**Online reference:**

http://pollution-plants.blogspot.com/

**Air Pollution (Ref. 9)**

**Trees Damaged by Acid Rain**   
Photo: [Lindley Ashline](http://www.flickr.com/people/angelslens/)

* *Acid rain* can kill trees, destroy the leaves of plants, can infiltrate soil by making it unsuitable for purposes of nutrition and habitation
* *Ozone holes* in the upper atmosphere can allow excessive ultraviolet radiation from the sun to enter the Earth causing damage to trees and plants
* *Ozone* in the lower atmosphere can prevent plant respiration by blocking stomata (openings in leaves) and negatively affecting plants’ photosynthesis rates which will stunt plant growth; ozone can also decay plant cells directly by entering stomata

**Water Pollution**

* May disrupt photosynthesis in aquatic plants and thus affecting ecosystems that depend on these plants (Ref. 10)
* Terrestrial and aquatic plants may absorb pollutants from water (as their main nutrient source) and pass them up the food chain to consumer animals and humans
* Plants may be killed by too much sodium chloride (ordinary slat) in water (Ref. 11)
* Plants may be killed by mud from construction sites as well as bits of wood and leaves, clay and other similar materials (Ref. 12)
* Plants may be killed by herbicides in water; herbicides are chemicals which are most harmful to plants (Ref. 13)

**Soil Pollution**

* May alter plant metabolism and reduce crop yields (Ref. 14)
* Trees and plants may absorb soil contaminants and pass them up the food chain

# The Effect of Soil Pollution on the Rate of Photosynthesis

Written by Kristal Rogers



Pollution upsets the chemical balance and physical properties of the soil. Plants adapted for specific environmental conditions may not have the mechanisms to react to these changes. Therefore, the rate of photosynthesis will be impacted. Photosynthesis is the process by which plants produce energy and food. Factors affecting the degree of the impact of soil pollution include the richness of the soil, climatic conditions, and the age of plants.

## Gas Exchange

Direct contact of pollutants on plant structures, such as leaves, disrupts photosynthesis by damaging vital sites of gas exchange, a major factor in photosynthesis.

## Nitrogen

Excessive soil nitrogen caused by pollution can negatively impact plant root systems, reducing plants' ability to take up water and carry out photosynthesis.

## Microorganisms

Soil pollution can cause a reduction in microorganisms, which benefit soils by increasing water flow, leading to a reduction in water uptake and the rate of photosynthesis.

## Aluminum

Mobilization of aluminum in soils polluted by acidic compounds causes a reduction in photosynthesis by limiting cell division and root growth.

## Stress

Soil pollution causes a reduction in photosynthesis by stressing plants, which will respond by focusing resources on recovery from the stress rather than carrying out photosynthesis.

#### References

* [Water Air Soil Pollution; "Long-term changes in forest soil acidity in Pennsylvania, USA"; April 1997](NULL)
* [Wildlife Gardener](http://www.wildlifegardener.co.uk/BenefitsOfWormsInGardens.html)
* ["Air Pollution" ; M. Rao; 1988](NULL)

## Friday, February 22, 2008

### Soil pollution and plants

**SOIL POLLUTION AND PLANTS**Most of the atmospheric pollutants finally come down and settle on the ground surface, causing soil pollution. Pollutants also come back to soil when polluted water is used for irrigation. Many pollutants are directly deposited on the soil as sewage, industrial effluents and chemical fertilizers. The soil pollution by various pollutants has far reaching effects on plants and vegetation.  
**Effects of soil acidification**  
The oxides of sulphur and nitrogen, chlorides, fluorides, ammonium etc. emitted into the atmosphere in combustion from various industries come down as dry or wet deposition (acid rain) onto the soil and lower the soil pH. Increased acidity of soil results in following effects.  
The activity of soil microbes, particularly of decomposers, is reduced. The decomposition of organic matter and consequently nutrient cycling in the soil is reduced. It ultimately adversely affects the growth of plants.  
The bases in the soil are leached down due to soil acidity. As exchangeable bases become deficient in the soil, plant growth is reduced due to nutrient deficiency.  
The roots, particularly the root hairs, are damages resulting in reduction in nutrient uptake by plants.  
Increased acidity mobilizes heavy metals like Al, Cd, Zn, Hg, Mn, Fe etc. These spread rapidly in the soil along with soil water and reach concentrations toxic to plants. Consequently, plants show species specific metal toxicity symptoms. Al-toxicity generally damages root hairs and reduces nutrient uptake while Fe-toxicity has general adverse effect on plant growth.  
In some soils, acidification increases weathering of silicate minerals destroying the mineral structure of the soil. This leads to poor growth of vegetation in general.  
In some marginal soils and grasslands, acidification increases the supply of plant nutrients like sulphur and nitrogen. The vegetation is thus, benefited by soil acidification and plants may show better growth.  
**Effects of pesticides**  
Various pesticides, insecticides, fungicides etc are used in agriculture as foliar spray or are applied to soil far in excess to the requirement causing soil pollution. These substances pollute the soil depending upon their volatility, biodegradability, persistence, leaching, chemical reactivity and adsorption on the soil particles. Many of these substances form cations, are adsorbed on silicate clay micelle or humus molecules on the pH-dependent exchangeable charge sites and are later absorbed by the plants.  
Absorbed pesticides substances produce characteristic species-specific toxicity symptoms in plants just like their aerial overdose.  
Fungicides reduce abundance of soil fungi and actinomycetes and interfere with decomposition of soil organic matter adversely affecting the nutrient cycling.  
Pesticides increase the abundance of some bacterial species, particularly of ammonifying bacteria while reduce the abundance of some susceptible bacteria.  
Insecticides reduce the abundance of predator soil microbes and consequently increase the abundance of their prey species.  
In general, species composition of the soil microflora and fauna is changed by pesticide substances .  
The inorganic pesticides contain arsenic and sulphur. These substances cause toxicity symptoms like yellowing, necrosis, shot holes, premature defoliation etc. in plants.  
**Effects of herbicides**  
Various herbicides are used for weed control in agricultural practice. General effects of some common herbicide substances on the plants are as follows. The symptoms in response to a particular herbicide may be characteristic but their development depends upon the dose to which plants are exposed, rate of growth of plant, weather conditions and the plant species.  
Acetanilides (e.g. Prochlor, Metachlor) cause stunting of plants and roots. In brassicas, these cause yellow, red and blue colouration of leaves with pronounced stunting.  
Amides and carbamates (E.g. Diphenamide, Propyzamide, Chlorpropham and Asulam) cause stunting without chlorosis or leaf-scorch in mild doses. Crops generally become greener in colour. Roots show thickening and stunting. In the cereals, coleptile becomes stunted and swollen.  
Benzonitriles (e.g. Dichlorobenil) cause stunting of plants and thickening of roots. In shrubs and bushes, bark at the ground level develops necrosis. In some cases, marginal yellowing occurs in the leaves.  
Aliphatic acids (e.g. TCA, Dolpon) cause stunted growth of shoot, loss of leaf wax and mild irregular chlorosis.  
Growth regulators (e.g. 2,4 D, MCPA, Chlopyralid, and Mecoprop) cause hormone-type distortion in leaves and fruits. In the brassicas, stem splitting occurs. In the cereals, ears become distorted, becoming blind or with shriveled grains.  
Ureas and Uracils (e.g. Diuron, Linuron, Bromocil, Lencil) cause inhibition of photosynthesis leading to yellowing along the veins that later extends across whole leaf. In the cereals, chlorosis starts in the middle of leaf but extends quickly to the tip.  
Sulphonyl ureas (e.g. Chlorsulfuron) cause inhibition of growth in susceptible plants and these ultimately die due to root growth being stopped.  
Triazinones (e.g. Metribuzin) cause inhibition of photosynthesis that leads to yellowing and tip-scorch in the leaves.  
Triazines (e.g. Atrazine, Simazine) cause chlorosis and necrosis spreading towards tips of leaves and inhibit photosynthesis. This is more severe in older leaves.  
Thiocarbamates and ethofumesates cause chlorosis, stunting and leaf-curling. Younger leaves become stuck to older leaves. In the cereals, this condition often leads to characteristic pink colouration at the base of the stem.  
**Effects of sewage and ash pollution**  
Sewage matter is commonly used as fertilizer or deposited as waste on the soil. Effects of such pollution are mostly common to all plants.  
The organic matter in sewage decomposes and produces nitrogenous substances that become excessive in the soil and harm the vegetation.  
Decomposition of sewage may also release various toxic heavy metals that cause characteristic heavy metal toxicity symptoms in plants.  
Detergent substances may also be released from sewage causing characteristic injury to plants.  
Ash produced mainly from combustion of coal in thermal and industrial plants used for landfilling or deposited on soil makes the soil unfit for vegetation. It may release many toxic substances in the soil causing characteristic plant injuries.  
**Effects of chemical fertilizers**Chemical fertilizers are generally used far in excess of the requirements of the crop. The unutilized fertilizers cause soil pollution.  
Toxic concentrations of nitrogen fertilizers cause characteristic symptoms of nitrite or nitrate toxicity in plants, particularly in the leaves. Nitrogenous fertilizers generally cause  
deficiency of potassium,  
increased carbohydrate storage and reduced proteins,  
alteration in amino acid balance and consequently change in the quality of proteins.  
Ammonium fertilizers produce ammonia around the roots that may escape the soil and cause ammonia injury to plants.  
Ammonium and nitrate produce acids in the soil and increase soil acidity.  
Nitrate and nitrite bacteria are reduced while ammonifying bacteria are increased in the soil disturbing the nitrogen cycle.  
Excessive potash in the soil decreases ascorbic acid and carotene in the plants.  
Superphosphates cause deficiency of Cu and Zn in plants by interfering with their uptake.  
Excessive lime prevents the release of Co, Ni, Mn and Zn from the soil and their uptake by plants is reduced causing their deficiency symptoms.  
Excessive deposition of various substances released from chemical fertilizers into the soil generally causes their over-absorption by plants. These over-absorbed substances become accumulated in plant parts (bioaccumulation) e.g. nitrogen and sulphur are deposited in the leaves.  
**Effects of industrial effluents**Various inorganic and organic substances are present in the industrial effluents. These substances mostly remain tied up in the soil and are not readily available to plants. However, they affect various soil characteristics.  
Effluents affect the mineral structure, soil pH, exchangeable base status etc. of the soil and thus indirectly affect the plants  
The pH of the soil is disturbed making soil either acidic or alkaline.  
Various inorganic and organic chemicals are accumulated in the soil up to levels toxic to plants.  
In highly polluted soils, plants absorb and accumulate toxic substances (bioaccumulation). These substances may or may not produce direct injury symptoms in plants but are passed on to higher trophic levels (biomagnification).  
**Effects of radioactive pollutants**  
A variety of radioactive waste materials like Strontium-90, Cesium-137, Iodine-131, Plutonium, Uranium, Americium, Curium, Neptunium etc. are added to soil from nuclear activities. These substances may be washed into water or may be directly added to water that is used as coolant in nuclear power plants.  
Uptake of radioactive substances by plants depends upon pH and organic matter status of the soil.  
Various radioactive materials show different solubility and absorption by plants. Plant uptake is generally highest for Neptunium, lowest for Plutonium and intermediate for Americium and Curium.  
Strontium-90 behaves as Ca in the soil and is absorbed by plants like it.  
Cesium-137 behaves like K but its uptake by plants is very limited.  
Absorbed radioactive substances are generally accumulated in the vegetative parts of the plants, particularly the leaves. Their accumulation in crop fruits and seeds is very low.  
Accumulation of absorbed radioactive substances in the plants may be up to 100 times their concentration in the soil of water.  
Radiation from radioactive substances may also adversely affect the plants. Pines are eliminated on exposure to 20-30 roentegen/day while most plants die at 200 roentgen/day. Only lichens and mosses are highly resistant to radiation.  
Radiation also damages chromosomes. It increases the frequency of chromosomal aberrations and causes genetic mutations. Such genetic changes may adversely affect plant metabolism or change their characteristics in subsequent generations.

Posted by [garg](http://www.blogger.com/profile/02383183486503037280) at [6:05 AM](http://pollution-plants.blogspot.com/2008/02/pollution-and-plants.html) [http://img1.blogblog.com/img/icon18_email.gif](http://www.blogger.com/email-post.g?blogID=9126937457465601832&postID=3215995587371444257)

### [Air pollution and plants](http://pollution-plants.blogspot.com/2008/02/air-pollution-and-plants.html)

**PRIMARY AIR POLLUTANTS AND PLANTS**  
Major primary air pollutants gases are sulphur dioxide, oxides of nitrogen particularly NO2, HF, HCl, chlorine, ammonia, ethylene and other organic substances. Particulate air pollutants are soot, dust, fine particles of cement and various other substances. Various fertilizers, pesticides and insecticides used in aerial spray are also important air pollutants. The common sources of the pollutants, factors affecting the effect of pollutant and the injury symptoms produced in plants are discussed below.  
**Major gaseous pollutants**  
The gaseous pollutants are emitted in large amounts into the atmosphere due to a variety of anthropogenic activities and form most important atmospheric pollutants that injuriously affect the plants. Important such pollutants are discussed below.  
  
**Sulphur dioxide (SO2)**  
It is the most important and common air pollutant produced in huge amounts in combustion of coal and other fuels in industrial and domestic use. It is also produced during smelting of sulphide ores.  
SO2 effects increase in high hymidity, windy conditions, in the early morning , in the deficiency of K and Cl2 and excess of sulphur in the soil. It interacts with ozone, NO2 and HF. The nature of interaction depends on the relative proportion of gases. The impact of SO2 decreases in low soil moisture, low temperature, deficiency of nitrogen, sulphur and phosphorus and sometimes in excess of nitrogen also.  
  
In angiosperms, young leaves and in conifers, needles are most sensitive to SO2 pollution. In general, seedlings are more sensitive than older plants. The effect of the gas usually decreases with age of the plant and lesser morphological and physiological symptoms appear in older plants.  
  
Injury symptoms: The gas is a strong reducing agent. In low comcentration, it is oxidized and used in protein synthesis of the plant. However, in high concentration, it causes swelling of thylakoids and interferes with electron transport chain. In SO2 pollution, plants show initial reduction of photosynthesis and increased respiration. The gas reduces stomatal opening and thus causes general water stress in plants. SO2 replaces oxygen in cellular materials and changes their nature. It affects structural proteins in the cell membrane and thus changes the membrane permeability. High concentration of the gas causes accumulation of sulphydril and decrease of sulphides in plants. SO2 interferes with amino acid metabolism and reduces the synthesis of proteins and enzymes. It stimulates the oxidation of PGA and increases the pentose phosphate cycle activity. It reduces the level of keto acids, ATP, sucrose and glutamate in plants and increases the level of glucose, fructose and glycolate. It inactivates many enzymes either by breaking their S-S bonds or by changing their stereo structure. In lichens , the gas induces photooxidation in the phycobiont part.  
  
Most common visible symptom of SO2 injury is water-soaked appearance of leaves which later become necrotic changing into brown spots. Colour and shape of necrotic spots is characteristic in different species and NO2 concentrations. In some species, characteristic intraveinal chlorosis is caused. In general, SO2 pollution results in abscission of older leaves and tip necrosis in flower and sepals.   
  
**Nitrogen dioxide (NO2)**  
  
Major sources of this gas are nitrate fertilizer factories. The NO gas produced during combustion of fossil fuels and other oxides of nitrogen viz. N2O3, N2O4 and N2O5 are all converted gradually to NO2 in the atmosphere.  
  
The impact of the gas on plants increases with humidity, low light intensity and deficiency of nitrogen and iron in the soil. The effect of gas decreases in the conditions of drought. Sensitivity of plants to this gas changes by a factor of six during day and night. NO2 interacts with SO2, O3 and HF and the nature of interaction varies with relative proportion of gases.  
  
NO2 mostly affects the leaves and seedlings. Its effects decrease with increasing age of the plant and tissue. Conifers are found to be more sensitive to this gas during spring and summer than in winters. Older needles are more sensitive to the gas than young ones.  
  
Injury symptoms: The gas causes formation of crystalloid structures in the stroma of chloroplasts and swelling of thylakoid membrane. As a result the photosynthetic activity of the plant is reduced.  
  
Most common visible injury symptoms are chlorosis in angiospermic leaves and tip burn in conifer needles. In angiosperms, most of the species produce water-soaked intraveinal areas that later become necrotic. Tip burn is common symptom in bracts, sepals and awns.  
  
**Fluorides**  
  
Many particulate and gaseous fluorides are produced when ores containing fluorine are processed and used in industries. Common gaseous fluoride pollutants are HF, SiF6, CF4 and F2. Particulate fluoride pollutants include Ca3AlF6 (Cryolite), CaF2, NH3F, AlF6, CaSiF, NaF and Na2SiF6. Aerosols are often formed from NaF, NaAlF6 and AlF6. Chief sources of fluoride pollutants are brickworks, aluminium factories, glassworks, steelworks, ceramic factories, phosphate fertilizer plants and uranium smelters. Some fluorine pollution also occurs during combustion of coal. Most injurious fluoride pollutant is gaseous hydrogen fluoride (HF).  
  
Fluorides in general, are accumulated in the plant tissues over long times. They are first accumulated in the leaves and then are translocated towards tips and margins of the leaves. The injury symptoms are produced only after a critical level of fluoride is attained. Due to such accumulation over long times, flurides generally and HF particularly can induce injury at very low atmospheric concentrations. Critical concentration for fluoride injury is 0.1 ppm for several days. Toxicity of particulate fluorides depends upon the particle size, their solubility and humidity of the atmosphere.  
  
HF gas is much lighter than air and so can cause damage in plants even at a distance of 30 km from the source. It is a hygroscopic gas and forms acidic cloud near the source. Generally the impact of HF pollution increases with humidity and excess of P in soil while decreases in low temperature, drought and deficiency of N and Ca in the soil. In some species, impact of HF has been reported to decrease with excess of N and Ca in the soil.   
  
In most of the species, recovery from moderate fluoride injury can occur within few days if exposure to pollutant stops. However, some highly sensitive species e.g. pine and spruce can never recover fully. HF generally affects immature leaves in angiosperms and needles in conifers.  
  
Injury symptoms: Fluorides combine with metal components of proteins or inhibit them otherwise and thus interfere with the activity of many enzymes. As a result the cell wall composition, photosynthesis, respiration, carbohydrate synthesis, synthesis of nucleic acids and nucleotides and energy balance of the cell are affected. In the leaves subjected to HF exposure, endoplasmic reticulum is reduced, ribosomes are detached from ER, number of ribosomes is reduced and mitochondria become swollen. Chlorophyll synthesis and cellulose synthesis are inhibited. Activities of UDP-glucose-fructose transglucosylase, phosphoglucomutase, enolase and polyphenol oxidase are reduced. On the other hand activities of catalase, peroxidase, pyruvate kinase, PEP-carboxylase, glucose-6-phosphate dehydrogenase, cytochrome oxidase and pentose phosphate pathway are stimulated.  
  
In conifer needles common visible injury symptoms are chlorosis later turning into red/brown discolouration, tip burn later turning into necrosis of whole needle, formation of sharply defined red/purple bands between healthy and injured tissue. Similar symptoms are common in angiospermic leaves also. In addition, the angiospermic leaves in many species also show zonation of necrotic areas, leaf cupping, curling of leaf edges and ragged leaf margins. In sepals, petals, bracts and awns, water-soaked margins and later tip and marginal necrosis are observed.  
  
**Chlorine (Cl2)**  
  
Many industrial activities are the sources of chlorine pollution. Although chlorine concentrations change very rapidly in the atmosphere due to atmospheric chemistry and light rain can remove all the chlorine from the air in a very short time, chlorine injury can occur to plants near the source of pollution.  
  
The impact of chlorine pollution increases in bright sunlight and decreases in drought and low temperature. Older plants are more sensitive to chlorine than seedlings. The age of tissue has little effect on the sensitivity and older as well as young tissues are almost equally afected by chlorine pollution.  
  
Injury symptoms: Chlorine injury symptoms can appear from 18 hours to 8 days after exposure. In most plant species, recovery from chlorine injury can occur 3 to 4 days after exposure is stopped. Chlorine injury symptoms are quite variable in different species. Most common visible symptoms in conifers are chlorosis, tip burn and necrosis is needles. In angiosperm leaves, marginal or intraveinal necrosis, water-soaked appearance, leaf cupping and abscission are common.  
  
**Hydrogen chloride (HCl)**  
  
HCl gas is released in large quantities in combustion of PVC and all chlorinated hydrocarbon material in large fires or incinerators. The HCl gas is very hygroscopic and quickly changes to hydrochloric acid by reacting with atmospheric moisture and forms aerosol droplets.  
  
The HCl injury can be caused to plants even at a distance of 800 meter from the source. Like fluorides, the chloride from HCl is accumulated in the leaves and translocated towards their margins and tips. Symptoms of HCl injury appear after a critical concentration is reached, usually between 24 and 72 hours after the exposure.  
  
Impact of HCl pollution decreases with increase in humidity, deficiency of Mg and excess of Ca. Mature plants are more sensitive to HCl than seedlings. Similarly, young fully expanded leaves are more sensitive than immature unexpanded leaves.  
  
Injury symptoms: Most common visible injury symptoms in conifer needles are red or brown discolouration and tip burn. In angiosperm leaves, common symptoms are intraveinal water-soaked streaks, yellow or brown necrosis, tip necrosis, bleached areas around the necrosis and shot-holing. Tip burn, necrotic stipple and discolouration in sepals and petals are also observed.  
  
**Ammonia (NH3)**  
  
Continuous releases of ammonia from the sources are rarely high enough to cause acute injury but occasional high release or spillage may cause ammonia pollution. High concentrations of ammonia are sometimes found around intensive farm units e.g. chicken batteries. Extent of injury reduces rapidly with increase in distance form the source. Under certain conditions the ammonia may remain as a cloud above ground level causing more injury to trees than to the ground flora. Injury symptoms may take upto 9 days to develop. In most plant species, recovery may occur in about 2 weeks after exposure is stopped.  
  
Impact of ammonia on plants generally increases with humidity and decreases with drought. Effect of darkness on ammonia sensitivity is highly variable among species. Some species are more sensitive to low concentrations of ammonia than to its high concentration. Age of tissue has little effect on sensitivity and both young and old tissues are equally sensitive to ammonia.  
  
Injury symptoms: Most common visible symptoms in conifers are black discolouration, usually sharply bordered tip burn and abscission of needles. In angiosperm leaves, common symptoms are water-soaked appearance later turning black, intercostal necrosis, slight marginal and upper surface injury, glazong/bronzing of upper surface, desiccation and abscission.  
  
**Organic gases (Ethylene)**  
  
Among organic gaseous pollutants, ethylene is most common. Other organic gases are propylene, butylene and acetylene. Ethylene is continuously emitted from many sources involving combustion or processing of petroleum or its products or burning of organic materials e.g. straw burning. Other organic gases are also produced in various chemical industrial processes.  
  
Ethylene is a natural plant growth substance so the injury effects produced by it on plants are very similar to growth abnormality symptoms. Other organic gases also produce symptoms similar to those of ethylene pollution. However, the sensitivities of species to different gases are variable.  
  
Ethylene injury symptoms develop in plants only in exposure to high concentrations and take several days to develop. After exposure to the gas is stopped, level of recovery is variable in different species. Generally, younger plant parts recover but older parts do not. Much ‘acute’ damage to plants is caused on the fringes of polluted area or by a steady leakage of gas in low concentration.  
  
Impact of ethylene on the plants increases with high temperature. The gas interacts with SO2 and CO2 in atmosphere and the interaction is antagonistic i.e. high levels of these latter gases inhibit the development of ethylene injury.  
  
Injury symptoms: In injuriously high concentrations of ethylene, growth of plants is stopped. In low concentrations, growth abnormalities appear. In conifers, yellow tips in needles and abscission of branches and cones is common. In angiosperms, common symptoms are epinasty or hyponasty, loss of bark, abscission of leaves and flowers, premature flower opening and fruit ripening.  
  
**Minor gaseous pollutants**  
Many other air polllutants which are highly injurious to animals and human beings also cause damage to plants. However, plants are affected by these gases at quite higher concentrations than the animals.Common such gaseous pollutants are CO, H2S, Br2, I2 and Hg-vapour.  
  
**Hydrogen sulphide (H2S)**  
  
Plants show wilting on exposure to this gas but the symptoms develop after about 48 hours. No injury occurs below the exposure of 40 ppm for 4 hours.  
  
**Carbon monoxide (CO)**  
  
Like ethylene this gas produces epinasty, chlorosis and abscission. However, concentration of over 1000 times that of ethylene is needed to produce same degree of damage. No injury to plants occurs below exposure of 100 ppm for 1 week.  
  
**Bromine (Br2) and Iodine (I2)**  
  
Studies show these gases are highly toxic to plants.HI and I2 are readily absorbed and accumulated by plants producing visible injury symptoms similar to those of SO2. Injury occurs at exposure of 0.1 ppm for 18 hours.  
  
Common injury symptoms of bromine in angiosperms are necrosis of leaf margins, leaf tips and tendrils; brown discolouration and black spots later spreading to entire leaf. In conifers, yellow/white needle tips or red/brown discolouration later becoming grey/brown are common symptoms.  
  
**Hercury vapour (Hg)**  
  
Unlike other pollutants, flowers are more sensitive to Hg than leaves. Injury symptoms usually appear within 24 hours of Hg exposure but often go on increasing upto 5 days.  
  
Common injury symptoms due to Hg-vapour pollution are abscission of oldest leaves, interveinal necrosis, chlorosis around veins, flower abscission, loss of petal colour, buds remaining closed and later becoming necrotic, blackening of stamens, pistils and peduncles.  
  
**Particulate pollutants**  
  
Different types of solid particulate materials are also important air pollutants. Each of these affects the plants in characteristic manner. Some common particulate air pollutants have been discussed below.  
  
**Cement-kiln dust**  
  
Cement factories are the chief source of cement dust pollution. The composition of such dust varies with the source. Main component of cement dust is CaO and varying amounts of K2O, Na2O and KCl and traces of Al, Fe, Mn, Mg, S and silica. Dust with more than 24% CaO is more injurious to plants. Fine particles cause more damage than larger particles. Cement-kiln dust is alkaline in natureand dissolves in atmospheric moisture forming a solution of pH 10-12.   
  
In generals, plants having hairy surface of leaves trap more dust and are, therefore, damaged more than the plants with shiny leaf surface. The cement dust forms crusts on the surface of leaves, twigs and flowers. This inhibits gaseous exchange from the surfaces of plant parts. Such crust on the leaves also inhibits light penetration and consequently reduces photosynthesis. Such crusts are especially thicker in conditions of dew, mist or light rains. In dry conditions, dust blowing with wind is highly abrasive and damages the cuticle of leaves. Cuticle is also damaged due to alkalinity of cement dust. Due to damaged cuticle plants become more susceptible to infection by pathogens.  
  
**Lime and gypsum**  
  
Lime and gypsum processing industries and mining deposits are chief sources from where fine particles of these substances are blown away to great distances. Deposited on the soil from the air, these change the pH of the soil and thus affect the nutrient availability to plants. Such deposition usually causes appearance of various nutrient deficiency symptoms in the plants. Lime and gypsum are less adhering as compared to cement-kiln dust. However, these are also trapped and deposited on the surface of plant parts particularly the leaves with hairy surfaces and produce injury symptoms similar to cement dust. Lime and gypsum particles blowing with wind are also highly abrasive for cuticle.  
  
**Soot**  
  
Burning of fossil fuels, organic matter or natural forest fires produce huge quantities of fine carbon particles which form the soot pollution. Soot can be dispersed over a quite wide area and transported to great distances by blowing winds.  
  
Soot deposited on the surface of leaves may be washed away by rains so its damage may be reduced. However, in bright sunlight and high temperature, the damage is increased.  
  
Soot deposited on the surface of leaves inhibits light penetration, increased surface temperature due to absorption of heat and clogging of stomata. The result of these is reduced gaseous exchange, reduced photosynthesis and general weakening of the plant growth. Necrotic spots also develop in many species due to soot deposition.  
  
**Magnesium oxide**  
  
Magnesium roasters are the chief sources of such pollution. The magnesium oxide dust may be carried by winds and deposited even at a distance of 5 km from the source.  
  
In the atmosphere, magnesium sulphate (MgSO4) combines with carbon dioxide and water to form Mg(CO3)2. Both these compounds are alkaline and slightly soluble in water. Deposited on the soil these compounds can soon increase the soil pH to levels injurious to plants. Deposition of these substances on the soil prevents germination of seedlings. The seedlings that are able to emerge usually have yellow/brown tips of leaves and their roots are stunted. In areas of heavy pollution, composition of the vegetation changes completely.  
  
**Boron**  
  
Boric acid and borax are common raw materials in many industries. Oven and refrigerator manufacturing industries are chief sources of boron pollution. Severe injury to plants is observed even at a distance of 200 meters from the source and mild injury may be observed upto 500 meters in all the directions from the source.  
  
Impact of boron pollution is more severe on older leaves than on younger leaves. Boron is also accumulated in the leaves and produces injury symptoms quite similar to fluoride pollution.  
  
**Chlorides of sodium, potassium and calcium**  
  
Sodium and calcium chlorides are commonly used in colde countries on the roads during winters to melt ice and snow. Potash industry produces aerial emission of KCl and NaCl in ratio of 3:1. All such chlorides are carried away by winds and deposited on the soil and plants. Injury symptoms produced by these chlorides in plants are very similar to those produced by SO2 and fluoride pollution.  
  
**Sodium sulphate**  
  
Sodium sulphate dust can cause necrosis of leaves. The damage increases in moist condition.  
  
**Pesticides, insecticides and herbicides**  
  
A large variety of such chemicals are sprayed on the crops these days. These substances may drift with wind to nearby areas. Generally, these chemicals are deposited on the soil and form important soil pollutants. However, in frosty conditions when crops and other plants damaged by early frost are quite susceptible to foliar spray of these chemicals, these may also be injurious air pollutants. Injury symptoms vary with the plant species and the type of chemical. Generally, the symptoms are produced on foliage and are quite similar to those produced when these substances act as soil pollutants.   
  
**SECONDARY POLLUTANTS AND PLANTS**  
Many of the primary pollutants under specific environmental conditions may interact with each other and produce secondary environmental pollutants or certain complex environmental conditions that are injurious to plants. Such secondary pollutants and pollution conditions are discussed below.  
  
**Photo-oxidants**  
  
In presence of strong sunlight and in hot weather a series of complex chemical reactions involving nitrogen oxides and hydrocarbons may produce certain photo-oxidant chemicals. These chemicals do not have any specific anthropogenic source but are formed over wide areas in which suitable environmental conditions are prevailing. Two such photo-oxidants that can reach ambient concentrations toxic to plants are PAN (Peroxyacetylnitrate ) and ozone.  
  
**PAN (Peroxyacetylnitrate-CH3CO.O2.NO2)**  
  
Impact of this secondary pollutant is not affected by humidity. However, the impact decreases with lowering of temperature and increasing drought conditions. The impact also increases in the morning and in bright sunlight. Young plants and young rapidly expanding leaves are more sensitive to this pollutant. PAN interacts with SO2 and O3 in complex manner producing variable impact conditions.  
  
The common visible symptoms of exposure to PAN are chlorosis and necrosis in leaves. It also interferes with photosynthesis, respiration and absorption and synthesis of carbohydrates and proteins. It inhibits photorespiration, NADP reduction, carbon dioxide fixation, cellulose synthesis and the enzymes associated with photosynthesis and respiration.  
  
**Ozone (O3)**  
  
The impact of ozone on plants increases with humidity and decreases with drought, darkness, low temperature, high soil salinity, deficiency of soil phosphorus and excess of soil sulphur. Middle aged leaves and young plants are more sensitive to ozone. This pollutant interacts with SO2, NO2, PAN and heavy metals in complex manner.  
  
Common symptoms of ozone pollution are yellowing, flecking and blotching in leaves, premature senescence and early maturity. It interferes with pollen formation, pollination, pollen germination and growth of pollen tubes. Increase in the level of RNA, starch, polysaccharides and number of polysomes is observed in ozone pollution. Ozone stimulates respiration, inhibits oxidative phosphorylation and changes membrane permeability. In some species, it inhibits the synthesis of glucon and cellulose and reduces the level of reducing sugars, ascorbic acid and ATP while in other species the effect is opposite to it.  
  
**Secondary pollution conditions**   
Certain primary inorganic and organic pollutants in the atmosphere under certain specific environmental conditions, undergo a variety of complex photochemical and other chemical reactions. These reactions produce certain specific secondary atmospheric pollution conditions that also adversely affect plants. Important such secondary atmospheric pollution conditions are acid rains, photochemical smog, ozone depletion and greenhouse problem.

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## Friday, February 22, 2008

### [Water pollution and plants](http://pollution-plants.blogspot.com/2008/02/water-pollution-and-plants.html)

**Water pollution and plants**  
The water bodies of the earth are being continuously polluted by a variety of sources. The pollution is occurring in all types of water bodies; both freshwater bodies like ponds, lakes and rivers as well as marine bodies like coastal and deep-water seas. Major causes of water pollution are deposition of acid, organic sewage, detergents, agricultural chemicals, industrial effluents, silt, oil and heat into the water bodies.  
  
**Effects of acid deposition**  
Various acid gases, aerosols and other acidic substances released into the atmosphere from the industrial or domestic sources of combustion of fossil fuels eventually come down to the ground. These substances are deposited directly on the water bodies. In addition, these substances also reach the water bodies along with run-off rainwater from the polluted soil. Deposition of acidic substances causes acidification of water by lowering its pH below 6.0. The sulphates, nitrates and chlorides have been reported to make water bodies like lakes, rivers and ponds acidic in many countries.  
  
Nutrient deficiency in aquatic ecosystem: The decomposing bacteria and fungi decrease in acidified water. This reduces the rate of decomposition of organic matter and, therefore, the nutrient cycling in the aquatic ecosystem. Thus, low pH causes nutrient deficiency and consequent general reduction in abundance of aquatic plants in the affected water body.   
Decrease of species diversity: Critical pH for most of the aquatic species is 6.0. The number and variety of aquatic species in the water body generally decreases below this pH.   
Change in species composition: The number and abundance of acid tolerant species increases while that of sensitive species decreases.   
In the initial phase of water acidification, filamentous algae grow very fast and form thick mats. However, most of the diatoms and green algae disappear below the pH 5.8. Diatoms and small siliceous phytoplankton populations are highly sensitive to pH changes and species composition of their communities shows highly specific changes with pH change of the water body. Among green algae, Cladophora is highly acid tolerant species and becomes abundant in highly acidic freshwater bodies. Euglena and some other unicellular algae are found up to pH of 1.6 while Chlamydomonas acidophila is found in water up to pH of 1.0.   
Macrophytes are generally absent in extremely acidic water. Potamogeton pectinalis is only aquatic macrophyte found in heavily acdified water. At pH lower than 4.0, angiosperm species using dissolved carbon dioxide e.g. Juncus bulbosus, Juncus effusus, Sparganium emersum, Gyceria fluitans, Eleocharis acicularis, Typha latifolia and bryophytes like Polytrichum, Anisothecium, Fontanalis, Catharina become the only survivors. The roots of macrophytes are generally affected adversely in acidic water and result in poor plant growth. Plants with deep roots and rhizomes are less affected while plants with short root systems are severely affected. Yellowing of plants is common in polluted water.   
**Effects of organic matter deposition**  
Large amounts of dead and decaying animal and plant material, fecal material and other organic material is deposited directly from sewage discharges or is washed along with rainwater into the water bodies. Most important consequnces of such organic matter deposition are as following.  
  
Increase in decomposer microbes: Increased addition of organic matter into the water body results in rapid multiplication and increase in decomposer aerobic and anaerobic bacteria. The rapid decomposition of organic matter by these increases nutrient availability in the water.   
Eutrophication: Addition of organic matter and its rapid decomposition resulting in increased nutrient supply causes much nutrient enrichment (eutrophication) of water body. In such a condition, planktonic green and blue-green algae grow very rapidly causing water blooms. In addition to these many types of hydrophytes like Salvinia, Azolla, Eicchhornia etc. also become abundant. All this rapid growth of planktonic and free-floating hydrophytes reduces light penetration into deeper layers of water body and submerged flora gradually declines. Abundant flora after death further increases supply of organic matter in the water body.   
Oxygen depletion: Rapid decomposition of organic matter by aerobic bacteria during eutrophication phase consumes much water-dissolved oxygen. On the other hand, gradual decrease of submerged aquatic flora results in reduced oxygenation of water. Both these phenomena together result in increase in biological oxygen demand (B.O.D.) of the water. Biological oxygen demand (B.O.B.) of water is defined as the amount of oxygen needed by a unit volume (usually one litre) of water sample to completely decompose the organic matter present in it by microbial activity, measured at 20oC and tested at least five days after sampling. The B.O.D. value of fresh, unpolluted water is usually below 1 ppm while in organic matter polluted water, it may be more than 400 mg/litre.   
**Effects of detergent deposition**  
Various detergents from domestic or industrial use directly released or washed down into the water bodies cause serious effects of plants.  
  
Most of the domestic and industrial detergents contain high (up to 40%) phosphate content. Addition of such detergents into water results in phosphate-enrichment of water.   
Most of the detergents that are toxic, enter the plants through roots or surface absorption. Common effects of detergents on plants are as follows.   
Retardation of plant growth, root elongation, carbon dioxide fixation, photosynthesis, cation uptake, pollen germination and growth of pollen tubes.   
Destruction of the chlorophylls and cell membranes.   
Alteration of the absorption maxima of chlorophylls.   
Binding of membrane lipids and proteins.   
Denaturation of proteins and thus causing enzyme inhibition in various metabolic processes.   
Non-degradable alkyl benzene sulphonates and phosphate-rich detergents interfere with gaseous exchange even in very low concentrations.   
Cation-active compounds hinder algal growth between 0.1 and 10.0 ppm while non-ionic compounds hinder algal growth between <1.0 and around 10,000 ppm concentrations depending upon the species and the compound.   
Macrophytes are most sensitive to damage by anionic surfactants.   
Effects of agricultural chemical deposition  
Many chemical fertilizers, pesticides, insecticides, herbicides etc. are applied to crops far in excess. These excess chemicals are washed away with rainwater, first into the soil then finally into the water bodies.  
  
Chemical fertilizers entering the water bodies result in eutrophication by enriching the water with major plant nutrients. Many of these fertilizers are acidic in nature e.g. ammonium. These cause acidification of water.   
Pesticides, herbicides and insecticides also cause pH changes in the water bodies. The effects of these plants on aquatic plants are similar to those of their overdose in foliar application. The herbicides act directly on aquatic flora but insecticides act indirectly by allowing algal blooms to develop in the water body. Different substances have different patterns of their toxic action, decomposition pathways and environmental persistance. Most common effect of these substances is reduced photosynthesis. Some may uncouple oxidative phosphorylation or inhibit nitrate reductase enzyme. The uptake and bioaccumulation of these substances in aquatic plants is great due to their low solubility in water.   
**Effects of industrial effluent deposition**  
Various inorganic and organic waste products from industries and mining activities are directly deposited into the water bodies. A large amount of these substances deposited on the soil, comes into water bodies indirectly along with surface run-off. Fly-ash, various organic/liquid effluents and heavy metals e.g. Hg, Cu, Cd, Pb, Zn, Ni, Ti, Se etc. are important industrial pollutants of water.  
  
Fly ash forms thick, floating covering over the water surface. This reduces the penetration of light into deeper layers of water body. Fly-ash increases the alkalinity of water and thus, causes reduced uptake of essential bases. All these phenomena cause death of aquatic plants.   
Organic/liquid effluents disturb the pH of water and depending upon their chemical composition, cause specific toxicity effects on the aquatic plants. Change in the floristic composition of the water body is most obvious and direct effect of pollution by such effluents.   
Heavy metals usually occur together and with many other types of pollutants so the effects of single metal are usually difficult to interpret. There may be synergistic, additive or antagonistic interactions between metals regarding their effects on plants. Impact of metals is reduced in hard, well-buffered freshwater systems. For example, Cd-uptake by Nitella and Elodea is less in hard water, Zn-toxicity is less with high Ca for Stigeoclonium and Hormidium while is less with high pH for Hormidium. Bioaccumulation of metals is more in mosses than in angiosperms and is usually more in lower plant parts. Chelators decrease while methylated forms increase the metal toxicity to aquatic plants. Reduced oxygen and low temperature also increase metal toxicity. While bryophytes appear to be highly resistant to heavy metal toxicity, in all classes of algae, strains vary in tolerance to metals. Photosynthesis and growth in most of the algae is inhibited at 1-2 ppm of Cu++. Cholrella is more sensitive to Cu++ than Scendensmus. Cholrella is retarded more by Ag than by Cd, Hg or Ni while cell division in the genus is reduced more by Cd than by Cu or Hg at 0.32 ppm. Lemanea is quite resistant to Zn and Pb.   
Efects of silt deposition  
The top soil removed due to erosion is carried with rainwater or flood water and deposited into the water bodies causing silt deposition in them.  
  
The deposition of silt increases the turbidity of water and reduces light-penetration deep into the water, causing decline in submerged flora.   
Silt deposition, in general, inhibits growth of aquatic plants. Phytoplankton is particularly affected by silt deposition due to reduction in surface exchange of gases and nutrients.   
Species tolerant to turbidity (e.g. Ceratophyllum demersum, Lemna minor agg., Nuphar lutea, Polygonum amphibium, Sagittaria sagittifolia, Scirpus lacustris) becomes highest followed by species of intermediate tolerance (e.g. Callitriche spp., Myriophyllum spicatum, Potamogeton natans, P. pectinatus, Sparganium emersum, S. erectum) while least tolerant species (e.g. Elodea canadensis, Potamogeton perfoliatus, Ranunculus spp., Mosses) are much reduced.   
**Effects of oil deposition**  
Washing of oil tankers and storage containers in many rivers, large lakes and particularly near sea coasts causes deposition of oil slicks on water. Oil spills in water are also common during normal transport operations or during accidents involving oil tankers.  
  
Oil pollution of water body prevents oxygenation of water.   
Oil depletes oxygen of the water body by consuming dissolved oxygen in oil degradation.   
Oil inhibits planktonic growth and photosynthesis in aquatic macrophytes.   
Oil may even cause destruction of aquatic flora if it catches fire.   
**Effects of waste heat deposition**  
Many industries, particularly thermal power plants, take water from rivers, lakes or sea to cool the heat-producing boilers and equipment. The heated water is then returned to the water body. The deposition of waste heat into the water body has many consequences for the plants in it.  
The solubility of oxygen in water is reduced at higher temperature. Thus, the reduced oxygenation of water adversely affects the aquatic flora.   
Reduced oxygenation and high temperature of water causes reduction in the activity of aerobic decomposers. The reduced decomposers result in decreased organic matter decomposition and consequently, reduced nutrient availability in the water body.   
In high temperature, aquatic plants show increased respiration, reduced photosynthesis and general inhibition of enzyme activity with increasing temperature.   
The aquatic flora and primary productivity of the aquatic ecosystem declines with increasing temperature. Green algae are mostly replaced by blue-green algae, which have comparatively less primary productivity.   
With increase in temperature, species diversity of the water body declines and heat-tolerant species gradually become dominant.

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