

## Chapter 6: Lecture Air Pollution

5 How is everybody today? Let's begin because we've got a lot to cover. Today, we are going to look at the problem of air pollution. And to understand air pollution, I want to look at one of the particularly harmful gases that causes it. So, that's where we'll start, and then we'll move on to discuss trees. Yes, that's right, trees. And we'll look at how trees are a great low technology solution to air pollution. OK. So we have these two areas to cover.

10 Let's start by looking at air pollution in urban areas . . .that is, cities. What we see in urban areas is that air pollution can be especially intense because the human population in cities is so big. When we look at population statistics for an urban area worldwide, these numbers are interesting. The world population is over six billion in 2005, and of this six billion, almost fifty percent live in cities. Another way to say that is more than 3 billion people, three billion, live in cities!

15 Why am I telling you these numbers? Let me explain why. It is important to understand these urban population statistics because when we look at the problems caused by air pollution in urban areas, we can see that in cities a huge number of people are affected by pollution. And we also see that it is this same huge number of people that cause the pollution as well. So cities are key places to look at the causes and effects of air pollution.

20 So, let's move now to look at some of the specific causes of air pollution. In order to give us an idea of how air pollution works, I want to explain the impact of one pollutant on air quality. The pollutant is a gas, a gas called *sulphur dioxide*. How many of you have heard of this? The chemical symbol for this is  $\text{SO}_2$ . Sulphur dioxide is a mix of sulfur . . . the chemical symbol is S, and oxygen molecules. The chemical symbol is  $\text{O}_2$ . The sulfur we are talking about is present in fuel. What I mean by fuel is material that is burnt to supply heat or power, like oil and coal. OK. Let's look at how  $\text{SO}_2$  is formed then. Let me put a slide up for you to look at while I explain the process. OK? Here it is. This shows four steps or so of the process.

30 First, we have a fuel that contains sulfur, and it is burned. The sulfur is released into the air. You can see it coming from these factories here. Next, the sulfur then mixes with oxygen in the air. This becomes  $\text{SO}_2$ —sulfur dioxide. So, that is how it is formed, but, let's look at what happens next. The  $\text{SO}_2$  then rises into the air. At this point, it mixes with water in the clouds. The mix forms a substance called *sulfuric acid*. And now, the sulfuric acid interacts with other gases in the air to form something called a *sulfate*.

40 The fourth step shows that sulfuric acid then falls with the rest of the water in the clouds as something called *acid rain*. You've probably heard of this. This acid rain is extremely dangerous to the environment, land, and water. So, that's the process of how  $\text{SO}_2$  is formed and becomes acid rain. Let me spell out the problems sulfur dioxide can cause for both people and the environment.

45 People exposed to  $\text{SO}_2$ —many of them living in cities—have a difficulty with things

like this . . . difficulty with breathing, watering eyes, and burning nose and throat. For some, these effects are temporary, but in other cases SO<sub>2</sub> can actually cause permanent damage.

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Now, let's look at the effects on the environment. Here are some examples. Sulphur dioxide in acid rain damages forests and growing things and even changes the soil—in other words, the ground the plants grow in. It also increases the acid level in water. By water I mean . . . oceans, and lakes, and streams. It makes them so acidic that fish and other living creatures cannot live in them.

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I think I've painted a general picture of how serious air pollution is. You have a pretty good idea of how terribly it affects every living thing. So, let's turn our attention to what's being done about this problem. Let's turn our focus to one unique solution.

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Let's talk about trees. Trees provide both environmental services and economic benefits. What does this mean? It means that trees actually help save money.

I want to talk now about how trees help in and around densely populated urban areas.

Let me start by defining an important term . . .and that is, *urban forest*. The term *urban forest* means "planting and maintaining individual trees and small forests in and around urban areas." For example, an urban forest can be tree-lined streets, trees in school yards, trees in downtown parks, and trees along the highways. You get the picture.

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So, let me explain what these trees do to reduce pollution. First, trees absorb polluting gases through their leaves. They take in pollutants and break them down so that they're less harmful. You can think of trees working kind of like a sponge for various forms of pollution. So trees help reduce existing pollution.

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Trees are also helpful in preventing pollution from occurring. Trees actually help cities stay cooler by reducing high temperatures in general. How does this work? Trees as you know, provide valuable shade. And shade is good because once the air is cooler, there is less of a need for using air conditioners. Some urban forest organizations claim that just three—only three—well-placed trees around a home can lower air conditioning bills by up to fifty percent. This is amazing! Lowering home electricity bills is just part of the story of how trees help. Power plants that produce electricity are one of the biggest sources of SO<sub>2</sub>.

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Urban forestry is an international effort that you can see in cities all over the world.

Let me give you a few examples—Beijing, China; Dublin, Ireland; and Mexico City, to name just a few, all have significant urban forestry programs.

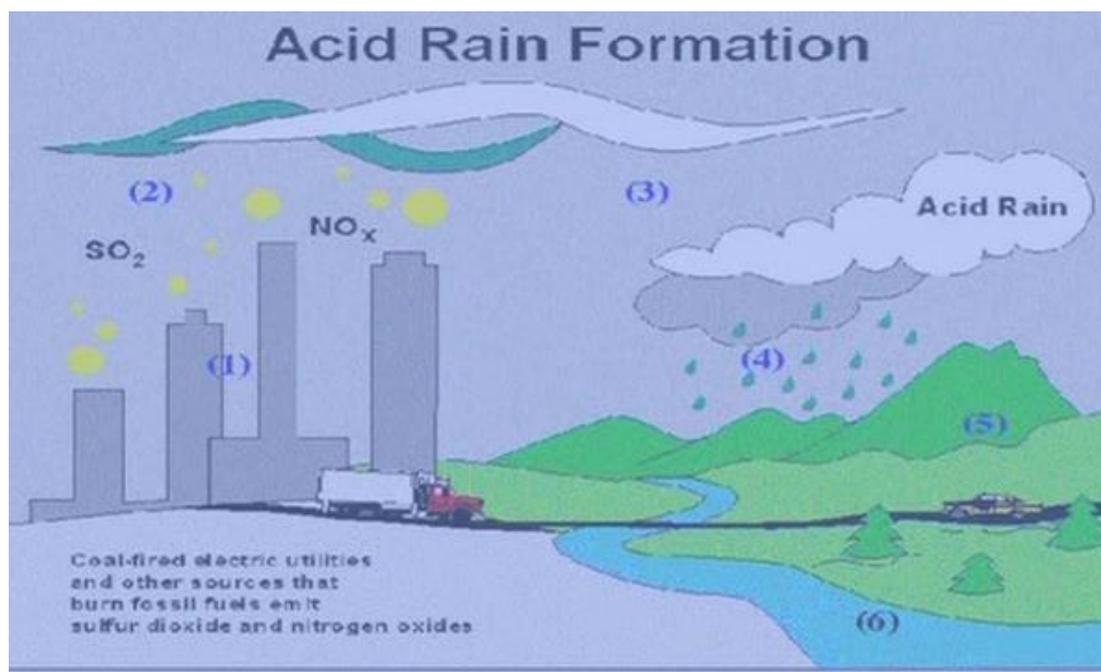
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I'm going to stop here today. But I hope to leave you with an understanding of one polluting gas, sulfur dioxide, and the advantages of trees and the urban forest.

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There are many ways to explain cause and effect. Look at these various patterns which use *cause* and *result* as either a noun or a verb.

- |                       |  |
|-----------------------|--|
| The cause of X is Y.  | The <b>cause of</b> lung cancer is smoking.  |
| Y causes X.           | Smoking <b>causes</b> lung cancer.           |
| X is caused by Y.     | Lung cancer <b>is caused by</b> smoking.     |
| The result of Y is X. | The <b>result of</b> smoking is lung cancer. |
| Y results in X.       | Smoking <b>results in</b> lung cancer.       |



### chemistry vocabulary

Solutions with a pH less than 7 are **acidic** and solutions with a pH greater than 7 are **basic (alkaline)**.

hydrogen H	atom
carbon C	molecule
nitrogen N	acid (n.)
sulfur S	acidic (adj.)
oxygen molecule O <sub>2</sub>	acidify (v.)
ozone O <sub>3</sub>	basic (alkaline)
carbon monoxide CO	pH
carbon dioxide CO <sub>2</sub>	
sulfur dioxide SO <sub>2</sub>	

## Lecture Ready 2 Chapter 6 Unique Solutions to Pollution

### Notes

#### 1. air pollution

- a. one harmful gas -  $\text{SO}_2$
- b. trees - low technology solution

#### 2. urban areas

- a. high pop. = high pollution
- b. 50% of world's pop. (3 bill. in 2005) lives in cities
- c. cities are important in solving air pollution

#### 3. causes

- a.  $\text{SO}_2$  (1 sulfur + 2 oxygen atoms) from fuel

#### 4. $\text{SO}_2$ process

fuel is burned, S goes into air, mixes with O  $\rightarrow$   $\text{SO}_2$ , mixes with water in clouds  $\rightarrow$  sulfuric acid, mixes with other gases  $\rightarrow$  sulfates  $\rightarrow$  acid rain  $\rightarrow$  harms fish and ecosystems

#### 5. effects of $\text{SO}_2$ on people

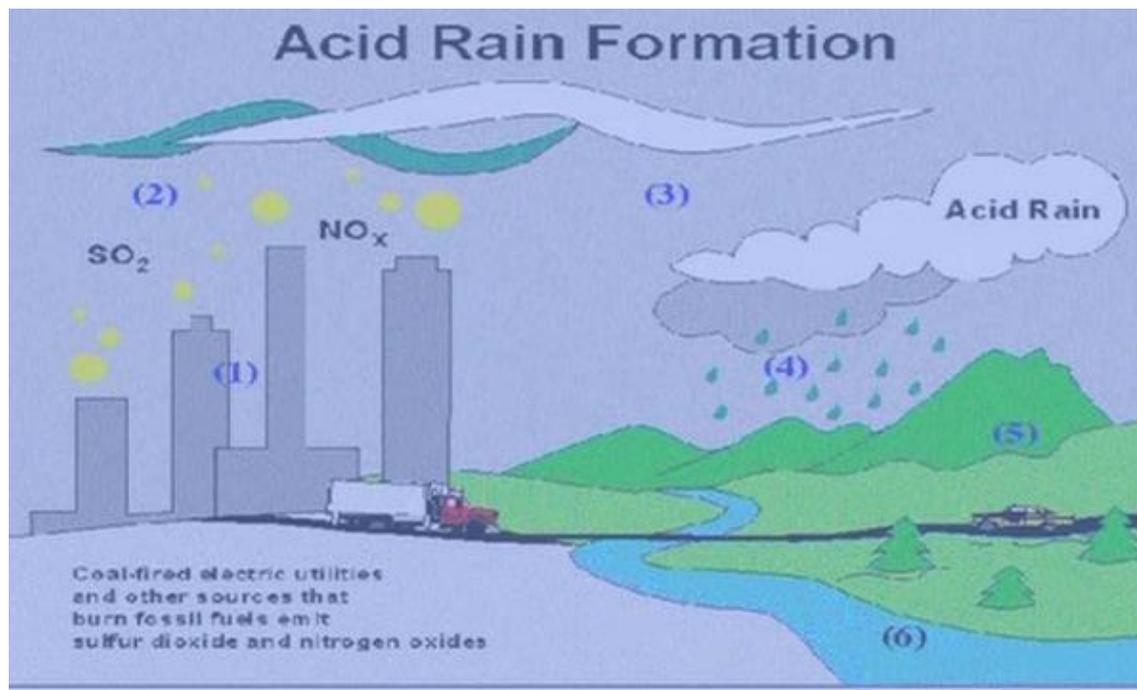
- a. breathing, watering eyes, burning nose and throat
- b. temporary or permanent damage

#### 6. effects of $\text{SO}_2$ on environment

- a. plants, soil
- b. acidic water harms fish

#### 7. solutions

- a. trees in urban areas, urban forests - ex. school yards, parks, along highways
- b. trees absorb polluting gases, like a sponge
- c. cooling effect, so less air conditioning used, so less  $\text{SO}_2$  from electricity generators
- d. Beijing, Dublin, Mexico City - urban forestry programs



## Cause and Effect

### 1. Active Voice

- a. Burning fuel **produces** CO<sub>2</sub>.
- b. The use of fossil fuels **causes** global warming
- c. The use of electricity **leads to** acid rain.
- d. Acid rain **results in** deadly acid levels in lakes.
- e. Acid rain **affects** the fish living in lakes.

### 2. Passive Voice

- a. CO<sub>2</sub> **is produced by** burning fossil fuel.
- b. Global **warming is caused by** the use of fossil fuels.
- c. Fish living in lakes **are affected by** acid rain.

### 3. Nouns

- a. Acid rain has a harmful **effect** on fish.
- b. The **cause** of acid rain is the burning of fossil fuels.
- c. The energy crisis is producing a deadly **result**.
- d. Every form of energy production has a negative **effect** on the environment.

### 4. Conjunctions relating cause and effect

- a. Global warming happens **because of** burning of fossil fuels.
- b. All the fish in the lake died **because** people in this region used coal to produce electricity.
- c. They used large amounts of coal, **so** of course acid rain became a serious problem.
- d. The government forced the energy companies to install expensive chimneys **so that** they would release less SO<sub>2</sub> and NO<sub>2</sub>. (*so that* expresses the purpose of an action, or the intention behind an action)
- e. The government forced the energy companies to install expensive chimneys **in order to** reduce the acid rain problem.

## 1. Language Structures for Explaining Cause and Effect

### a. Active Verbs

this causes... this leads to... this results in... this affects... this produces + NOUN (DIRECT OBJECT)

### b. Passive Verbs

this is caused by... this is affected by... this is produced by... + NOUN (SUBJECT)

### c. Nouns

the cause is... the result is... the effect is...

## 2. Conjunctions explaining cause and effect

- X happens *because of* Y [*because of* + NOUN]
- X happened *because* Y happened [*because* + S + V]
- Y happened, *so* X happened
- X happened *so that* Y would happen [*so that* explains the purpose of the action X]
- X did Y *in order to* + VERB [this is a way to explain the purpose of the action Y]

You can also explain cause, effect and a second effect with sentences that follow this logical pattern:

*If A, then B, so C*                      *OR*            *When A, then B, so C*

*If (A)* you work too much overtime, *then (B)* you become very tired, *so (C)* you actually don't produce more just because you work a longer time. *When (A)* you get too tired, *then (B)* you will make more mistakes, *so (C)* sometimes it is better to stop working and come back to work when you are rested. [*then* is often omitted in speaking and writing]

## 3. Explain a sequence of causes and effects

*first, then, next, finally*

## 4. Feedback loops

A series of causes and effects sometimes becomes a *feedback loop*. This is called either a *negative or positive feedback loop*, or a *vicious circle* or a *virtuous circle*. It is also called an upward or downward spiral.

### A vicious (bad) circle or a virtuous (good) circle?

As humans burn more fossil fuel, the planet becomes warmer. This **results in** more ice and snow melting. Then the atmosphere becomes warmer **because** there is less white snow reflecting solar energy back toward space. This is an example of a *vicious circle* or *negative feedback loop*. The **effects** become additional **causes** of the original problem, so the problem gets worse at an *exponential* (non-linear rate) rate. In economics there are many other examples. A factory closes → The former workers spend less money in stores → Stores close... A virtuous circle moves in the opposite way. A factory opens → More people come to a town to work in the factory → New stores open...

On a graph, a *linear effect* appears as a straight line. An *exponential effect* appears as a curved line. In the equation  $4^3 = 64$ , 3 is the *exponent*. Feedback loops always show an *exponential relationship* between causes and effects, so the line of a graph explaining a problem like global warming is a curve showing the *exponential relationship*. It could be shown in its simplest form as  $a=b^c$ .

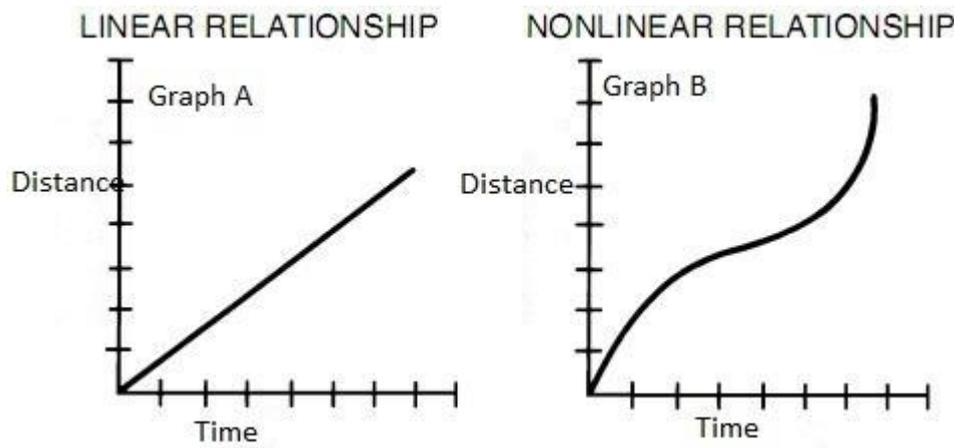
**Cause and Effect, Causal Relationships**  
**Feedback Loops, Spirals and Vicious & Virtuous Circles: The Greenhouse Effect**

Everyone knows that **if** you **sit** in a car on a summer day with the windows closed, you **will begin to feel** very hot. The energy from the sun comes through the glass and into the car, but it doesn't go back out fast enough, **so** the car heats up. The glass **causes** the temperature to go up. Farmers create a warm space in the same way by making a greenhouse **in order to** grow vegetables in the winter.

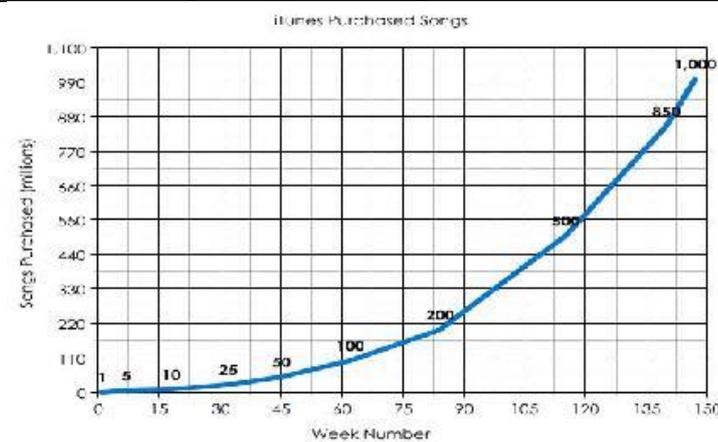
Global warming **is caused by** a similar process, so **this is the reason** it is sometimes called the “greenhouse effect.” In this case, it is increasing levels of gasses such as CO2 that are like the glass or plastic of a greenhouse. Sunlight comes to earth, but the heat doesn't go back out to space as much as it used to. The CO2 has the same **effect** as the glass windshield of a car, and this **leads to** higher temperatures.

**Exponential:** 指数関数

**Non-linear:** 非線形



A non-linear, exponential relationship



A spiral pattern gets bigger with each repetition

