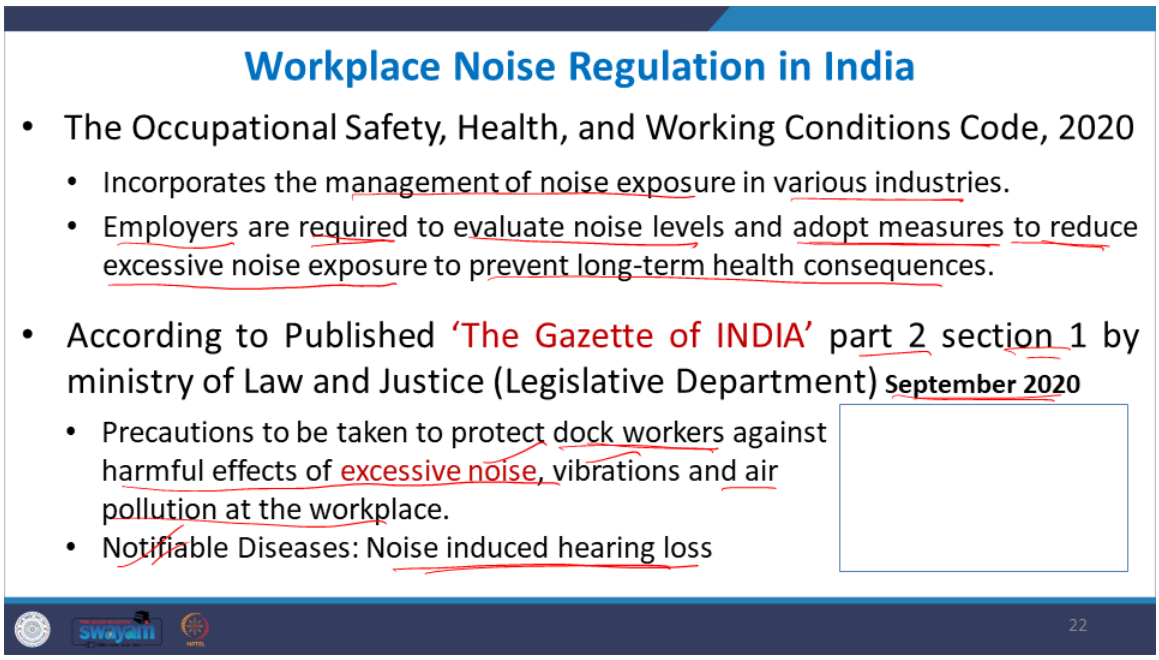


Okay, so since you know we studied a lot about occupational noise exposure and you know how workplace noise can be very dangerous, decrease productivity, and lead to noise-induced hearing loss. So, there are special laws to regulate workplace noise. So, let us first see what is in place in India. So, it becomes very important for workers' health and safety. And also, it could help if you can regulate the noise; the workers will be more focused, there will be less disturbance, and this would minimize their errors, cause fewer accidents, improve the efficiency, and the productivity of the workers. So, you have multi-fold benefits; it's better for the workers' health and also better for productivity. So, the very famous Factories Act of 1948 was implemented and was charted out in India. According to this act, the employers must ensure a safe working environment, and in the safe working environment, it is not just the exposure to hazardous chemicals or dangerous fumes but also includes the exposure to dangerous noise levels. So all of this needs to be managed, even the noise levels, so that the workers' health can be protected, and not just that. The employers must ensure that they provide hearing protection to their

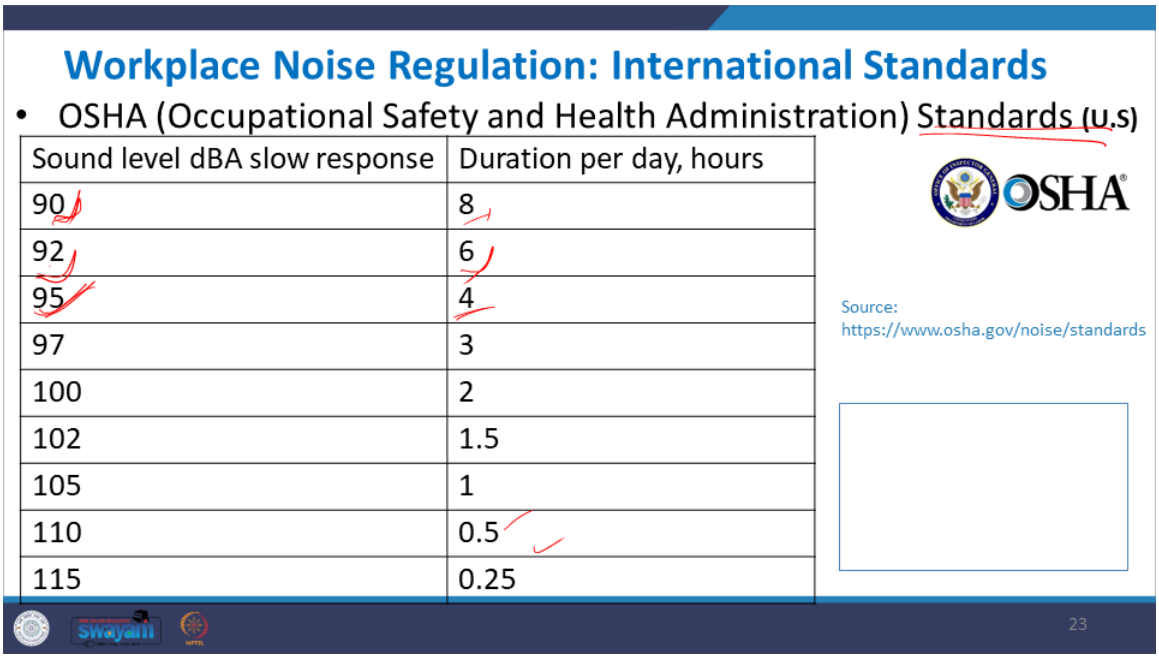
workers who are being exposed to these hazardous noise levels, and they ensure that regular hearing tests are being done to monitor whether their workers are suffering from any hearing loss.



Okay. Then we have the Occupational Safety, Health, and Working Conditions Code of 2020. It incorporates the management of noise exposure in various industries, and again, the employers are required to evaluate the noise levels in their factories and various industrial areas and adopt whatever measures they can in their capacity to reduce excessive noise exposure and prevent any long-term health consequences. You know, a very famous article was published by the Gazette of India in Part 2, Section 1. This is produced and published by the Ministry of Law and Justice or the Legislative Department of India. In this article here in September 2020, they have specifically directed that precautions need to be taken to protect the dock workers against the various harmful effects of excessive noise, vibrations, and other air pollution at the workplace, and here, noise-induced hearing loss has been indicated and quantified as a notifiable disease among these workers.



Okay, so this is the workplace noise regulation in India. So, what is happening worldwide? Let us see some of the international standards with respect to workplace noise regulation. So, the first standard body is OSHA, the Occupational Safety and Health Administration. Now, every country has its own standard body, but we will just see a couple of them in this particular course. One is OSHA, which is the Occupational Safety and Health Administration standards. These are set by the USA. So, they have stated what should be the maximum sound exposure level and the maximum duration over which it can be exposed. So, which means that if this is the noise level, then the exposure time within an occupational setting should never exceed a particular time, and vice versa. If this is the exposure time, then the noise level should not exceed beyond this. So, if a worker is working 8 hours a day, The noise levels are set to 90 dB average, which means that they should not be exposed beyond 90 dB in an 8-hour day. If it is 6 hours, then they can be exposed to a maximum of 92 dB, and vice versa, and so on. So, as you know, as you are increasing the noise exposure level, the duration, the maximum duration to which the worker can be exposed per day, is going down, and so on.



And you see that, you know, the exposure to continuous steady-state noise should be limited to a maximum of 115 dBA. It should not exceed 115 dBA. And any exposure to impulsive or impact noise should not exceed 140 dB peak noise level. So, for continuous exposure, 115 dBA is the limit for Just, you know, transient, impulsive, or one-time exposure, 140 dB is the limit. And whenever the noise levels are above this, 85 dB average over 88 working hours in a week, then the employers have to implement a hearing conservation program.

Workplace Noise Regulation

International Standards

- OSHA (Occupational Safety and Health Administration) Standards (U.S)
  - Exposure to continuous, steady-state noise is limited to a maximum of 115 dBA.
  - Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.
  - When noise exposure is at or above 85 dBA averaged over 8 working hours, employers must implement a hearing conservation program.

Source: https://www.osha.gov/noise/standards

So, with this, I would like to end this lecture. Thank you for listening

Thank You