Department of Civil Engineering
College of Engineering
King Saud University

GE 302 – Industry and the Environment
Topic 7

Noise Pollution and Control

Sounds and Noise

- **Sound** is a pressure variation(wave) that travels through air and is detected by the human ear.
- **Noise** is unwanted and potentially harmful sound.
- Noise is perhaps one of the most undesirable **by-products of** a modern **mechanized lifestyle**.
- Noise is a pollution problem that affects human health and well-being and that can contribute to a general deterioration of environmental quality.
- It takes energy to produce all sound, so, in a manner of speaking, **noise is a form of waste energy**.
- Not all sound is noise. What may be acceptable to one person may be noise to another.

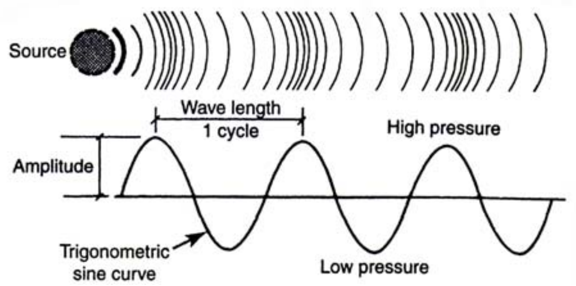
- Noise from **highway traffic**, **construction activities**, and other sources in the community is of special concern to environmental engineers.
- Noise can have impacts ranging from temporary public or **personal nuisance** to **permanent hearing loss** in individuals.
- Excessive noise pollution (undesirable and unwanted sound) can have harmful effects, ranging from:
  - physical damage to the ear
  - temporary or permanent hearing loss
  - physiological effects of raising blood pressure and pulse rates
  - causing stress
  - Irritability and anxiety

Basics of Sounds

- Sound energy is produced by **mechanical vibrations** of a sound source.
- We can't measure acoustic energy very well, but we can measure sound pressure well
- Sound pressure is a surrogate for acoustic energy.
- The vibrations are transmitted or carried away from the source in the form of **sound waves**.
- Sound waves can be transmitted through solids, liquids, or gases, but they cannot be transmitted in a vacuum, where there is no medium or material to transmit the vibrations.

Basics of Sounds

- The physical characteristics of sound waves are wavelength, frequency, and amplitude.
  - **Wavelength** is the distance between air pressure peaks (or valleys)
  - **Frequency** is the number of wavelengths that passes a fixed point in 1 sec.
  - **Amplitude** of the sound wave is the height of the air pressure peaks (i.e., above the average air pressure) measured in **decibels** (**dB**).



Basics of Sounds

- A single wavelength is called a **cycle**, and the frequency is expressed in terms of **cycles per second** (cps).
- The term "**hertz**" (**Hz**) is often used for frequency, where **1 Hz = 1 cps**.
- The relationship among the three characteristics is

$$v = \lambda \times f$$

- where v is the speed of sound in m/s, λ is wavelength in m per cycle, and f is the frequency in Hz (or cps).
- The speed of a sound wave v in air is about **340 m/s**.

Basics of Sounds

Example 1:

What is the wavelength of a sound traveling through the steel rails of a railroad track if the frequency of the sound caused by a moving train is 500 Hz?

(Assume that sound travels at a speed of 5000 m/s in steel).

Solution:

wave length $\lambda = v/f = 5000/500 = 10$ m.

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Basics of Sounds

- Human perception of sound includes its **loudness** (amplitude) and **pitch** (frequency).
- **Loudness** is related to the amplitude of the wave as well as other factors.
- **Pitch** is a function of the frequency of the wave that produces it.
- The human ear can detect sounds in the frequency range of about 20 to 20,000 Hz
- The average atmospheric pressure is about 1 bar, and an average person can typically detect **a sound with amplitude** as small as **0.0002 μbar**.
- The human ear can perceive sound pressures as high as 10,000 μbar before ear damage occurs.
- The **audibility of a sound depends** on both **frequency and amplitude**.

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Basics of Sounds

- **Decibel scale** is used for noise measurement, and **sound pressure levels** (SPLs) are expressed in terms of decibels (**dB**).
- An SPL = 0 dB is the lowest audible sound, and an SPL of 140 dB just exceeds the human threshold of pain.

Sound level in dB	Environmental conditions
140	Threshold of pain
130	Pneumatic chipper
120	Loud automobile horn (distance 1 m)
110	Overhead jet plane
100	Inside subway train (New York)
90	Inside motor bus
80	Average traffic on street corner
70	Conversational speech
60	Typical business office
50	Living room, suburban areas
40	Library
30	Bedroom at night
20	Broadcasting studio
10	Threshold of hearing
0	

The decibel (dB) scale is used to measure noise levels

The Decibel Scale

- A **decibel is** essentially a **ratio of two pressures**; logarithms are used to convert the range of the ratios into more manageable and convenient numbers.
- The **magnitude of** volume or **a sound** expressed in decibels is called a **sound pressure level** (SPL). An SPL is defined mathematically as

$$\mathbf{SPL = 20 \times \log\left(\frac{P}{P_o}\right)}$$

SPL= sound pressure level, dB
P = RMS sound pressure, µbar (RMS = Root Mean Square)
P_o = reference pressure (**0.0002 µbar**, is the hearing threshold or lowest audible sound pressure)

The Decibel Scale

Example 2:

An ambulance siren causes a sound pressure of 200 "bar. What is the SPL of the siren?

$$\text{SPL} = 20 \times \log\left(\frac{200}{0.0002}\right) = 20 \times \log(10^6)$$

$$= 20 \times 6 = 120 \text{ dB}$$

Frequency-Weighting

- A common measurement referred to as **A-weighted decibels**, or **dBA**, **filters out the low-frequency and very high-frequency sounds**, where the human ear is less efficient.
- Using dBA level helps to match the meter readings with the sensitivity of the ear and with average person's judgment of the relative loudness of various sound.
- Tow sound levels of equal dB level but of different frequencies have different dBA levels; the lower frequency sound has the lower dBA level

Typical handheld sound level meter (typically supplied with built-in frequency filter, the **A filter**)

Noise Standards: Criteria level

OSHA's "Table G-16" Showing Permissible Noise Exposures

Duration per day (hours)	Sound level, dB(A) slow response
8	90
6	92
4	95
3	97
2	100
1-1/2	102
1	105
1/2	110
1/4 or less	115

There are two factors determines how hazardous noise is:

- Intensity (loudness) measured in dBA
- Time of exposure measured in hours and minutes

OSHA = Occupational Safety & Health Administration

Combined Noise

- In many instances. it is necessary to predict what the combined sound pressure level will be when two or more nearby noise Sources act at the same time.

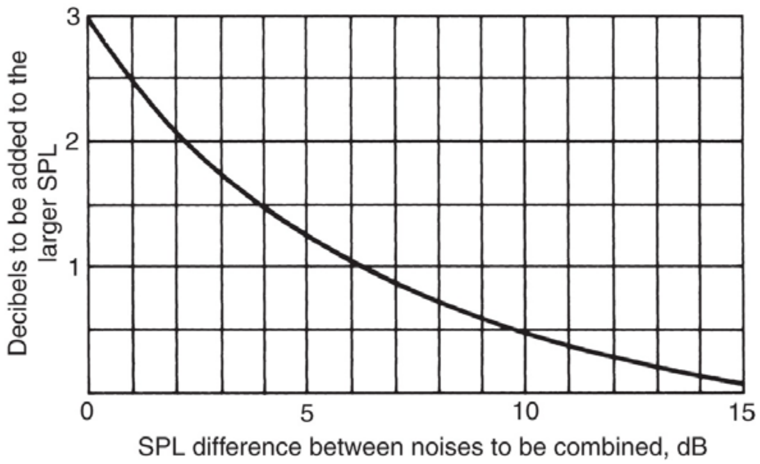

Figure 14-4 (from textbook): addition of decibels values when combining two or more sound level

Combined Noise

Example 3:

Four identical dozers are available for excavation of soil at a construction site. **Each dozer has an SPL of 90 dB** when operating alone. What is the SPL when the four dozers are operating at the same time?

(For simplification, the effect of distance from the noise source has been ignored in the discussion of SPL for this problem, it is assumed that the dozers are operating together in a confined area.)

Solution

- Consider what occurs when only two of the machines are operating. The numerical difference between the two SPL values is 90 - 90 = 0.
- Entering the curve in Figure 14-4 with a difference of 0, read a corresponding 3 dB value on the vertical axis.
- Therefore, the two dozers operating simultaneously will generate an SPL of **90 + 3 = 93 dB**.
- With a third dozer operating, add another 90 dB to the previous level of 93 dB for two dozers.
- The difference between the two SPL values is now 93 - 90 = 3 dB.

Continue of solution

- Entering the chart with a 3 dB difference, find that it is necessary to add an additional 1.7 dB to the 93 dB to obtain the combined SPL Thus, **93 + 1.7 = 94.7** dB from three dozers operating simultaneously.
- Remember that the SPL increment is always added to the larger of the two SPL values being combined.
- Finally, with a fourth dozer, combine the 94.7 dB with 90 dB. The difference is 4.7 dB, and the required increment from the chart is 1.3 dB.
- This results in **94.7 + 1.3 = 96 dB** being generated by the four machines.

Noise Control

- Noise can be controlled in four fundamental ways:
  - protect the recipient
  - increase the path length
  - block the path
  - reduce the noise at the source
- Earplugs or earmuffs protect recipients by as much as 40 dBA.

- One of the best, but often overlooked, methods of noise source reduction is regular and thorough maintenance of operating machinery.

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Noise Control

- Sound levels also drop significantly with **increasing distances from the noise sources**, so increasing path lengths between sources and recipients offers a passive means of control.
- If path length from a point source is doubled, for example, the intensity of the noise reaching the recipient is one fourth of the original intensity.
- Sound levels from line sources (e.g., highways) decrease 3 dBA for each doubling of the distance from the source.
- In industrial plants, noise reduction can be achieved by **enclosing machinery in acoustic absorbing materials** and by **using absorbent mounts and pads**.

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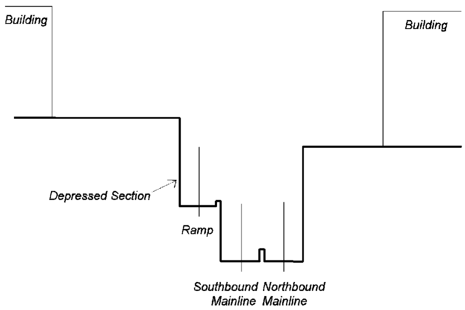
Noise Control

- Reducing noise levels from **construction sites** include **Barriers to block noise** and **restriction of hours of construction activity**
- Proper highway planning and design are essential for controlling **traffic noise**.
- **Lower speeds**, **depressed roadways**, and **construction of vertical wall barrier** are **methods used to control of traffic noise**.
- Most of automobile traffic noise comes from the movement of the vehicle tires on the pavement and wind resistant.



Noise Control

- The relationship between the sound level and distance from a line source can be written as follows:

$$SL_B = SL_A - 10 \times \log \frac{D_B}{D_A}$$

- SL_A = sound level at distance D_A from the source
- SL_B = sound level at distance D_B from the source

Example 4:

The sound level measured at a 4-m distance from the centerline of a busy highway is 85 dBA.

(a) What is the sound level at a distance of 12 m from the road centerline?

(b) At what distance from the road centerline is the sound level reduced to 79 dBA?

Solution:

a) $SL_B = SL_A - 10 \times \log\frac{D_B}{D_A}$

$SL_{12} = 85 - 10 \times \log\frac{12}{4} = \mathbf{80\ dBA}$

b) $SL_B = SL_A - 10 \times \log\frac{D_B}{D_A}$

$79 = 85 - 10 \times \log\frac{D_B}{4}$

$\log(\frac{D_B}{4}) = \frac{79 - 85}{-10} = 0.6$

$\frac{D_B}{4} = 10^{0.6} = 3.98$

D_B = 4 x 3.98 = **16 m**

Noise Control

- The path of traffic noise can also be blocked by the **construction of vertical walls or barriers along the highway**.

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GE 302 – Industry and the Environment
Topic 8

Environmental Impact Assessment

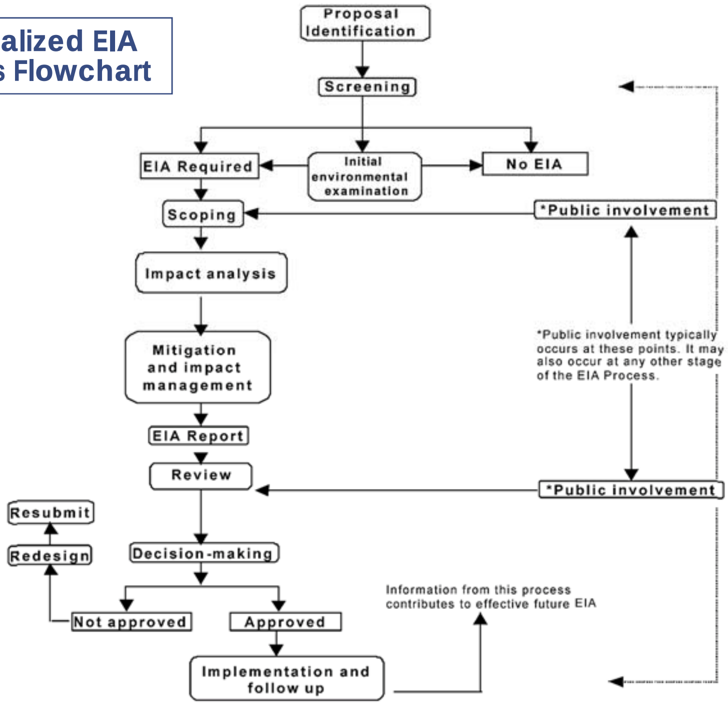
Environmental Impact Assessment

- **Environmental impact assessment** (**EIA**) is the **process** of determining and evaluating the effects that a proposed action would have **on the environment** before the decision is taken on whether or not to proceed with it.
- **Environmental impact statement** (**EIS**) is the most common name given to the printed **report** which documents the results of the EIA process for consideration by decision makers. (Several names are also used, including environmental impact report and environmental review).

Environmental Impact Assessment

- A basic objective of an environmental study is to **anticipate any potential impacts**, adverse or beneficial, of a proposed construction project on the environment.
- This is done so that **measures can be taken to minimize or eliminate the harmful impacts** when the project is implemented.
- It is supposed to be objective and unbiased, and it is meant to neither promote nor block the implementation of a proposed project.
- Unfortunately, EIS reports are sometimes manipulated by developers to promote a construction project, or they are misused by special interest groups to stop a project completely.

Generalized EIA Process Flowchart



The EIA process:

1. **Screening** – to determine whether or not a proposal should be subject to EIA and, if so, at what level of detail.
2. **Scoping** – to identify the issues and impacts that are likely to be important and to establish terms of reference for EIA.
   - Term of reference → assessment methodologies to be employed
3. **Examination of alternatives** – to establish the preferred or most environmentally sound option for achieving the objectives of a proposal
4. **Impact analysis** – to identify and predict the likely environmental, social and other related effects of the proposal.

The EIA process:

5. **Mitigation and impact management** – to establish the measures that are necessary to avoid, minimize or offset predicted adverse impacts and, where appropriate, to incorporate these into an environmental management plan or system.
6. **Evaluation of significance** – to determine the importance or acceptability of residual impacts that cannot be mitigated.
7. **Preparation of environmental impact statement** (EIS) or report – to document the impacts of the proposal, the significance of effects, and the concerns of the interested public and the communities affected by the proposal.

The EIA process:

8. **Review of the EIS** – to determine whether the report meets its terms of reference, provides a satisfactory assessment of the proposal(s) and contains the information required for decision-making.
9. **Decision-making** – to approve or reject the proposal and to establish the terms and conditions for its implementation.
10. **Follow up** – to ensure compliance with the terms and conditions of approval; to monitor the impacts of development and the effectiveness of mitigation measures.

Screening

ملحق رقم (٢)

أسس ومقاييس تقييم التأثيرات البيئية للمشاريع الصناعية والتنموية

<u>أولا : مشاريع الأشخاص :</u>

١- تقوم الجهة المرخصة بتصنيف المشروع المطلوب الترخيص له حسب دليل تصنيف المشاريع الصناعية والتنموية (ملحق رقم ٢-١) الصادر عن الجهة المختصة .

٢- تقوم الجهة المرخصة بناء على تصنيف المشروع باتباع التالي :

الفئة الأولى :

تزويد الجهة القائمة على تنفيذ المشروع باستمارة التقييم البيئي المبدئي (نموذج الفئة الأولى ملحق رقم ٢-٢).

الفئة الثانية :

تزويد الجهة القائمة على تنفيذ المشروع باستمارة التقييم البيئي المبدئي (نموذج الفئة الثانية ملحق رقم ٢-٣).

الفئة الثالثة :

تبليغ الجهة القائمة على تنفيذ المشروع أن المشروع مصنف ضمن مشاريع الفئة الثالثة والتي تتطلب إعداد دراسة تقييم تأثيرات بيئية شاملة للمشروع من ثلاث نسخ

النظام العام للبيئة واللائحة التنفيذية
الرئاسة العامة للأرصاد وحماية البيئة

Scoping

- The environmental impact assessment shall **identify, describe and assess** in an appropriate manner **the direct and indirect significant effects of a project on the following factors**:
  a) Population and human health.
  b) Biodiversity.
  c) Land, soil, water, air and climate.
  d) Material assets, cultural heritage and the landscape.
  e) The interaction between the factors referred to in points (a) to (d).
- **Terms of Reference (ToR)** → the proposed approaches for the definition of the environmental baseline, and the proposed methodologies for impact identification and evaluation, etc.

Assessment of Environmental Impacts

- Many procedures for conducting an environmental assessment have been developed over the years.
  - **Checklist method**, all potential environmental impacts for the various project alternatives are listed, and the anticipated magnitude of each impact is described qualitatively.
  - **Matrix methods**, an attempt is made to quantify or grade the relative impacts of the project alternatives and to provide a numerical basis for comparison and evaluation.

Example of Impact and Mitigation measures during operation of for Fertilizer plant

Aspect	VR	Impact	Mitigation	Significance Before Mitigation	Significance after Mitigation
Operation of Ammonia / Urea Plant	Air	Reduction of air quality due to dust and particulate generations	Recycle the collected urea dust via the cooler scrubber and use it as a feed material.	**Moderate**	**Minor**
		Reduction of air quality due to gas emissions	Regular monitoring and maintenance. Use best available techniques. Avoid unnecessary journeys and equipment use. CO_2-generating activities should be done efficiently.	**Moderate**	**Minor**
	Terrestrial Ecology and Biodiversity	Harmful emissions and noise causing their disturbance	Same measures to mitigate the reduction of air quality. Use muffled machinery and generators; use baffles and acoustic insulation; fit vehicles with silencers; and restrict working hours for intrusive activities.	**Insignificant**	**Insignificant**
	Economic Activities	Employment opportunities and revenue	Not applicable.	**Positive**	**Positive**
	Population	Nuisance due to increased ambient noise levels	Use muffled machinery and generators; use baffles and acoustic insulation; fit vehicles with silencers; and restrict working hours for	**Major**	**Moderate**

Example of Impact and Mitigation measures during operation of for Fertilizer plant

Aspect	VR	Impact	Mitigation	Significance Before Mitigation	Significance after Mitigation
	Traffic	Load on the traffic at the area	Adopt a traffic plan. Adequate planning of activities. Driver training.	**Minor**	**Insignificant**
Use of On-site Machinery and Equipment	Air	Reduction of air quality due to dust and particulate generations	Avoid unnecessary equipment use.	**Minor**	**Insignificant**
		Reduction of air quality due to gas emissions	Regular monitoring and maintenance. Use best available techniques. Avoid unnecessary equipment use.	**Minor**	**Insignificant**
	Soil	Degradation due to release of contaminants	Store and manage potentially contaminating materials according to best environmental practice. Implement a comprehensive Waste Management Policy.	**Insignificant**	**Insignificant**
	Groundwater	Quality degradation due to leaching of contaminants	Inspection of pipes. Store and manage potentially contaminating materials according to best environmental practice.	**Insignificant**	**Insignificant**
	Population	Nuisance due to increased ambient noise levels	Use muffled machinery and generators; use baffles and acoustic insulation; fit vehicles with silencers; and restrict working hours for intrusive activities.	**Moderate**	**Minor**
Waste Disposal	Soil	Degradation due to release of contaminants	Store and manage potentially contaminating	**Minor**	**Insignificant**

The Environmental Impact Statement

The writing of an EIS is preceded by two steps:

1. Step one – **An environmental inventory** must be conducted for the site and vicinity of the proposed project. This inventory includes a thorough description of the existing physical environment and serves as the basis for evaluating the possible impacts of the project.
2. Step two – involves a systematic and comprehensive **environmental assessment**. This assessment, a crucial part of the EIS process, identifies and analyzes the potential adverse environmental consequences of the project.

The Environmental Impact Statement

Generally, the following topics or sections are included in a final draft of the EIS:

1. Description of the existing environment
2. Description of the proposed project
3. Environmental assessment
4. Unavoidable adverse environmental impacts
5. Secondary or indirect impacts
6. Methods for reducing adverse impacts
7. Alternatives to the proposed project
8. Irreversible commitments of energy and resources
9. Consideration of public input and review

Items covered when descripting the Existing Environment

- Geology, soils, and topography
- Water resources
- Vegetation and wildlife
- Air quality and noise
- Transportation
- Public utilities
- Population, land use, and socioeconomics
- Historical or unique cultural features

Environmental Audits

- An **environmental audit** is an evaluation of an industrial facility's waste generation and waste management practices, as well as an assessment of the facility's compliance with environmental laws at the local, state, and federal levels.
- Environmental auditing is **a management tool** that enhances the overall environmental performance of manufacturing facilities
- Example of this tools: **ISO 14000 family - Environmental management**
- Is generally a requirement for property transfers and reduction of legal liabilities due to improper or inadequate waste management operations.