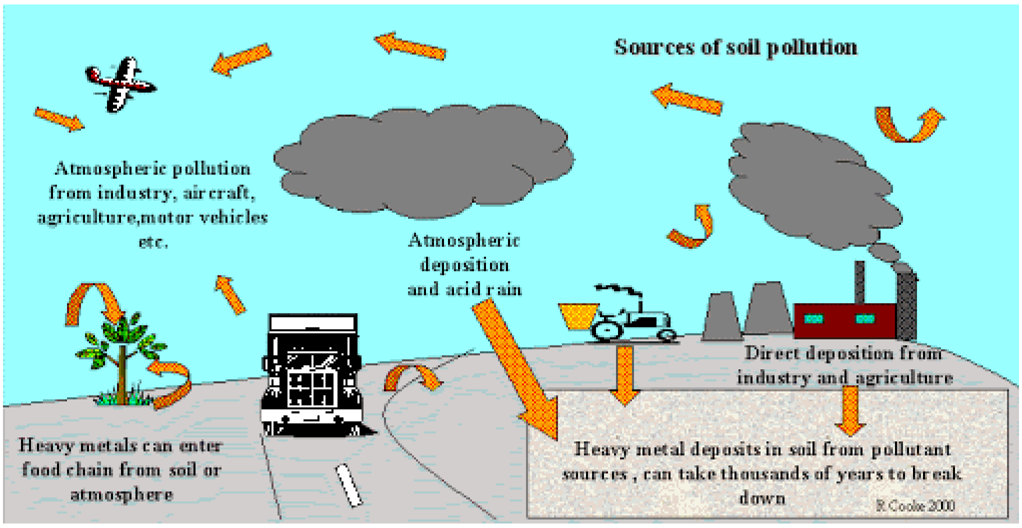
Organic Pollutants of soil

Pollution can be defined as the introduction of elements, compounds or energy into the environment at levels that impair its functioning or that present an unacceptable risk to humans or other targets that use or are linked to that environment.

Since urban expansion, soil has been used as a sink for dumping solid and liquid wastes. It was considered that once buried and out of sight, the contaminants would not pose any risk to human health or the environment and that they would somehow disappears. It is difficult to define soil pollution exactly because different opinions exist on how to characterize a pollutant; while some consider the use of pesticides acceptable if their effect does not exceed the intended result, others do not consider any use of pesticides or even chemical fertilizers acceptable. Soil pollution is an alarming issue. It has been identified as the third most important threat to soil functions in Europe and Eurasia, fourth in North Africa, fifth in Asia, seventh in the Northwest Pacific, eighth in North America, and ninth in sub-Saharan Africa and Latin America. The presence of certain pollutants may also produce **nutrient imbalances** and **soil acidification**, two major issues in many parts of the world.

Soil pollution is also caused by means other than the direct addition of xenobiotic (man-made) chemicals such as agricultural runoff waters, industrial waste materials, acidic precipitates, and radioactive fallout. Soils may fail to support vegetation because of phytotoxic effects of pollutants or disrupted biological cycling of nutrients.These soils may also affect the hydrosphere compromising the quality of drinking water resources and threatening the aquatic ecosystems. Pollutants can build up in soils from several sources. The spreading of wastes such as sewage sludge to land can be a problem especially where these wastes have been applied repeatedly over a number of years. Soils may become polluted by atmospheric deposition from traffic, and incinerator or metal smelting emissions over a period of time. Soils may also be polluted through the spillage of liquids such as oil or industrial solvents or through flooding or irrigation with polluted water.



Both organic (those that contain carbon) and inorganic (those that don't) contaminants are important in soil. The most prominent chemical groups of organic contaminants are fuel hydrocarbons, polynuclear aromatic hydrocarbons (**PAHs**), polychlorinated biphenyls (**PCBs**), chlorinated aromatic compounds, detergents, and pesticides**.** Whilst most of the early soil pollution related to metals or other inorganic pollutants, there has been an increasing concern over the last few decades regarding organic contaminants, a reflection of their widespread use in industry as solvents, feedstocks and their presence in industrial wastes. Fuel hydrocarbons, for examples, are major pollutants of soils and aquifers. Combustion processes have led to widespread contamination of soils with polycyclic aromatic hydrocarbons (PAHs).

Sources of organic pollutants in Soil

Potential sources of organic contaminants include:

1- Industrial leaks and spills,
2- Leaks from oil and chemical storage tanks,
3- Improper application of pesticides,
4- Careless disposal of cleaners, oil and antifreeze,
5- Improper disposal of household wastes,
6- Landfills and garbage dumps,
7- Leaks from pipeline, and
8- Accidents, spills during transportation (i.e. from real or tank cars).

An even more common type of hydrocarbon spill is leakage from underground storage tanks

COMMON ORGANIC SOIL POLLUTANTS

Pollutant	Source
Hydrocarbons and other VOCs including semi-volatile organic compounds, SVOCs.	Transport, solvents and industrial processes
Agrichemicals	Pesticides, herbicides and fungicides
Polyaromatic hydrocarbons	Incomplete combustion of coal, oil, gas, wood and garbage
Polychlorinated biphenyls, PCBs	Use as a coolant and insulator in electrical equipment such as transformers and generators.
Organotin compounds	Bactericides and fungicides used in paper, wood, textile and anti-fouling paint

The source of contamination is usually classified in space as either a **point source** or a **non-point (diffuse) source**. A point source is a contaminant release at one specific location, whereas a nonpoint source is released over a widespread area.

The **major point sources** are municipal landfills and industrial waste disposal sites, toxic chemicals spewing from pipes at industrial facilities, sewage treatment plants, accidental spills, and leaks of petroleum products of dense industrial organic. **Non-point sources** include atmospheric deposition, contaminated sediments, and many land activities that generate polluted runoff, such as agriculture and onsite sewage disposal. **Atmospheric deposition** refers to contaminants entering waters from polluted air. In place contaminants were generated by past activities, such as discontinued industrial discharges, logging, or one-time spills. In place contaminants often reside in sediments but continue to release pollutants back into the water column.

Natural sources refer to natural deposits of salts, gypsum, nutrients, and metals in soils that leach into groundwater. The source of contamination is also classified in time as either a **continuous source** or an **instantaneous (one time) source**. A continuous source is contamination that is released over a long period of time, whereas an instantaneous source is contamination that is released at only one time. The type of contamination source in space and time (that is, point source, non-point source, continuous source, instantaneous source) is important in determining the resulting spatial and temporal distribution of concentrations within a groundwater system. In some cases, the cumulative effects of point sources in proximity with each other can have similar characteristics to one or more non-point sources of contamination. The same sources can also be classified into **surface sources** (e.g. "spills" which must infiltrate) **subsurface sources** (e.g. septic tanks and leaking underground storage tanks which already exist in the subsurface).

Soil pollution due to Industrial Activity.

The range of chemicals used in industrial activities is vast, as is their impact on the environment. Industrial activities release pollutants to the atmosphere, water and soil. Gaseous pollutants and radionuclides are released to the atmosphere and can enter the soil directly through acid rain or atmospheric deposition; former industrial land can be polluted by incorrect chemical storage or direct discharge of waste into the soil; water and other fluids used for cooling in thermal power plants and many other industrial processes can be discharged back to rivers, lakes and oceans, causing thermal pollution and dragging heavy metals and chlorine that affect aquatic life and other water bodies. Heavy metals from anthropogenic activities are also frequent in industrial sites and can arise from dusts and spillages of raw materials, wastes, final product, fuel ash, and fires. According to the European Directive concerning integrated pollution prevention and control (IPPC), potentially polluting activities can be grouped into six main categories:

1) Energy industries;

2) Production and processing of metals;

3) Mineral industry;

4) Chemical industry and chemical installations;

5) Waste management; and

6) Other activities (which include paper and board production, manufacture of fibres or textiles, tanning of hides and skins, slaughterhouses, intensive poultry or pig rearing, installations using organic solvents, and the production of carbon or graphite). The use of phosphate rocks, which are naturally rich in radioactivity, in the production of fertilizers generates a by-product called phosphogypsum, which maintains nearly 80 percent of its original radioactivity due to 238U decay products such as radon, 226Ra, and polonium, 210Po. These industries generate a radioactive source of pollution, which constitutes a threat to the surrounding ecosystems and organisms.

Significant point-source soil pollution occurs from oil and gas extraction due to spills of crude oil and brines. Brines have high salinity levels and can also contain toxic trace elements and naturally occurring radioactive materials. Brine spills are widespread, in a study it was found that there have been approximately 3 900 brine spills associated with unconventional oil and gas production from the Bakken region of North Dakota since 2007. Spills of crude oil from well sites and from pipelines are also a major source of soil pollution in oil producing areas.

Salinization, another major threat to global soils, affects many soils which are close to certain industrial activities, mainly those associated with chlor-alkali, textiles, glass, rubber production, animal hide processing and leather tanning, metal processing, pharmaceuticals, oil and gas drilling, pigment manufacture, ceramic manufacture, and soap and detergent production

Soil Pollution due to Mining activity

Mining has had a major impact on soil, water and biota since ancient times. Many documented examples can be found of heavily contaminated soils associated with mining activities around the world. Metal smelting to separate minerals has introduced many pollutants into the soil. Mining and smelting facilities release huge quantities of heavy metals and other toxic elements to the environment; these persist for long periods, long after the end of these activities. Toxic mining wastes are stocked up in tailing,(a **tailings dam** is typically an earth-fill embankment **dam** used to store by-products of mining operations after separating the ore from the gangue) mainly formed by fine particles that can have different concentrations of heavy metals. These polluted particles can be dispersed by wind and water erosion, sometimes reaching agricultural soils. For example, in a research, high levels of lead and copper was found in agricultural fields located near a tailings dam in Namibia.

Toxic concentrations of chromium and nickel were also found in agricultural soils near an abandoned chromite-asbestos mine waste in India and in crops grown in those soils, resulting in a high risk to human and livestock health.

Soil Pollution Due To Urban and Transport Infrastructures

The widespread development of infrastructure such as housing, roads and railways has considerably contributed to environmental degradation. Their more evident negative effects on soil are soil sealing and land consumption. Apart from these known soil threats, another major impact of infrastructure activities is the entry into the soil system of different pollutants. Despite its being a major threat, soil pollution from infrastructure activities has received very minor consideration in terms of planning and impact assessment. Activities linked to transportation in and around urban centers constitute one of the main sources of soil pollution, not only because of the emissions from internal combustion engines that reach soils at more than a 100 m distance by atmospheric deposition and petrol spills, but also from the activities and the changes that result from them as a whole. Splashes generated by traffic during rainfall events and runoff, which may be significant if the drainage system is not well maintained, may translocate particles rich in heavy metals from the corrosion of metal vehicle parts, tires and pavement abrasion and other pollutants such as polycyclic aromatic hydrocarbons, rubber and plasticderived compounds. Soil pollution associated with roads and highways is especially important in urban and peri-urban soils, and can be a major threat when food production occurs in adjacent areas. Foliar deposition (leaves deposition) and root uptake and transfer to above-ground tissues of bioavailable heavy metals are the main processes observed in roadside soil. Grazing in roadside soils is also quite common, and the ingestion of contaminated soil and plants constitutes potential dietary transfer of pollutants affecting animal and human health. A major legacy source of soil pollution associated with transport is lead contamination of soils from leaded gasoline. It was found that over 10 million tonnes of lead was transferred to the global environment via the motor vehicle fleet, about 5.9 million tonnes in the United States of America alone. The soil contamination that resulted from this was concentrated around roads and is especially high in core urban area.

Municipal waste disposal by landfills, illegal or not, and untreated wastewater release into the environment are important sources of heavy metals, poorly biodegradable organic compounds and other pollutants which enter the soil. In most developed countries, strict regulations control the disposal and recycling of waste, solids and liquids, but there are countries where residue treatment and disposal are still posing a risk to the environment and to human health. Many household chemicals, particularly those used in bulk quantities such as detergents and personal care products (PPCPs), also end up as sanitary sewage. Biosolids generated from municipal wastewater treatment can be a major sink for many PPCPs, and their land application can potentially introduce these contaminants into terrestrial and aquatic environments. The historical and continuing use of DDT for control of vector-borne diseases such as malaria has led to pollution of soils in urban and peri-urban areas . Lead-based paint is a major legacy source of lead (Pb) contamination in urban areas. Soils become contaminated when lead-based paint is pulverized into dust or small particles during renovations or demolition and then enters the environment.

Plastics are also a major source of pollution. They are widely used in food packaging, shopping bags, and household items such as toothbrushes and pens, facial cleansers, and many other common items. Plastics have a strong presence in the environment globally. They are, in general, extremely persistent in the environment and they widely accumulate in oceans and landfills, but also in soils where producing factories are located. In addition, several thousand different additives such as brominated flame retardants, phthalates and lead compounds are used in the production of plastic. Many of these additives are considered harmful, with demonstrated disruptions to endocrine function, and carcinogenic and mutagenic effects on living organisms. All plastic, from the macro- to the nano-scale, are at risk of being leached and of adsorbing hazardous substances such as persistent organic pollutants and polycyclic aromatic hydrocarbons .They also accumulate heavy metals in high proportions . The size and surface area are important factors influencing the leaching and adsorption behaviour: the smaller the particle, the larger the surface-volume ratio. The capacity to release or bind compounds is therefore also higher for smaller particles than for larger ones. Plastics can reach the soil and aquatic systems via wastewater-treatment plants, but they can also be transported and suspended by wind from landfills and become airborne and widely dispersed. In agricultural fields in which plastic mulching is practised, an abundant source of plastic material is available in the soil.

Agricultural Activity

The different agricultural sources of soil pollutants include agrochemical sources, such as fertilizers and animal manure, and pesticides .Trace metals from these agrochemicals, such as, Cu, Cd, Pb and Hg, are also considered soil pollutants as they can impair plant metabolism and decrease crop productivity. Water sources for irrigation can also cause soil pollution if they consist of waste water and urban sewage. Excess N and heavy metals are not only a source of soil pollution, but also a threat to food security, water quality and human health, when they enter the food chain. Point sources of pollution in agricultural settings include accidental spills of hydrocarbons in agricultural fields used as fuels for machines or of agrochemicals during their transportation and storage stages.

WHAT ARE FERTILIZERS?

Fertilizers are generally defined as "any material, organic or inorganic, natural or synthetic, which supplies one or more of the chemical elements required for the plant growth." Most fertilizers that are commonly used in agriculture contain the three basic plant nutrients: nitrogen, phosphorus, and potassium. Some fertilizers also contain certain "micronutrients," such as zinc and other metals, that are necessary for plant growth. Fertilizers are applied to replace the essential nutrients for plant growth to the soil after they have been depleted.

Excessive application of fertilizers and manure or inefficient use of the main nutrients (N and P) in fertilizers are the main contributors to environmental issues linked to agriculture. These two nutrients are a source of diffuse pollution. Excess N can also be lost to the atmosphere through greenhouse gas emissions, and excess P contributes to the eutrophication of neighbouring sources of water. Excessive fertilizer usage can lead to soil salinity, heavy metal accumulation, water eutrophication and accumulation of nitrate, which can be a source of environmental pollution but also a threat to human health. The fertilizer industry is also considered to be a source of heavy metals such as Hg, Cd, As, Pb, Cu, Ni and Cu, and natural radionuclides like 238U, 232Th and 210Po. Proper handling and management of fertilizer is crucial to avoid polluting the soil.

Management of Fertilizers

WHY IS IT IMPORTANT TO MANAGE FERTILIZER USE?

ENVIRONMENTAL HEALTH

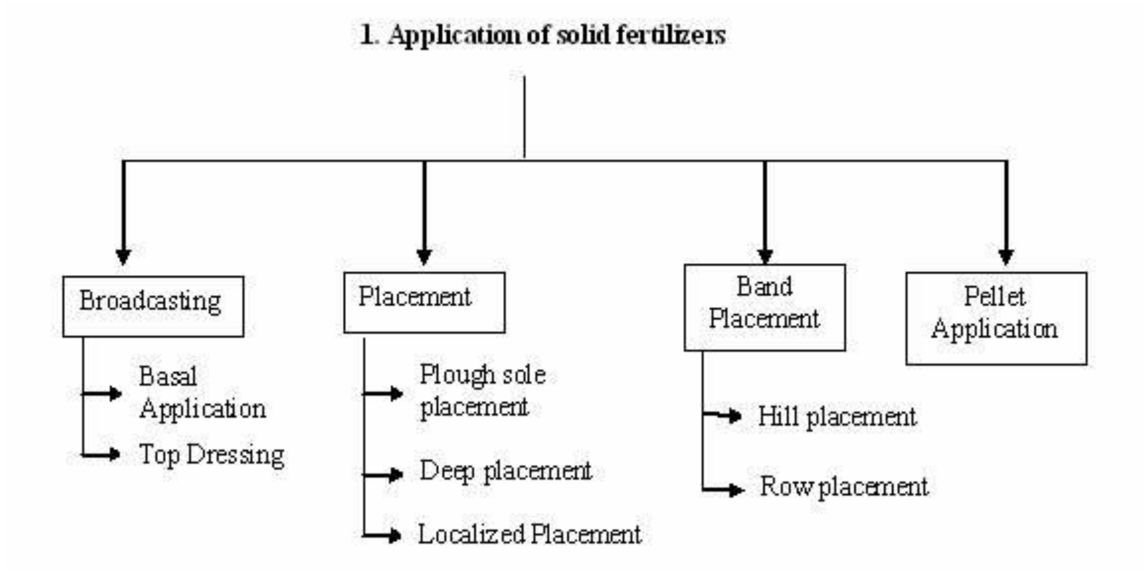
Nitrogen and **phosphorous** occur naturally in streams throughout Utah and are important nutrients to aquatic ecosystems. However, too much of these nutrients can cause serious problems in lakes and streams. Often times in agricultural areas, excess nitrogen enters the system from animal operations or from irrigation return flow. These added nutrients may lead to fish kills, noxious aquatic plant growth, and foul odors.

HUMAN HEALTH

Nitrogen fertilizer (organic and inorganic) can contribute to nitrates in drinking water. Pregnant or nursing women and infants are especially vulnerable to nitrate related potentially very serious health problems.

METHODS OF FERTILIZER APPLICATION

The different methods of fertilizer application are as follows:



a) Broadcasting

1. It refers to spreading fertilizers uniformly all over the field.
2. Suitable for crops with dense stand, the plant roots permeate the whole volume of the soil, large doses of fertilizers are applied and insoluble phosphatic fertilizers such as rock phosphate are used.

Broadcasting of fertilizers is of two types.

i) Broadcasting at sowing or planting (Basal application)

The main objectives of broadcasting the fertilizers at sowing time are to uniformly distribute the fertilizer over the entire field and to mix it with soil.

ii) Top dressing

It is the broadcasting of fertilizers particularly nitrogenous fertilizers in closely sown crops like paddy and wheat, with the objective of supplying nitrogen in readily available form to growing plants.

b) Placement

1. It refers to the placement of fertilizers in soil at a specific place with or without reference to the position of the seed.
2. Placement of fertilizers is normally recommended when the quantity of fertilizers to apply is small, development of the root system is poor, soil have a low level of fertility and to apply phosphatic and potassic fertilizer.

The most common methods of placement are as follows:

i) Plough sole placement

1. In this method, fertilizer is placed at the bottom of the plough furrow in a continuous band during the process of ploughing.

2. Every band is covered as the next furrow is turned.

3. This method is suitable for areas where soil becomes quite dry upto few cm below the soil surface and soils having a heavy clay pan just below the plough sole layer.

ii) Deep placement

It is the placement of ammoniacal nitrogenous fertilizers in the reduction zone of soil particularly in paddy fields, where ammoniacal nitrogen remains available to the crop. This method ensures better distribution of fertilizer in the root zone soil and prevents loss of nutrients by run-off.

iii) Localized placement

It refers to the application of fertilizers into the soil close to the seed or plant in order to supply the nutrients in adequate amounts to the roots of growing plants. The common methods to place fertilizers close to the seed or plant are as follows:

a) Drilling

In this method, the fertilizer is applied at the time of sowing by means of a seed-cum-fertilizer drill. This places fertilizer and the seed in the same row but at different depths. Although this method has been found suitable for the application of phosphatic and potassic fertilizers in cereal crops, but sometimes germination of seeds and young plants may get damaged due to higher concentration of soluble salts.

b) Side dressing

It refers to the spread of fertilizer in between the rows and around the plants. The common methods of side-dressing are

1. Placement of nitrogenous fertilizers by hand in between the rows of crops like maize, sugarcane, cotton etc., to apply additional doses of nitrogen to the growing crops and

2. Placement of fertilizers around the trees like mango, apple, grapes, papaya etc.

c) Band placement

If refers to the placement of fertilizer in bands.

Band placement is of two types.

i) Hill placement

It is practiced for the application of fertilizers in orchards. In this method, fertilizers are placed close to the plant in bands on one or both sides of the plant. The length and depth of the band varies with the nature of the crop.

ii) Row placement

When the crops like sugarcane, potato, maize, cereals etc., are sown close together in rows, the fertilizer is applied in continuous bands on one or both sides of the row, which is known as row placement.

Row placement

d) Pellet application

1. It refers to the placement of nitrogenous fertilizer in the form of pellets 2.5 to 5 cm deep between the rows of the paddy crop.
2. The fertilizer is mixed with the soil in the ratio of 1:10 and made small pellets of convenient size to deposit in the mud of paddy fields.

Advantages of placement of fertilizers

The main advantages are as follows:

i) When the fertilizer is placed, there is minimum contact between the soil and the fertilizer, and thus fixation of nutrients is greatly reduced.

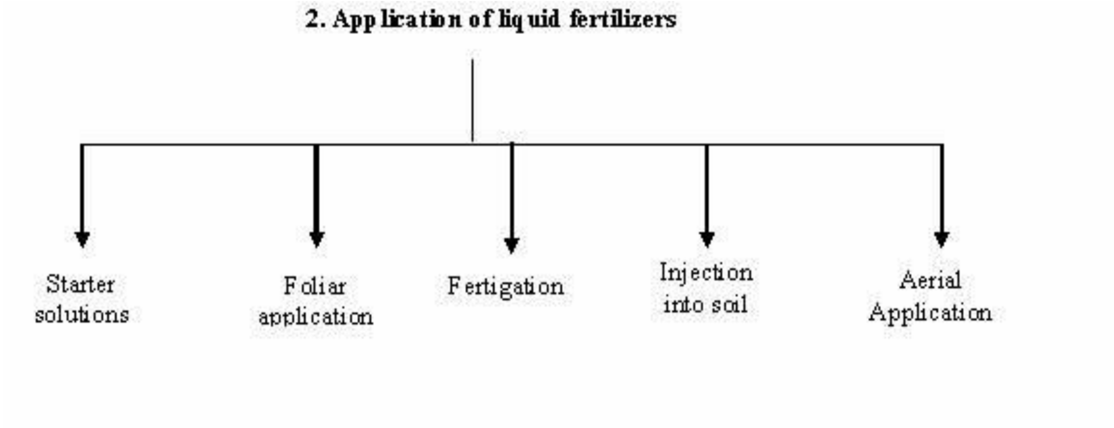
ii) The weeds all over the field can not make use of the fertilizers.

iii) Residual response of fertilizers is usually higher.

iv) Utilization of fertilizers by the plants is higher.

v) Loss of nitrogen by leaching is reduced.

vi) Being immobile, phosphates are better utilized when placed.



Following are the common methods of applying liquid fertilizers

a) Starter solutions

It refers to the application of solution of N, *$P2O5$ and* K2O in the ratio of 1:2:1 and 1:1:2 to young plants at the time of transplanting, particularly for vegetables. Starter solution helps in rapid establishment and quick growth of seedlings. The disadvantages of starter solutions are (i) Extra labour is required, and (ii) the fixation of phosphate is higher.

b) Foliar application

1. It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants.
2. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them.
3. The concentration of the spray solution has to be controlled, otherwise serious damage may result due to scorching of the leaves.
4. Foliar application is effective for the application of minor nutrients like iron, copper, boron, zinc and manganese. Sometimes insecticides are also applied along with fertilizers.

c) Application through irrigation water (Fertigation)

1. It refers to the application of water soluble fertilizers through irrigation water.
2. The nutrients are thus carried into the soil in solution.
3. Generally nitrogenous fertilizers are applied through irrigation water.

d) Injection into soil

1. Liquid fertilizers for injection into the soil may be of either pressure or non-pressure types.
2. Non-pressure solutions may be applied either on the surface or in furrows without appreciable loss of plant nutrients under most conditions.
3. Anhydrous ammonia must be placed in narrow furrows at a depth of 12-15 cm and covered immediately to prevent loss of ammonia.

e) Aerial application.

In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest lands, in grass lands or in sugarcane fields etc

Management

TIMING

Fertilizers with nitrogen present should be applied as closely as possible to the period of maximum crop uptake. Partial application of fertilizer in the spring with small additions as needed can reduce leaching and improve nitrogen uptake. Fertilizing in the fall has been shown to cause groundwater degradation.

It is necessary to sample soil every year to determine crop nutrient needs for accurate fertilizer recommendations. To calculate the optimal rate of application other sources that contribute nitrogen and phosphorous to the soil should be considered. Organic matter and manure contribute phosphorous. Crops can quickly take up nitrate forms of nitrogen, but are subject to leaching loss. Fertilizer with nitrogen should be limited when leaching potential is moderate to high. If the leaching potential is moderate to high, ammonium nitrogen fertilizers should be used because they are not subject to leach immediately. However, in warm, moist conditions ammonium quickly turns into nitrate. More slowly available nitrogen fertilizers should be used in these situations. Although phosphorous is less prone to leach, loss through surface runoff is common so phosphorous should only be applied as needed and at recommended rates.

*Fertilizer application equipment should be checked and calibrated annually.

*Fertilizer should never be applied when the ground is frozen.

*Fertilizer application should be limited on slopes and areas with high runoff.

Irrigated crop production has the highest potential for water contamination because of the large quantity of water that is applied. When excess water is applied nitrogen and phosphorous can leach into groundwater or runoff into surface water. Using systems such as sprinklers, low energy precision applications, surges and drips help producers apply water efficiently and uniformly. Delivery systems such as lined ditches and gated pipes as well as reuse systems such as field drainage recovery ponds are efficient.