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Definition of Acid Rain

- Precipitation that has a pH of less than that of natural rainwater (which is about 5.6 due to dissolved carbon dioxide).
- It is formed when sulphur dioxides and nitrogen oxides, as gases or fine particles in the atmosphere, combine with water vapour and precipitate as sulphuric acid or nitric acid in rain, snow, or fog.

Causes of Acid Rain

- Natural Sources
  - Emissions from volcanoes and from biological processes that occur on the land, in wetlands, and in the oceans contribute acid-producing gases to the atmosphere
  - Effects of acidic deposits have been detected in glacial ice thousands of years old in remote parts of the globe

Causes of Acid Rain

- The principal cause of acid rain is from human sources
  - Industrial factories, power-generating plants and vehicles
  - Sulphur dioxide and oxides of nitrogen are released during the fuel burning process (i.e. combustion)

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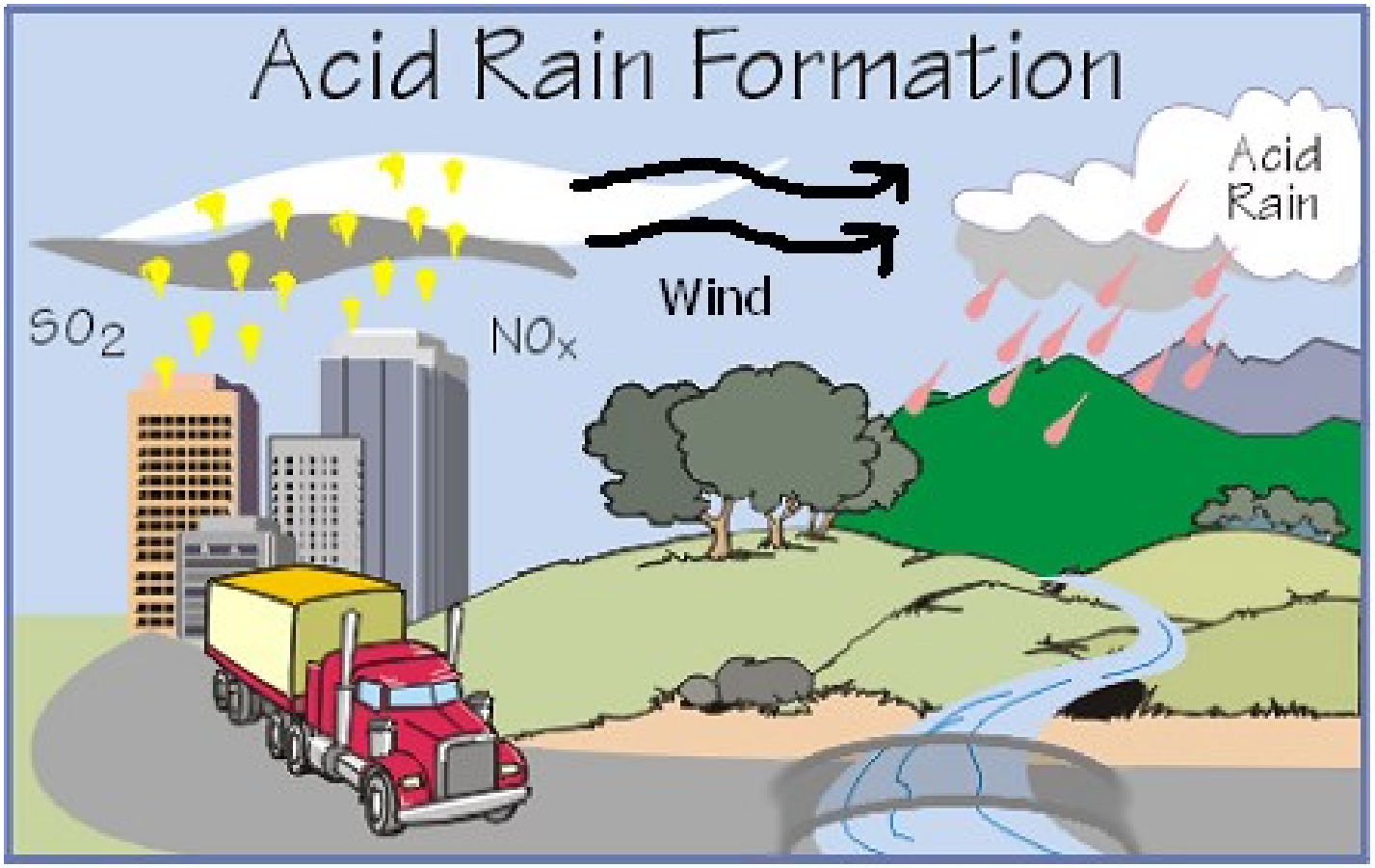
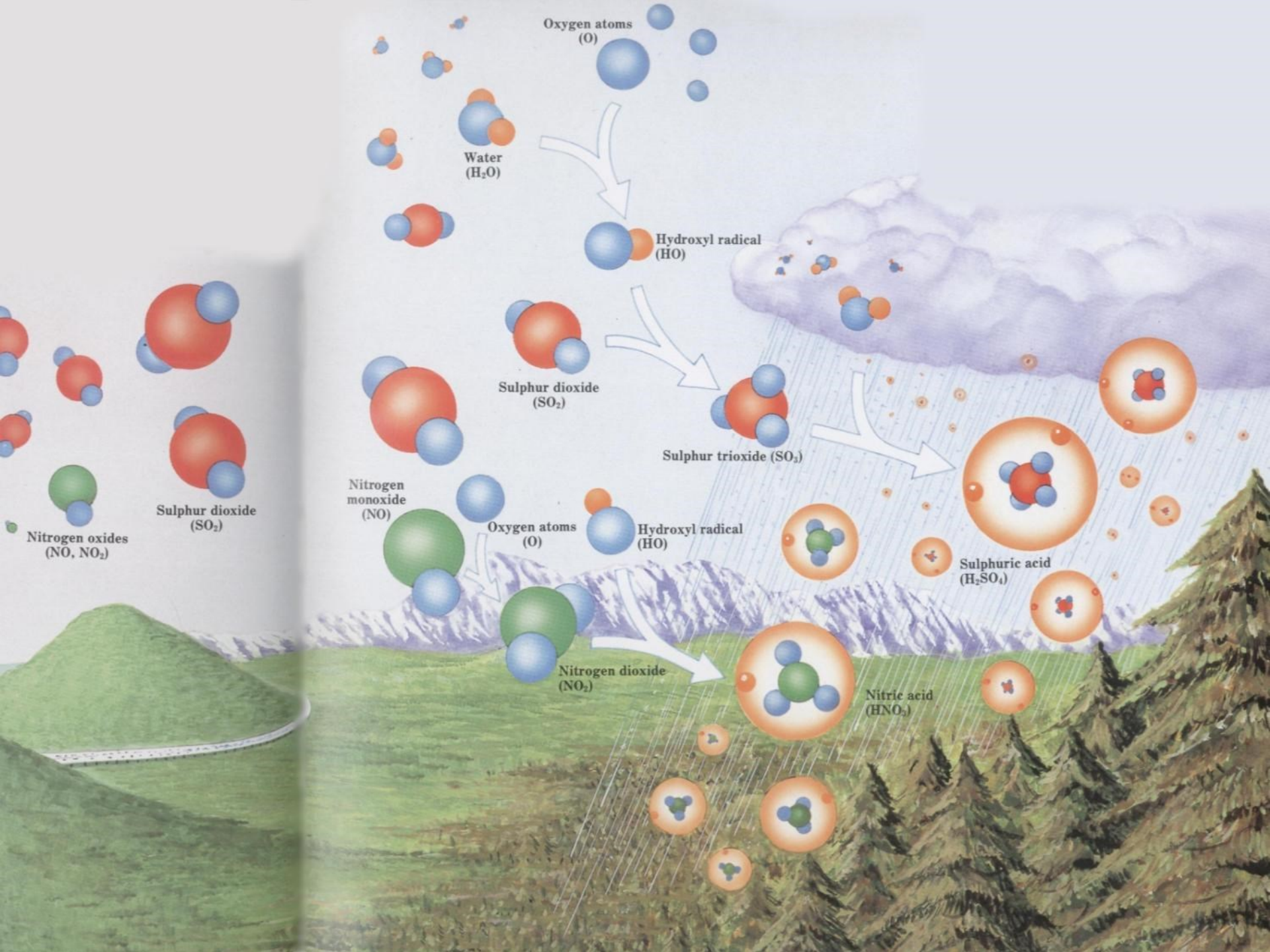
Formation of Acid Rain



Formation of Acid Rain

- When water vapour condeses, or as the rain falls, they dissolve in the water to form sulphuric acid (H_2SO_4) and nitric acid (HNO_3).
- While the air in cleaned of the pollutants in this way, it also causes precipitation to become acidic, forming acid rain


Oxygen atoms
(O)
Water
(H_2O)
Hydroxyl radical
(HO)
Sulphur dioxide
(SO_2)
Sulphur trioxide (SO_3)
Nitrogen oxides
(NO, NO_2)
Sulphur dioxide
(SO_2)
Nitrogen
monoxide
(NO)
Oxygen atoms
(O)
Hydroxyl radical
(HO)
Sulphuric acid
(H_2SO_4)
Nitrogen dioxide
(NO_2)
Nitric acid
(HNO_3)

Affected Areas

- Canada
  - Acid rain is a problem in Canada
  - Water and soil systems lack natural alkalinity such as lime base
    - Cannot neutralize acid
  - Canada consists of susceptible hard rock such as granite
    - Do not have the capacity to effectively neutralize acid rain

Affected Areas

- Industrial acid rain is a substantial problem in China, Eastern Europe and Russia and areas down-wind from them.
- Acid rain from power plants in the Midwest United States has also harmed the forests of upstate New York and New England.
- This shows that the effects of acid rain can spread over a large area, far from the source of the pollution

Effects of Acid Rain

- Harmful to aquatic life
  - Increased acidity in water bodies
  - Stops eggs of certain organisms (e.g. fish) to stop hatching
    - Changes population ratios
    - Affects the ecosystem

Effects of Acid Rain

- Harmful to vegetation
  - Increased acidity in soil
  - Leeches nutrients from soil, slowing plant growth
  - Leeches toxins from soil, poisoning plants
  - Creates brown spots in leaves of trees, impeding photosynthesis
  - Allows organisms to infect through broken leaves

Effects of Acid Rain

http://abacus.bates.edu/~ganderso/biology/bio270/clover_leaf_burns_pH2_30d.gif

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Effects of Acid Rain

- Accelerates weathering in metal and stone structures
  - Eg. Parthenon in Athens, Greece; Taj Mahal in Agra, India

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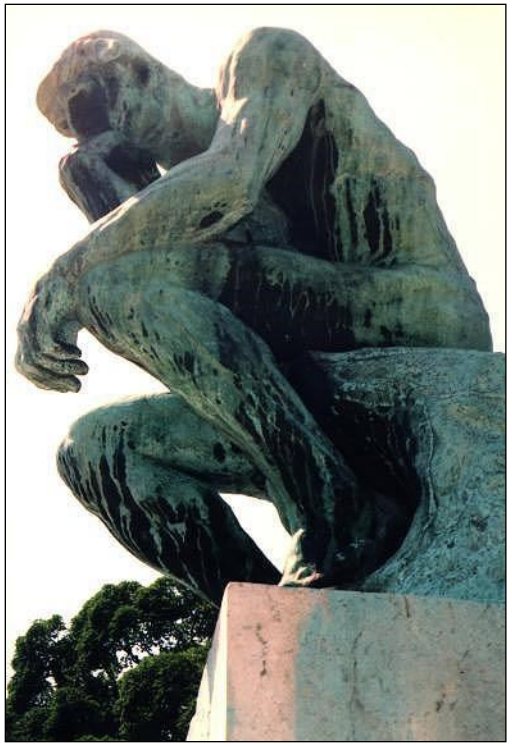

http://www.lauraknauth.com/photos/france/thinker.jpg

Effects of Acid Rain

- Affects human health
  - Respiratory problems, asthma, dry coughs, headaches and throat irritations
  - Leeching of toxins from the soil by acid rain can be absorbed by plants and animals. When consumed, these toxins affect humans severely.
  - Brain damage, kidney problems, and Alzheimer's disease has been linked to people eating "toxic" animals/plants.

Preventive Measures

- Reduce amount of sulphur dioxide and oxides of nitrogen released into the atomosphere
  - Use less energy (hence less fuel burnt)
  - Use cleaner fuels
  - Remove oxides of sulphur and oxides of nitrogen before releasing
    - Flue gas desulphurization
    - Catalytic Converters

Preventive Measures

- Use cleaner fuels
  - Coal that contains less sulphur
  - "Washing" the coal to reduce sulphur content
  - Natural Gas

Preventive Measures

- Flue Gas Desulphurisation (FGD)
  - Removes sulphur dioxide from flue gas (waste gases)
  - Consists of a wet scrubber and a reaction tower equipped with a fan that extracts hot smoky stack gases from a power plant into the tower
  - Lime or limestone (calcium carbonate) in slurry form is injected into the tower to mix with the stack gases and reacts with the sulphur dioxide present

Preventive Measures

- (continued)
  - Produces pH-neutral calcium sulphate that is physically removed from the scrubber
  - Sulphates can be used for industrial purposes

Scrubber at work

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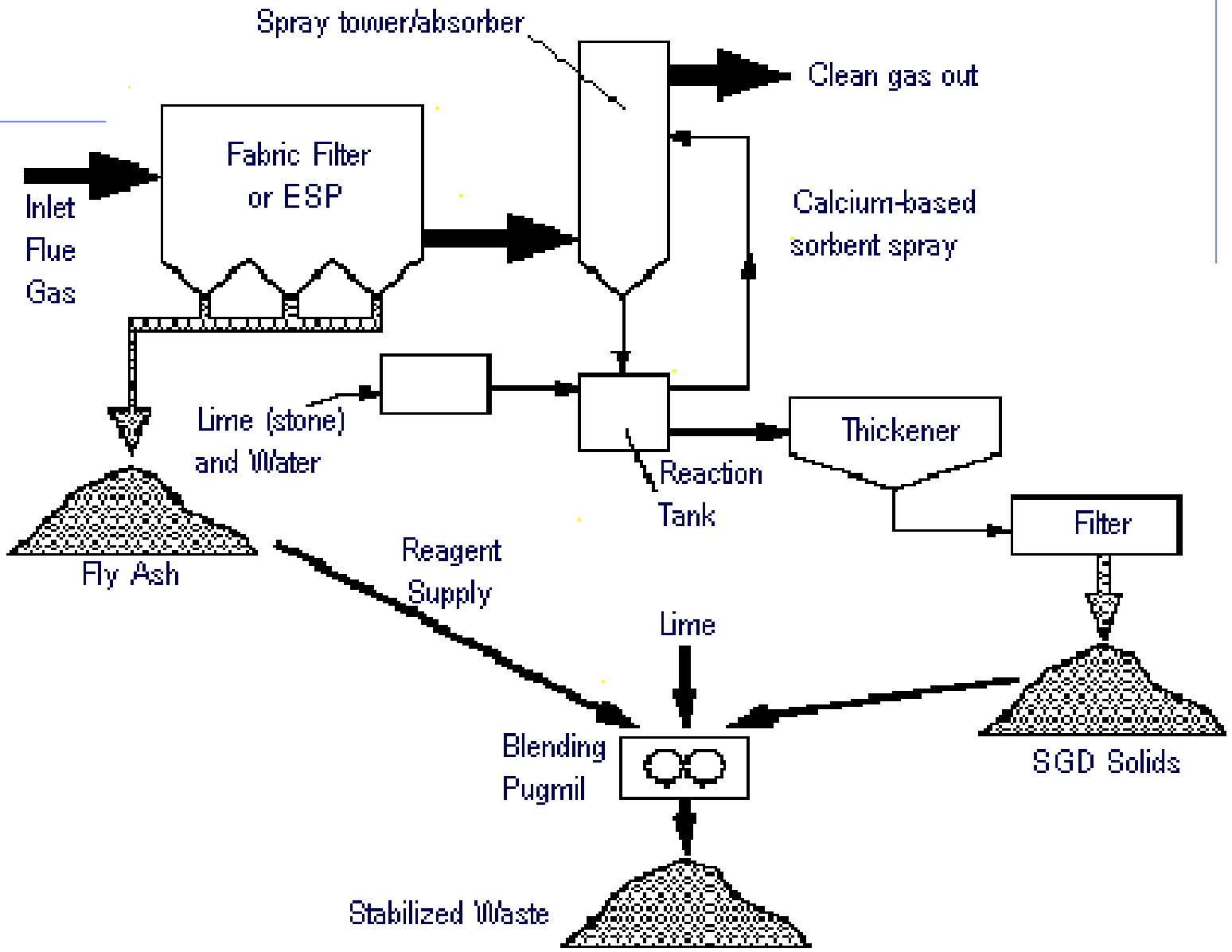
Spray tower/absorber
Clean gas out
Fabric Filter
or ESP
Inlet
Flue
Gas
Calcium-based
sorbent spray
Lime (stone)
and Water
Thickener
Reaction
Tank
Filter
Fly Ash
Reagent
Supply
Lime
Blending
Pugmil
SGD Solids
Stabilized Waste

Preventive Measures

- Use other sources of electricity (i.e. nuclear power, hydro-electricity, wind energy, geothermal energy, and solar energy)
  - Issue of cost

http://upload.wikimedia.org/wikipedia/commons/4/4e/Nuclear_Power_Plant_Cattenom.jpg

Reducing the effects of Acid Rain

- Liming
  - Powdered limestone/limewater added to water and soil to neutralize acid
  - Used extensively in Norway and Sweden
  - Expensive, short-term remedy

Bibliography

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- Marian Boderick. (1994). Weather and Climate. Hong Kong: Time Life Asia.
- Katherine K. Rothschild. (1994). Matter and Chemistry. Hong Kong: Time Life Asia.

Thank You

Problem Scenario

- Suppose you worked in the government. A company wants to set up a factory in your country. It would bring jobs, but it would also bring about pollution, which would lead to acid rain. Would you allow it? Justify your answer.

II continued: II

- Acidic particles and vapours are deposited via two processes - wet and dry deposition.

- Wet deposition is acid rain, the process by which acids with a pH normally below 5.6 are removed from the atmosphere in rain, snow, sleet or hail.

- Dry deposition takes place when particles such as fly ash, sulphates, nitrates, and gases (such as SO_2 and NO), are deposited on, or absorbed onto, surfaces.

- The gases can then be converted into acids when they contact water.