# F1 FERTILISERS

## WHAT ARE FERTILISERS?

CHEMICAL INDUSTRIES RESOURCE PACK

## Introduction

A fertiliser is a substance applied to soil to enhance its ability to produce plentiful, healthy plants. Fertilisers are natural and manufactured chemicals containing nutrients known to improve the fertility of soils. Nitrogen, phosphorus, and potassium are the three most important nutrients for crop growth; some plant scientists think sulfur is also a major nutrient because of its benefit to plant health and growth.

These and other nutrients are found naturally in soils. Soils used for agriculture, however, become depleted in these nutrients and frequently require fertilising before the soils can be used successfully again. The most efficient way to produce fertiliser is through mining or industrial processes.

***This material was obtained from the United States Geological Survey Fact Sheet 155-99. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Jasinski, S. M.; Kramer, D. A.; Ober, J. A.; Searls, J. P. 1999. Fertilisers - Sustaining Global Food Supplies. [Online]. Available: http://pubs.usgs.gov/fs/fs155-99/fs155-99.html [1 July 2010].***

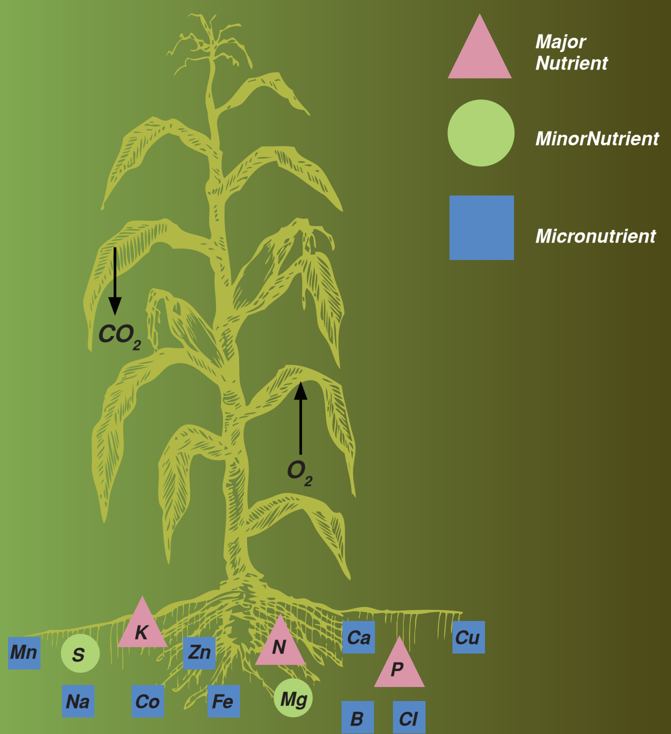
***Healthy fruit on a tree***

### DID YOU KNOW?

***A nutrient is a substance that is used in an organism's metabolism or physiology and which must be taken in from the environment. Organic fertilisers refer to fertilisers made from natural products, for example manure. Inorganic fertilisers refer to those containing industrially synthesised components.***

***Source: Wikipedia***

***Plants require many different elements for optimum growth.***




*Source: International Fertiliser Industry Association*

## Why do we use fertilisers?

Like all living organisms, plants are made up of cells. Numerous metabolic chemical reactions occur within these cells and are responsible for growth and reproduction. Since plants do not eat food like animals, they depend on nutrients in the soil to provide the basic chemicals for these metabolic reactions. The supply of these components in soil is limited, however, and as plants are harvested, it dwindles, causing a reduction in the quality and yield of plants.

Fertilisers replace the chemical components that are taken from the soil by growing plants. However, they are also designed to improve the growing potential of soil, and fertilisers can create a better growing environment than natural soil. They can also be tailored to suit the type of crop that is being grown.

***This material was obtained from the website www.madehow.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Madehow.com. 2010. Fertiliser. [Online]. Available: www.madehow.com/Volume-3/Fertiliser.html [1 July 2010].***

# Why do we need fertilisers?

The global population increased from 2,5 billion people in 1950 to more than 6 billion people today. Even if the average diets remained the same, the global food output would have to become more than twice as large in just two generations - a challenge unprecedented in human history. With the population predicted to increase to 7,7 billion by the year 2020 there is an ever increasing need to produce more food, and do so more efficiently.

The results of fertiliser use are more fertile soil, higher crop yields and communities that are self-sufficient for food. Research has shown that typically, organic agriculture at its most efficient can produce around 200 kg of protein per hectare. By contrast, the most productive fields, fertilised with large amounts of inorganic nitrogen can yield 800 kg of protein per hectare. Because fertilisers increase soil fertility, farmers can increase their yields without expanding the area under cultivation. In 1960, farmers harvested about 1,4 billion hectares worldwide. In the 1990's, there were still less than 1,45 billion hectares under cultivation, but the food and feed supplies had doubled.

***This material was obtained from a publication written by Prof Vaclav Smil. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Smil, V. 1999. Long-range perspectives on Inorganic Fertilisers in Global Agriculture. [Online]. Available: http://www.vaclavsmil.com/wp-content/uploads/docs/smil-article-1999-hignett-lecture.pdf [1 July 2010].***

# What's inside fertilisers?

Typically, fertilisers are composed of nitrogen, phosphorus, and potassium compounds. They also contain trace elements that improve the growth of plants. The primary components in fertilisers are nutrients which are vital for plant growth. Plants use nitrogen in the synthesis of proteins, nucleic acids, and hormones. When plants are nitrogen deficient, they are marked by reduced growth and yellowing of leaves.

Plants also need phosphorus, a component of nucleic acids, phospholipids, and several proteins. It is also necessary to provide the energy to drive metabolic chemical reactions. Without enough phosphorus, plant growth is reduced. Potassium is another major substance that plants get from the soil. It is used in protein synthesis and other key plant processes. Yellowing, spots of dead tissue, and weak stems and roots are all indicative of plants that lack enough potassium.

Calcium, magnesium, and sulfur are also important materials in plant growth. They are only included in fertilisers in small amounts, however, since most soils naturally contain enough of these components.

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# NPK ratio

Fertilisers are graded by using a series of numbers that represent the amount of nutrient that is available to the plant. The content of each nutrient is expressed as a percentage by weight of fertiliser product. Usually three numbers appear on the fertiliser bag that indicates the percentages of N, P and K in order. The number in brackets indicates the percentage by mass of N, P, and K in the fertiliser. (38% in this case)

| For example, | N | P | K | |
|---|---|---|---|---|
| | 3 | 1 | 5 | (38%) |

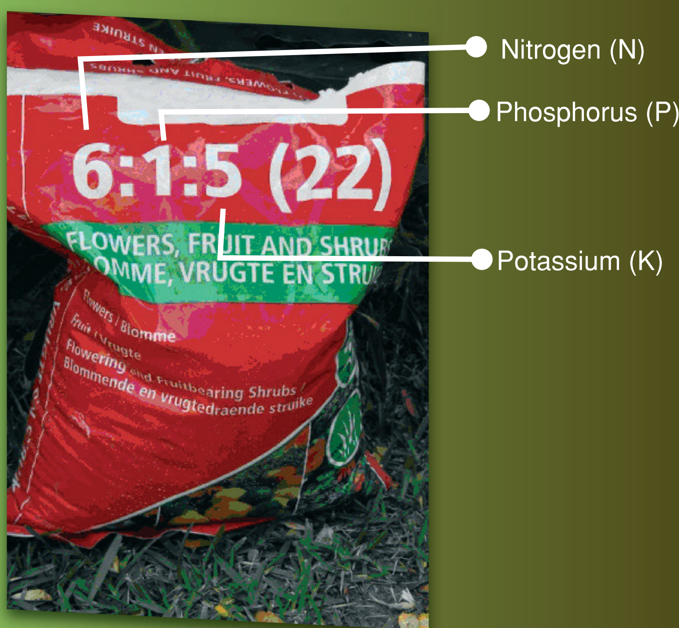
%N: 3 in every 9 parts of the 38% contain nitrogen.
%P: 1 in every 9 parts of the 38% contains phosphorus
%K: 5 in every 9 parts of the 38% contain potassium

Some countries express the phosphorus content as $P_2O_5$ and the potassium content as $K_2O$. South Africa expresses the NPK ratio in terms of the elements present, as indicated above.

The balance of the fertiliser (62%) is made up of fillers, such as gypsum, lime and sand. Other micronutrients are often added to the blend. Fertiliser companies can blend specific compounds for specialised crop needs.

***This material was supplied by Sasol Group Services. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: UCT Chemical Engineering Schools Project. 2010. Chemical Industries Resource Pack. Cape Town.***

## A bag of fertiliser




***The Grade or Analysis of a fertiliser is designated by three numbers which are always listed in the same order. Additional nutrients may be listed elsewhere, but are not typically considered part of the grade.***

*Photograph: Elvera Viljoen*

# F2 FERTILISERS

## HISTORY OF THE FERTILISER INDUSTRY

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## Fertilisers - then and now

The process of adding substances to soil to improve its growing capacity was developed in the early days of agriculture. Ancient farmers knew that the first yields on a plot of land were much better than those of subsequent years. This caused them to move to new, uncultivated areas, which again showed the same pattern of reduced yields over time. Eventually it was discovered that plant growth on a plot of land could be improved by spreading animal manure throughout the soil.

Over time, fertiliser technology became more refined. New substances that improved the growth of plants were discovered. The Egyptians are known to have added ashes from burned weeds to soil. Ancient Greek and Roman writings indicate that various animal excrements were used, depending on the type of soil or plant grown. It was also known by this time that growing leguminous plants on plots prior to growing wheat was beneficial. Other types of materials added include sea-shells, clay, vegetable waste and waste from different manufacturing processes.

Organised research into fertiliser technology began in the early seventeenth century. Early scientists such as Francis Bacon and Johann Glauber described the beneficial effects of the addition of saltpeter ($KNO_3$) to soil. Glauber developed the first complete mineral fertiliser, which was a mixture of saltpeter, lime, phosphoric acid, nitrogen, and potash ($K_2O$). As scientific chemical theories developed, the chemical needs of plants were discovered, which led to improved fertiliser compositions. Organic chemist Justus von Liebig demonstrated that plants need mineral elements such as nitrogen and phosphorus in order to grow. The chemical fertiliser industry could be said to have its beginnings with a patent issued to Sir John Lawes, which outlined a method for producing a form of phosphate that was an effective fertiliser.

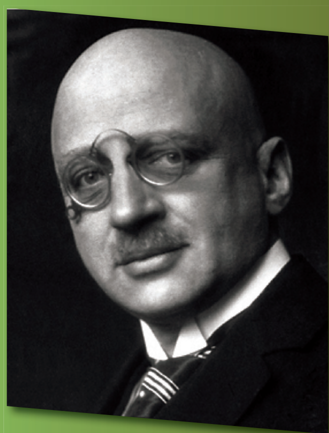
The synthetic fertiliser industry experienced significant growth after the First World War, when facilities that had produced ammonia and synthetic nitrates for explosives were converted to the production of nitrogen-based fertilisers.

***This material was obtained from the website www.madehow.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Madehow.com. 2010. Fertiliser. [Online]. Available: www.madehow.com/Volume-3/Fertiliser.html [1 July 2010].***

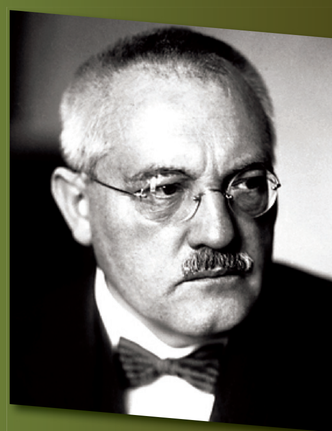
## Fertiliser timeline

The manufacturing of fertiliser in South Africa dates back to 1903 when the South African Fertiliser Company (SAFCO) in Durban commissioned the first phosphate plant, which used animal bones as raw material. Subsequent development of the mining industry necessitated the production of explosives in South Africa and enabled the production of large quantities of sulfuric acid as a byproduct. The sulfuric acid was used in fertiliser production, which became a viable proposition. This led to the commissioning of the Kynoch superphosphate plants at Umbogintwini in 1919, and two years later Cape Explosives (Capex) (originally called De Beers Explosives) at Somerset West.

South Africa was dependent on imported fertiliser products, which were mixed and blended with the local products. Import supplies dried up during the Second World War. Price control was introduced as a war measure during the early 1940s and was abolished on



Fritz Haber
(1868-1934)
Nobel Prize Winner
1918



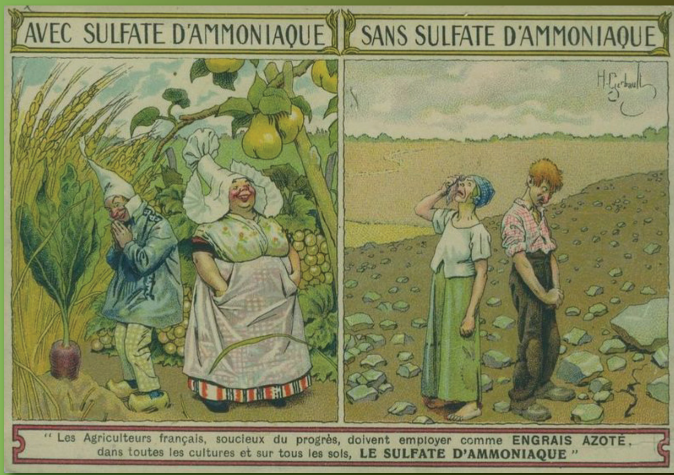
Carl Bosch
(1874-1940)
Nobel Prize Winner
1931

*Source: http://nobelprize.org.*


***In the early decades of the 20th Century, the Nobel prize-winning chemists Carl Bosch and Fritz Haber developed the process that enabled nitrogen to be synthesised cheaply into ammonia, for subsequent oxidation into nitrates and nitrites.***

*Source: Wikipedia*

'With ammonium sulfate' 'Without ammonium sulfate'




***An old French fertiliser advertisement***

***Source: Wikimedia Commons***

1 January 1984.

The original Kynoch and Capex joined forces in 1924 as AE&E, which later became AE&CI, and in the 1960s another factory under the same umbrella was established at Modderfontein. In 1944 the name changed to African Explosives and Chemical Industries, AECI Limited.

Foskor, a wholly owned subsidiary of the Industrial Development Corporation (IDC), developed the apatite deposit at Phalaborwa in 1951. The Sasolburg oil-from-coal plant was brought on stream between 1950 and 1960. Raw materials for fertiliser production became available and the Fisons and Windmill fertiliser factories were established at Sasolburg, and the Bosveld factory at Phalaborwa. By 1969 these factories, together with Fisons factory at Milnerton, had became part of Fedmis.

Omnia started with distribution of agricultural lime in 1953 and opened its first fertiliser factory at Sasolburg in 1967/68. Three liquid fertiliser plants at Dryden, Danielsrus and Hectorspruit, a second factory at Sasolburg and a phosphoric acid plant at Phokeng near Rustenburg followed this.

Triomf established its factory at Potchefstroom in 1967. A factory at Richards Bay followed this in the 1970s. In the 1970s Triomf and the non-nitrogen interests of AE&CI joined forces as AECI Limited. The lifting of price control on fertilisers in 1984 coincided with several other events. The most severe drought in two centuries, and the coincidence of the worst recession since 1930s had a serious effect on both farmers and the fertiliser industry. Sasol Limited, which previously had been a supplier to other manufacturers only, established its own fertiliser company (Sasol Fertilisers) and started marketing directly to farmers in 1984. Triomf and AECI separated their interest. Triomf kept the factories at Potchefstroom and Richards Bay, whilst AECI revived the name Kynoch Fertilisers with their factories at Somerset West, Umbogintwini and Modderfontein, which they repossessed in 1986 Kynoch took over the local interest of Triomf. At about the same time an overseas consortium (Indian Ocean Fertilisers (Pty) Ltd, or IOF) took over the Richards Bay plant. IOF produces phosphoric acid and soluble phosphates mainly for the export market.

In 1988, the operational interests of Fedmis, a division of Sentrachem, were taken over by Sasol Fertilisers, Kynoch Fertilisers and Omnia Fertilisers. During 1990, Foskor became a shareholder in IOF. In 1992 Sasol Fertilisers decided to cease its direct marketing to farmers. In 1993, Kynoch Fertilisers took over the nitrogen interests of AECI. Chemfos (a subsidiary of Samancor), which mined rock phosphate at Langebaan, ceased its activities at the end of 1993.

The years 1999 to 2002 were characterised by large scale rationalisation and acquisitions in the industry. Foskor obtained the entire shareholding in IOF, resulting in the latter becoming a fully owned subsidiary of Foskor, and IOF was changed to Foskor Richards Bay. Norsk Hydro obtained the controlling interest in Kynoch, AECI's fertiliser division. Sasol Fertiliser, which had been trading as Sasol Agri since 2000, obtained a 100 percent interest in Fedmis of Phalaborwa, which was operated as a 50-50 joint venture by AECI-Kynoch and Sasol Fertilisers.

***Apricots***

***Maize plants***

***This material was obtained from a publication from the Department of Minerals and Energy. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Ratlabala, M. E. An Overview of South Africa's Mineral - based Fertilisers, DME Report 41. 2003. p. 1-2.***

# F3 FERTILISERS

THE FARMERS' WAY

CHEMICAL INDUSTRIES RESOURCE PACK

## Manure

Manure is organic matter used as organic fertiliser in agriculture. Manures contribute to the fertility of the soil by adding organic matter and nutrients, such as nitrogen, that are trapped by bacteria in the soil. Manure is an excellent fertiliser containing nitrogen, phosphorus, potassium and other nutrients. It also adds organic matter to the soil which may improve soil structure, aeration, soil moisture-holding capacity, and water infiltration.

The nitrogen compounds in manure are eventually converted to the available nitrate form. Nitrate is soluble and is moved into the root zone with water. However, the release of available nitrogen from the complete organic compounds during manure decomposition is very gradual. This slow release of nitrogen is manure's most important asset. It extends nitrogen availability and reduces leaching, a problem especially in sandy soils.

The idea is to first apply enough manure to meet the first year's need of available nitrogen. Decreasing amounts are then applied in following years because of the carry-over organic nitrogen that will be released from previous applications. If the same rate of manure is applied each year, it is possible for a field originally low in nitrogen to accumulate unnecessarily high levels in successive years.

*This material was adapted from Wikipedia. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Wikipedia. 2010. Manure. [Online]. Available: http://en.wikipedia.org/wiki/Manure [1 July 2010].*

Green manures are crops grown for the express purpose of ploughing them under. In so doing, fertility is increased through the nutrients and organic matter that are returned to the soil. Leguminous crops, such as clover, also "fix" nitrogen through rhizobia bacteria in specialised nodes in the root structure. This further contributes to the fertility of the soil by feeding the fungi in the soil.

## Guano

Guano is the excrement (feaces and urine) of seabirds, bats, and seals. Guano manure is an effective fertiliser due to its high levels of phosphorus and nitrogen and also its lack of odour. Superphosphate made from guano is used for aerial topdressing. Soil that is deficient in organic matter can be made more productive by addition of this manure. Guano consists of ammonia, along with uric, phosphoric, oxalic, and carbonic acids, as well as some earth salts and impurities. Guano also has a high concentration of nitrates. Currently vast volumes of phosphorus are needed to produce fertiliser, as it is an essential plant macronutrient. Guano is rich in phosphorus and is an intensely effective phosphorus fertiliser. Guano was mined off the South African West Coast from as early as 1666 and provided the first farmers with fertilisers for their crops. The exploitation of guano started in the 1840's and by the turn of the century farmers had to find other ways to fertilise their fields.

## Crop rotation

Crop rotation avoids a decrease in soil fertility, as growing the same crop repeatedly in the same place eventually depletes the soil of various nutrients. A crop that depletes the soil of one kind of nutrient is followed during the next growing season by a different crop that returns that nutrient to the soil or draws a different ratio of nutrients, for example, rice followed by cotton. Rotating crops adds nutrients to the soil. Legumes have nodules on their roots which contain nitrogen-fixing bacteria. It therefore makes good sense agriculturally to alternate them with plants that require nitrates. A common modern crop rotation is alternating soybeans and maize (mealies). Crop rotation is a type of agricultural control that is also used to control pests and diseases that can become established in the soil over time. This principle is of particular use in organic farming, where pest control may be achieved without synthetic pesticides.

*This material was adapted from Wikipedia. Learners- if you use any part of it you need to write it in your own words and include the following in your reference list: Wikipedia. 2010. Crop rotation. [Online]. Available: http://en.wikipedia.org/wiki/Crop _ rotation [1 July 2010].*

## The use of lime in farming

The addition of lime to acidic soil increases the pH value of the soil. The increase in pH level of the soil increases the solubility of nitrogen, potassium and phosphorous compounds, which will therefore be more readily available for absorpsion by plants. Limestone ammonium nitrate, or LAN, is often used as a fertiliser.

### Limestone

**Source: www.mii.org**

## Chemical fertilisers

As far as can be ascertained, the first time chemical fertiliser was used in South Africa was in 1890. This was a small consignment of "corn and hay" fertiliser imported for a certain Van Heerden of Malmesbury.

### Did you know?

***Lime is a general term used for various forms of a basic chemical produced from calcium carbonate rocks such as limestone ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$).***

***Quicklime is calcium oxide (CaO) and is produced by heating limestone.***

$CaCO_3 \rightarrow CaO + CO_2$

***The quicklime dissolves in water to form calcium hydroxide.***

$CaO + H_2O \rightarrow Ca(OH)_2$

***Calcium hydroxide will dissociate as follows when dissolved in water:***

$Ca(OH)_2 \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$

**Source: Wikipedia**

## Plant nutrient deficiency symptoms

***Nitrogen (N) deficiency***
Symptoms: Older leaves, generally at the bottom of the plant, will yellow. Remaining foliage is often light green. Stems may also yellow and may become spindly. Growth slows.

***Phosphorus (P) deficiency***
Symptoms: Small leaves that may take on a reddish-purple tint. Leaf tips can look burnt and older leaves become almost black. Reduced fruit or seed production.

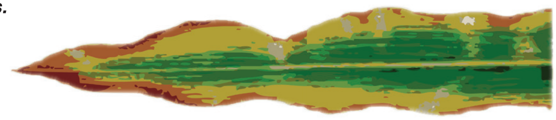
***Potassium (K) deficiency***
Symptoms: Older leaves may look scorched around the edges and/or wilted. Interveinal chlorosis (yellowing between the leaf veins) develops.

***Sulfur (S) deficiency***
Symptoms: New growth turns pale yellow, older growth stays green. Stunts growth.

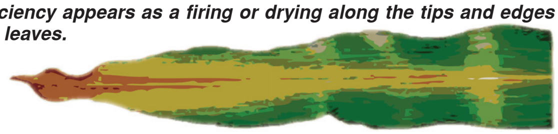
### Nutrient deficiency in maize plants

***HEALTHY leaves with a rich dark green colour when adequately fed.***

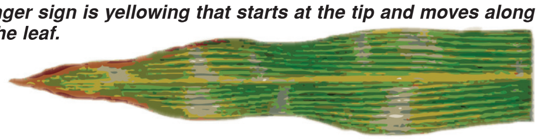
***PHOSPHATE shortage marks leaves with reddish-purple, particularly on young plants.***



***POTASH deficiency appears as a firing or drying along the tips and edges of the lowest leaves.***

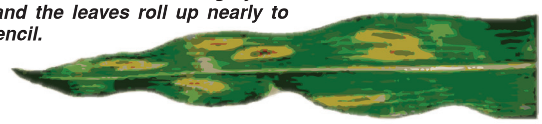


***NITROGEN hunger sign is yellowing that starts at the tip and moves along the middle of the leaf.***



***MAGNESIUM deficiency causes whitish strips along the veins and often a purplish colour on the underside of the lower leaves.***

***DROUGHT causes the maize to have a greyish-green colour and the leaves roll up nearly to the size of a pencil.***



***DISEASE, helminthosporium blight, starts in small spots, gradually spreads across the leaf.***

***CHEMICALS may sometimes burn tips and edges of leaves. Tissue dies and leaf becomes whitecap.***

**Source: Queen's Printer for Ontario, 2010**

# F4 FERTILISERS

## BUILDING FERTILISERS FROM MOLECULES 1

CHEMICAL INDUSTRIES
RESOURCE PACK

### Did you know?

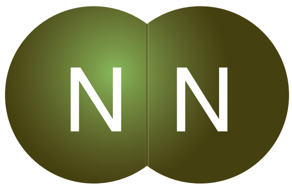
***The nitrogen supply for ammonia synthesis is truly inexhaustible since the atmosphere contains 3,8 quadrillion tonnes of the element.***

## Nitrogen

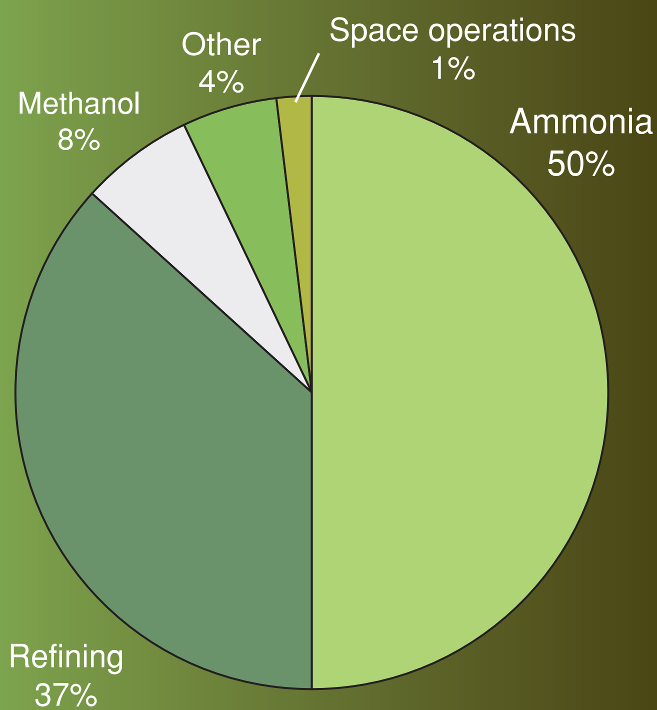
Nitrogen comes from the air. 78% of the air that we breathe is nitrogen. Air can be liquefied and nitrogen obtained by fractional distillation of air. The strong chemical bond between the two nitrogen atoms in a nitrogen molecule leads to the molecule being unreactive and most plants can't use nitrogen directly. We therefore need a process to convert this abundant resource into a usable form for plants.

Other sources of nitrogen include: nitrogen fixing bacteria; decomposing bacteria and fungi; nitrifying bacteria; lightning.

***A representation of the nitrogen molecule***




The largest consumers of hydrogen today

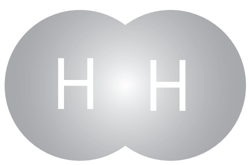



*Source: Bellona Foundation*

## Hydrogen

Hydrogen has been produced and used for industrial purposes for over one hundred years. Of the world's total hydrogen production of approximately 45 million tons, over 90% comes from fossil raw materials. The largest producers of hydrogen are the fertiliser and petroleum industries.

***A representation of the hydrogen molecule***

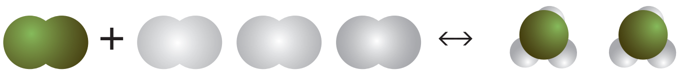



*This material was obtained from the Bellona Foundation. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Bellona Foundation. 2002. Report 6: Hydrogen Technologies. [Online]. Available: http://www.interstatetraveler.us/Reference-Bibliography/Bellona-HydrogenReport.html] [1 July 2010].*

# The Haber-Bosch synthesis of ammonia

Fritz Haber discovered that at a temperature of 600°C and a pressure of 200 atm, nitrogen and hydrogen form an equilibrium mixture in the presence of a suitable catalyst. The equation for the reaction can be seen below:

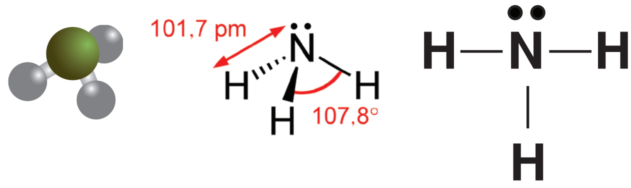
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; $\Delta H = -92$kJ/mol of $N_2$




The conditions giving rise to the maximum yield of ammonia are high pressure and low temperature. In practice the operating temperature is usually about 400 - 450°C because at lower temperatures the reaction is too slow, even in the presence of a catalyst. The operating pressure is normally about 25 MPa (~250 atm), although pressures up to 101 MPa (~1000 atm) have been used. The best catalyst is iron mixed with various promoters such as aluminium and potassium oxides to increase its catalytic activity.

# Ammonia ($NH_3$)

***Different representations of the ammonia molecule***



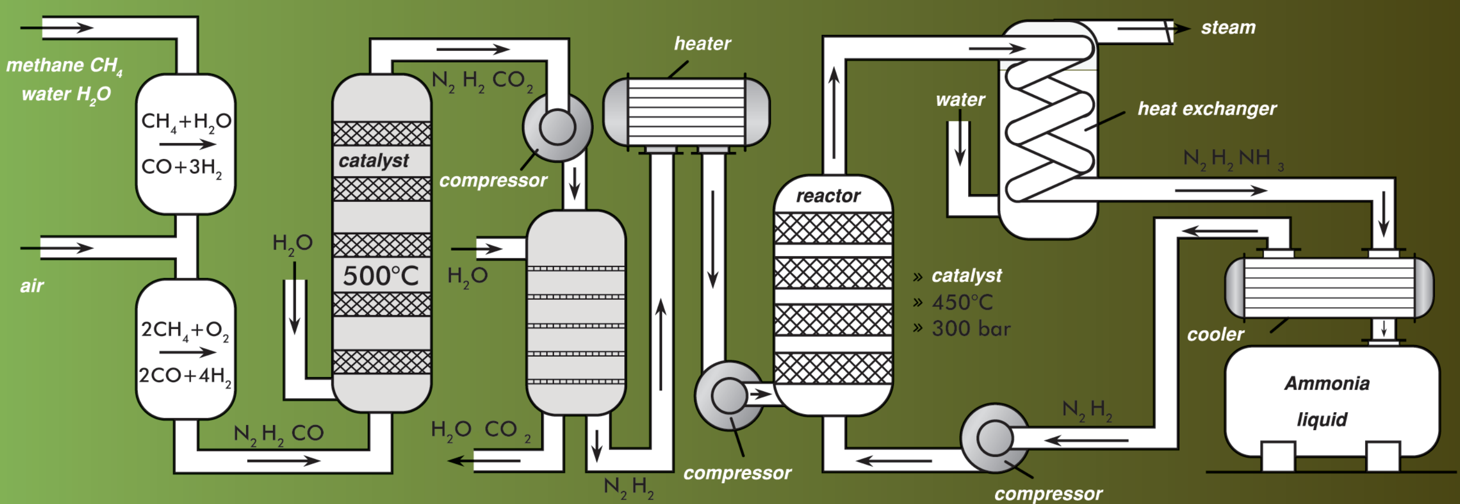

***Source: Wikimedia Commons***

Properties of ammonia:

- Melting point : -78°C
- Boiling point: -33,5°C
- Extremely soluble in water:
  $NH_3(g) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
- Reacts with and corrodes copper, zinc, and many alloys
- It is a colourless gas at room temperature with a characteristic pungent odour
- Less dense than air

***This material was adapted from Wikipedia. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Wikipedia.org. 2010. Ammonia. [Online]. Available: http://en.wikipedia.org/wiki/Ammonia [1 July 2010].***

# Production of synthesis mixture and production of ammonia




***Source: Wikimedia Commons***

# F5 FERTILISERS

BUILDING FERTILISERS FROM MOLECULES 2

CHEMICAL INDUSTRIES
RESOURCE PACK

## The Ostwald process

Once ammonia has been produced by the Haber process, it can be converted into nitric acid through a multi-step procedure known as the Ostwald process. In the first step in this reaction, ammonia and oxygen gas react, in the presence of a catalyst, to form nitrogen monoxide according to the following reaction:

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$
$\Delta H(25°C) = -905$ kJ/4 mol of $NH_3$ converted

The reaction is quite exothermic. In the commercial reaction, the catalyst used is a platinum-rhodium metal gauze that is heated to about 900°C. However, even a hot copper wire can catalyse the reaction in the laboratory. Once the reaction has started, the energy it produces is enough to keep the catalyst hot enough to sustain the reaction.

In the next step, the nitrogen monoxide (NO) reacts with oxygen to produce nitrogen dioxide ($NO_2$). No catalyst is required for this reaction.

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
$\Delta H(25°C) = -147$k/2 mol of NO converted

Instead of storing the $NO_2$, we can use it to produce nitric acid. The $NO_2(g)$ reacts with water to produce nitric acid ($HNO_3$) and nitrogen monoxide (NO). The nitric acid is separated by distillation, and the NO can be recycled and reacted to form $NO_2$ through the above reaction.

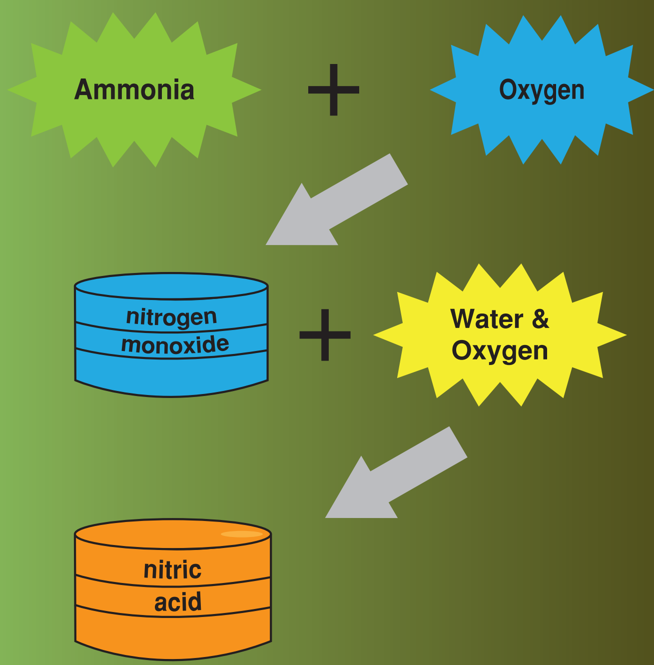
$3NO_2(g) + H_2O(\ell) \rightleftharpoons 2HNO_3(aq) + NO(g)$
$\Delta H(25°C) = -138$kJ/3 mol of $NO_2$ converted

The nitric acid can then be used in the manufacture of countless numbers of different nitrogen-containing compounds. For example, ammonia will react with the nitric acid to produce ammonium nitrate, one of the most important forms of nitrogen fertilisers.

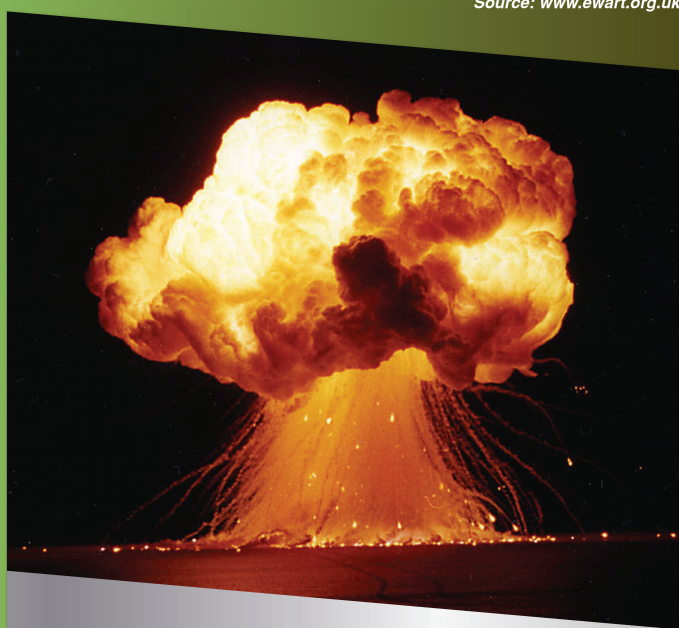
$NH_3(g) + HNO_3(aq) \rightarrow NH_4NO_3(s)$
$\Delta H(25°C) = -112$kJ/mol of $HNO_3$ converted

*This material was written by David Dice and reprinted with permission from http://digipac.ca/chemical. Learners — if you use any part of it you need to write it in your own words and include the following in your reference list: Dice, D. 2008. Manufacturing nitrates: The Ostwald Process. [Online]. Available: http://www.digipac.ca/chemical/mtom/contents/chapter3/fritzhaber _ 2.htm [1 July 2010].*

### Making nitric acid




*Source: www.ewart.org.uk*



## *Did you know?*

***Ammonium nitrate is used as an explosive. It is also used in cold packs, as hydrating the salt is an endothermic process - it takes in heat and the reaction mixture will feel cold.***

## Sulfuric acid

There is a similar reaction of ammonia with sulfuric acid to produce ammonium sulfate that is is also used as a fertiliser:

$2NH_3(g) + H_2SO_4(\ell) \rightarrow (NH_4)_2SO_4(s)$

### The manufacturing of sulfuric acid:

Sulfuric acid is manufactured using the contact process. Sulfur is reacted with oxygen according to the following reaction:

$S(s) + O_2(g) \rightarrow SO_2(g)$

The sulfur dioxide is then converted into sulfur trioxide:

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

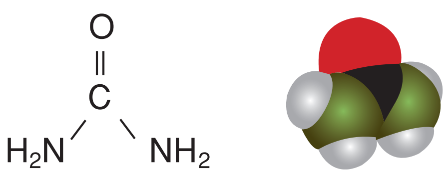
If water is added to sulfur trioxide sulfuric acid will be formed. However, this reaction is so uncontrollable that it creates a fog of sulfuric acid. Instead, the sulfur trioxide is first dissolved in concentrated sulfuric acid to form fuming sulfuric acid, or oleum:

$H_2SO_4(\ell) + SO_3(g) \rightarrow H_2S_2O_7(\ell)$

This can then be reacted safely with water to produce concentrated sulfuric acid - twice as much as you originally used to make the fuming sulfuric acid.

$H_2S_2O_7(\ell) + H_2O(\ell) \rightarrow 2H_2SO_4(\ell)$

## Urea




Different representations of urea

***Source: Wikimedia Commons***

In 1828, the German chemist Friedrich Wöhler obtained urea by treating silver cyanate with ammonium chloride in a failed attempt to prepare ammonium cyanate.

$AgNCO + NH_4Cl \rightarrow (NH_2)_2CO + AgCl$

This was the first time an organic compound was artificially synthesised from inorganic starting materials, without the involvement of living organisms. More than 90% of world production of urea is destined for use as a nitrogen-release fertiliser. Urea has the highest nitrogen content of all solid nitrogenous fertilisers in common use (46,7%). Therefore, it has the lowest transportation costs per unit of nitrogen nutrient.

***This material was obtained from the book Molecules That Changed The World. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Nicolaou, K. C.; Montagnon, T. 2001. Molecules that change the world. Wiley. 2001.***

# Fire at AECI factory in Somerset West

**16 December 1995**

A veld fire spread to stockpiled sulfur at the AECI factory in Somerset West. The 15 000 tons of sulfur ignited and smoke plumes quickly engulfed the nearby disadvantaged community of Macassar. Two young men died the same night, and an estimated 15 000 people were poisoned to varying degrees.

Pets also died, as did garden plants and crops as a result of acid rain. During the late 1990s the Desai Commission of Enquiry into the fire found AECI's conduct was "casually negligent". Now, following years of litigation, AECI has recently paid out an estimated R8 million to the victims of Macassar.

***This article was published in the Helderberg Sun. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: Helderberg Sun. 2000. Fire at AECI factory in Somerset West. [Online]. Available: http://folc.ca/sulphur _ storage/fires.htm [1 July 2010].***

# Disaster strikes Texas City

**16 April 1947**

The Texas City Disaster was a major 20th-century industrial accident in Texas City in the United States. The incident started with a mid-morning fire on board the French-registered vessel SS Grandcamp in the Port of Texas City. The fire detonated approximately 2 300 tonnes of ammonium nitrate and the resulting chain reaction of fires and explosions killed at least 581 people. The 32,5% ammonium nitrate, used as fertiliser and in high explosives, was manufactured in Nebraska and Iowa and shipped to Texas City by rail before being loaded on the Grandcamp. It was manufactured in a patented explosives process, mixed with clay, petrolatum, rosin and paraffin to avoid moisture caking. It was packaged in paper sacks, then transported and stored at temperatures that increased its chemical activity. Longshoremen reported the bags were warm to the touch prior to loading.

Attempts at control failed as a red glow returned after each effort. Shortly before 9:00, the Captain ordered his men to steam the hold, a firefighting method where steam is piped in to put out fires in the hope of preserving the cargo. The cargo hold and deck began to bulge as the forces increased inside. At 09:12, the ammonium nitrate reached an explosive threshold and the vessel then detonated, causing great destruction and damage throughout the port. The tremendous blast sent a 4,5 m wave that was detectable over nearly 160 km of the Texas shoreline.

***This article was obtained from Wikipedia. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: Wikipedia.org. 2010. Texas City Disaster. [Online]. Available: http://en.wikipedia.org/wiki/Texas _ City _ Disaster [1 July 2010].***

# F6 FERTILISERS

## PHOSPHATE PRODUCTION

CHEMICAL INDUSTRIES
RESOURCE PACK

## Phosphorus

Phosphorus is present in all living cells and is essential to all forms of life. Phosphorus is naturally present in rock, sediment, soil, and organic matter; in fact, it is the eleventh most abundant element in the Earth's crust. Phosphorus is the second most abundant of all the mineral nutrients contained in our bodies. It can be found in every cell, but nearly 80 percent of phosphorus found in people is concentrated in teeth and bones. The source of phosphorus in fertiliser is fossilised remains of ancient marine life found in rock deposits. The countries with the most phosphorus resources are the United States, China, India, Russia and Brazil. In South Africa, phosphate ore is mined at Phalaborwa and at Langebaan.

***This material was adapted from an article by the Florida Department of Environmental Protection. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: WaterandWildlife.org. 1999. Industrial Wastewater Program Phosphate Industry. [Online]. Available: http://www.tfi.org/factsandstats/fertiliser.cfm] [1 July 2010].***

## Phosphate production

Phosphate production begins with the mining of calcium phosphate (phosphate rock). Phosphate rock, sand and clay is mined and deposited in a shallow containment area known as a well. While in the well, the matrix is sprayed by high-pressure water guns that liquefy the material into a mixture called a slurry. The material is then transported through pipelines to a beneficiation plant, where the clay and sand are separated from the phosphate rock. Also separated in the process is a mixture of sand and finer particles of phosphate (concentrate) that is then put through a process called flotation. In the flotation process, the mixture is put in a vessel of water where reagents such as fuel oil, soap or fatty acids are mixed in to coat the concentrate and attach air bubbles, allowing it to float, separating it from the sand. Once the phosphate has been separated from the matrix and dewatered, it is ready to be processed into components used in inorganic fertilisers. In order to make the phosphorus in phosphate rock more readily available to plants, the phosphorus must be in a soluble form. Making fertilisers begins with the phosphate rock being ground into a fine uniform grain size. It is then reacted with sulfuric acid to release the phosphorus from its chemical bond with calcium and other elements. The reaction of the phosphate rock with the sulfuric acid produces phosphoric acid and hydrated calcium sulfate (phosphogypsum), a byproduct. The phosphoric acid is then separated from the phosphogypsum and concentrated. The concentrated phosphoric acid is finally used to manufacture ingredients for inorganic fertiliser.

Examples of ingredients are diammonium phosphate and monoammonium phosphate which are produced when phosphoric acid is reacted with anhydrous ammonia (for its plant-available nitrogen). Another fertiliser ingredient, produced by mixing phosphoric acid with finely ground phosphate rock, is granular triple superphosphate. Meanwhile, water is added to the phosphogypsum byproduct to create a slurry that is hydraulically pumped to a settling dam.

As phosphogypsum dams fill, the solids are scooped out to build up the sides, forming another dam on the resulting phosphogypsum stack that increases in height (up to 70 metres high) as the process continues. The process water that remains after the solids settle out is returned to be reused in processing the phosphoric acid. Without proper treatment aquatic life can be seriously affected when this highly acidic water enters waterbodies from careless spills or failed structures.

***This material was adapted from an article by the Florida Department of Environmental Protection. Learners – if you use any part of it you need to write it in your own words and include the following in your reference list: WaterandWildlife.org. 1999. Industrial Wastewater Program Phosphate Industry. [Online]. Available: http://www.waterandlife.org/FloridaDEPFluorideWasteWater-cache.htm [1 July 2010].***

Nitrogen fertiliser

Phosphorus fertiliser

Potassium fertiliser

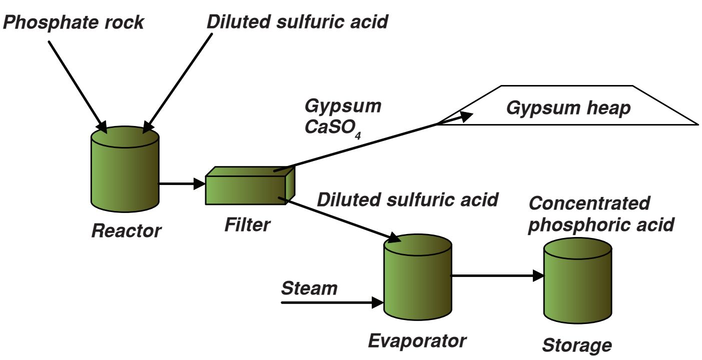
# Orthophosphoric acid, $H_3PO_4$, and its salts.

The acid is made industrially by treating phosphate rock, usually an apatite like fluorapatite ($Ca_5(PO_4)_3F$) or hydroxyapatite ($Ca_5(PO_4)_3OH$), with dilute sulfuric acid.

$$Ca_5(PO_4)_3F + 5H_2SO_4 \rightleftharpoons 5CaSO_4 + 3H_3PO_4 + HF$$

The solid calcium sulphate formed is filtered off and the solution of phosphoric acid concentrated up in the evaporator. The main use of phosphoric acid is in the manufacture of phosphates, particularly triple superphosphate and ammonium phosphate, which are used as fertilisers.

## Diagram of phosphoric acid production




# Single superphosphate, SSP fertiliser:

$$2Ca_5(PO_4)_3F + 7H_2SO_4 \rightleftharpoons 3Ca(H_2PO_4)_2 + 7CaSO_4 + 2HF$$

SSP is a mixture of solid $Ca(H_2PO_4)$ and solid $CaSO_4$ and it is about 16% $P_2O_5$.

# Triple superphosphate, TSP fertiliser:

$$Ca_5(PO_4)_3F + 7H_3PO_4 \rightleftharpoons 5Ca(H_2PO_4)_2 + HF$$

TSP is about 48% $P_2O_5$, and it is called 'triple super-phosphate' because its phosphate content is about three times that of SSP.

# Ammonium phosphate

Phosphoric acid is also reacted with ammonia to give ammonium phosphate, another good primary fertiliser.

$$3NH_3 + H_3PO_4 \rightleftharpoons (NH_4)_3PO_4$$

***This material was written for this resource pack by Lance Job. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Job, L. 2010. Phosphate production. Chemical Industries Resource Pack. University of Cape Town. 2010.***

# Potassium

Potassium is found in potash, a term that includes various mined and manufactured salts; all containing potassium in a water-soluble form. Potash is produced at underground mines, from solution-mining operations, and through the evaporation of lake and subsurface brines. Minerals mined for potash include potassium chloride (KCl or muriate of potash, MOP), potassium-magnesium sulfate ($K_2SO_4 \cdot MgSO_4$ or sulfate of potash magnesia, SOPM), or mixed sodium-potassium nitrate, ($NaNO_3$ + $KNO_3$ also known as Chilean saltpeter). Manufactured compounds are potassium sulfate ($K_2SO_4$ or sulfate of potash, SOP) and potassium nitrate ($KNO_3$ or saltpeter). Deposits of this kind are not accessible in South Africa, and so the potassium required for fertilisers here, is imported as potassium salts.

In 2001, South Africa imported 243 kiloton potassium chloride (KCl) and 26 kiloton potassium sulfate from mainly Belgium, Israel, Russia, Germany and Chile. Potassium is retained by the soil and does not require frequent application, in contrast to the nitrates.

*Healthy leaves*

**DID YOU KNOW?**

***A slurry is a thick suspension of solids in a liquid.***

## Potash rock

*Source: Potash One Inc.*

# F7 FERTILISERS

LET'S VISIT A CHEMICAL PLANT

CHEMICAL INDUSTRIES RESOURCE PACK

*A chemical plant*

## Raw materials

The raw materials for making fertilisers can be supplied to fertiliser manufacturers in bulk quantities of thousands of tonnes, drum quantities, or in metal drums and bag containers.

Primary fertilisers include substances derived from nitrogen, phosphorus, and potassium. Various raw materials are used to produce these compounds. When ammonia is used as the nitrogen source in a fertiliser, one method of synthetic production requires the use of natural gas and air. The phosphorus component is made using sulfur, coal, and phosphate rock. The potassium source comes from potassium chloride, a primary component of potash.

Secondary nutrients are added to some fertilisers to help make them more effective. Calcium is obtained from limestone, which contains calcium carbonate, calcium sulfate, and calcium magnesium carbonate. The magnesium source in fertilisers is derived from dolomite. Sulfur is another material that is mined and added to fertilisers. Other mined materials include iron from ferrous sulfate, copper, and molybdenum from molybdenum oxide.

***This material was obtained from the website www.madehow.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Madehow.com. 2010. Fertiliser. [Online]. Available: www.madehow.com/Volume-3/Fertiliser.html [1 July 2010].***

## Choosing the factory site

A company considering a new place to build a fertiliser factory needs to think about things like these:

- Closeness to raw materials
- Closeness to ports if anything is to be imported or exported
- The road network
- The water supply
- The labour force
- The cost of land
- Community interests
- Environmental impact

***Did you know?***

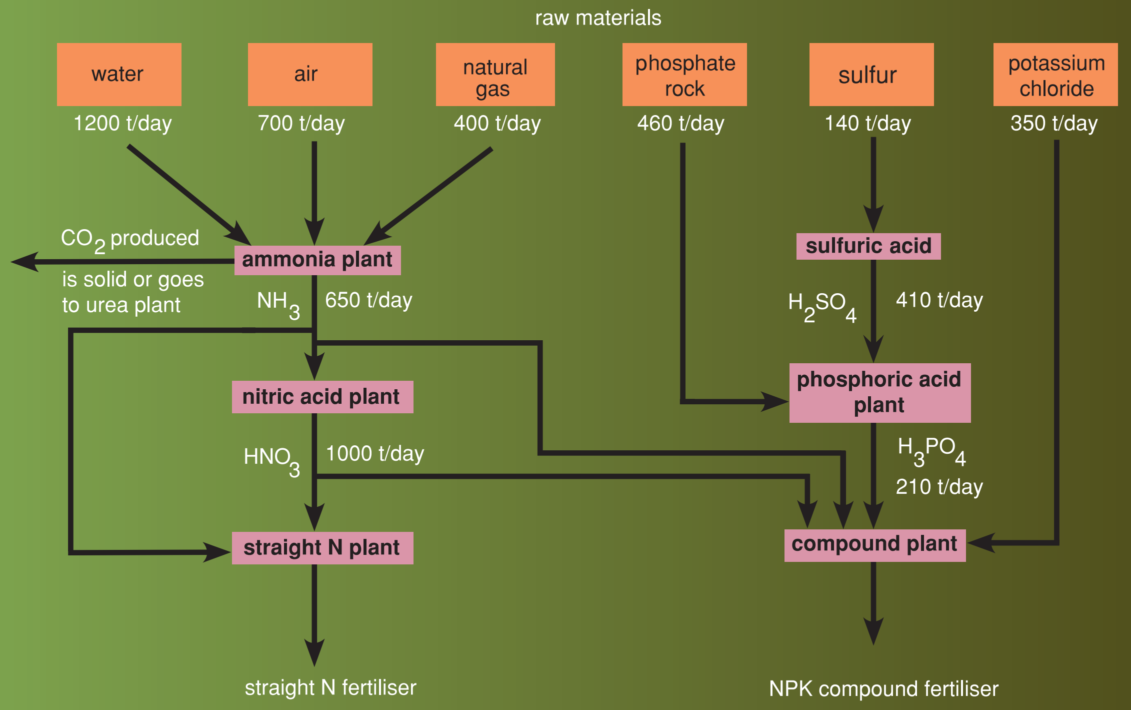
***A plant is another name for a chemical factory.***

## Quality control

To ensure the quality of the fertiliser that is produced, manufacturers monitor the product at each stage of production. The raw materials and the finished products are all subjected to a sequence of physical and chemical tests to show that they meet the specifications previously developed. Some of the characteristics that are tested include pH, appearance, density, and melting point. Since fertiliser production is governmentally regulated, composition analysis tests are run on samples to determine total nitrogen content, phosphate content, and other elements affecting the chemical composition. Various other tests are also performed, depending on the specific nature of the fertiliser composition.

***This material was obtained from the website www.madehow.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Madehow.com. 2010. Fertiliser. [Online]. Available: www.madehow.com/Volume-3/Fertiliser.html [1 July 2010].***

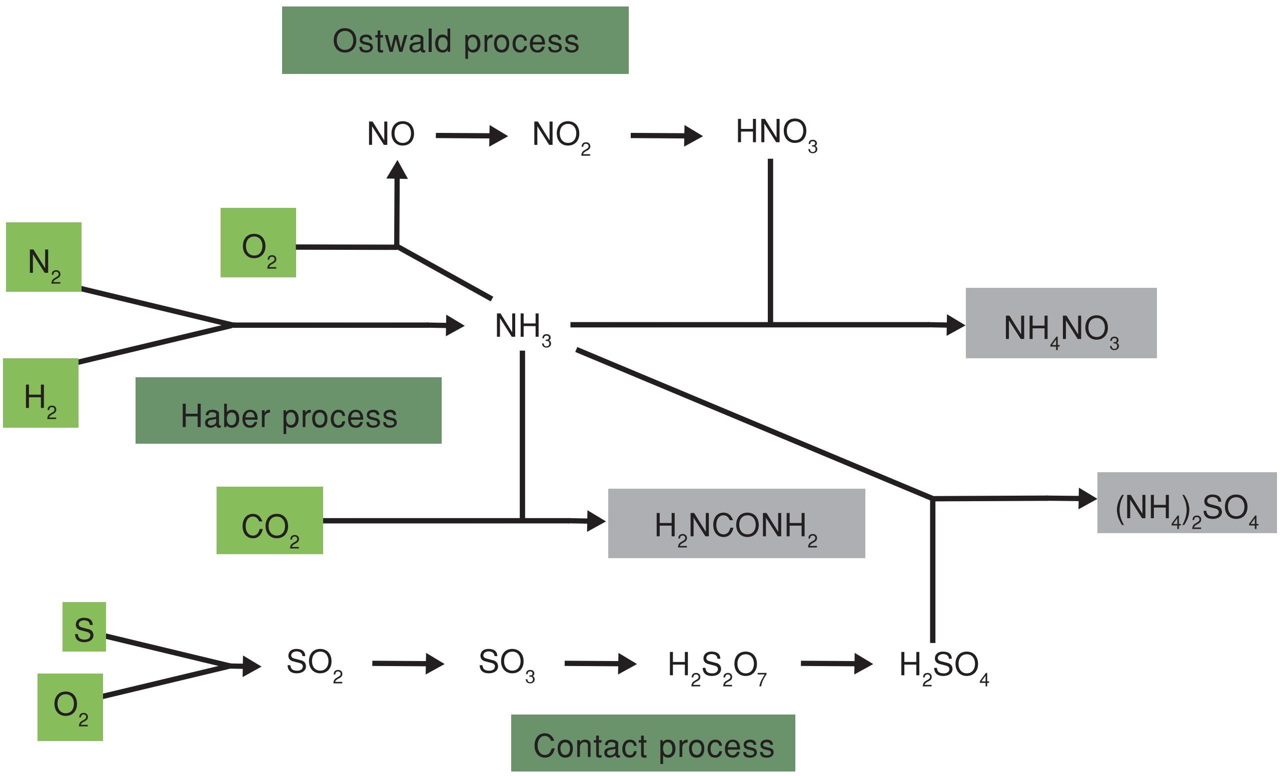
## A flow diagram of the fertiliser production process




***This flow chart illustrates how raw materials are combined to form the fertilisers we need. A factory is not just a single unit. It can be many plants built close together on the same site. Each plant is controlled so that it is making the right amount of a substance at the right time.***

***Source: Coordinate Science***

## A flow diagram to show how industrial processes fit together to make fertilisers




***This flow diagram illustrates how a large number of chemical compounds are needed in different processes to make fertilisers.***

***Source: Chemical Industries Resource Pack***

## Sasol Nitro

Sasol Nitro is a division of Sasol Chemical Industries which is a major company in Sasol's family of businesses. Sasol's core business is Gas-To-Liquid and Coal-To-Liquid processes. Some of the by-products of these processes provide raw material for fertiliser manufacturing. Sasol Nitro produces and markets ammonia, ammonium nitrate based fertilisers, ammonium sulfate, commercial explosives, nitric acid, phosphoric acid and a range of specialised blasting accessories.

*Source: www.sasol.com*

## Yara SA (previously known as Kynoch)

Yara is one of the world's largest suppliers of crop nutrients with sales to more than 120 countries. Yara's headquarters are in Oslo in Norway. Yara acquired a controlling stake in the fertiliser company, Kynoch in South Africa. Kynoch Fertiliser Limited was a subsidiary of AECI Limited. They produced nitrogenous fertiliser. Yara SA produces the following mineral-based fertiliser components: NPK with the incorporating growth and quality enhancing nutrients, like calcium and magnesium, to micronutrients that help prevent or cure deficiencies resulting from particular soil or crop conditions.

*Source: www.yara.com*

## Foskor

Foskor started as a single mining operation. Since then Foskor has rapidly grown into a producer and processor of phosphate rock and phosphoric acid. The starting point for the production of these phosphate fertilisers is phosphoric acid, which is produced at Foskor's Richards Bay plant, concentrated and sold locally and internationally to fertiliser producers. Phosphate fertilisers are produced and distributed to wholesale customers.

*Source: www.foskor.co.za*

## Omnia

Today Omnia is a diversified, specialist chemical services company providing customised solutions in the chemical, mining and agriculture markets. Omnia produces the following mineral based fertiliser components: limestone ammonium nitrate (LAN), single super phosphate and potassium sulfate, NPK, Ca & Mg supplements.

*Source: www.omnia.co.za*

## Fertiliser distribution and logistics

The two most common marketing channels in the commercial sector are:

1. **Direct from the manufacturer / blender to the farmer.**

The manufacturer employs sales representatives and technical support staff (e.g. agronomists). This model is preferred by most of the national and regional operators.

2. **Manufacturer / blender to farmer via an agent or dealer**.

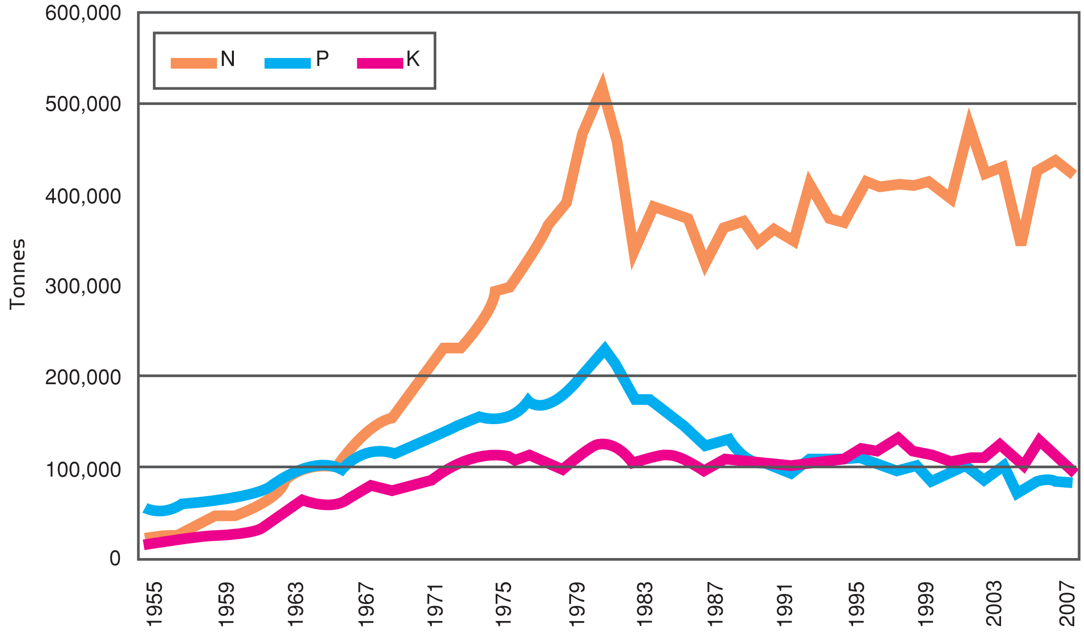
The manufacturer enters into agreements with independent agents, who may also act on behalf of other agro-input suppliers, for example of seeds and agro-chemicals. The manufacturer / blender would normally supply technical assistance as and when required.

3. **The situation in South Africa**

Field crops dominate South African agriculture. This holds true for the area planted, fertiliser use and the total value of production. Maize and wheat alone account for more than half of the area planted, 48 percent of fertiliser use and 39 percent of the total value of production. With the exception of citrus and deciduous fruits destined for export, crop production in South Africa is destined for the domestic market. Fertiliser demand is a derived demand for food and future growth in fertiliser use depends on this demand. Nearly half of South African households are vulnerable to food insecurity.

***This material was obtained from the Food and Agricultural Organisation of the United Nations. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: FAO. 2005. Fertiliser use by crop in South Africa. [Online]. Available: ftp://ftp.fao.org/agl/agll/docs/fertusesouthafrica.pdf [1 July 2010].***

## N, P and K in South Africa 1995 - 2008




***Source: FSSA***

***Grapes***

# F9 FERTILISERS

THE FUTURE

## Fertiliser research

Fertiliser research is currently focusing on reducing the harmful environmental impacts of fertiliser use and finding new, less expensive sources of fertilisers. Some of the things that are being investigated to make fertilisers more environmentally friendly are improved methods of application, supplying fertiliser in a form which is less susceptible to runoff, and making more concentrated mixtures.

New sources of fertilisers are also being investigated. It has been found that sewage sludge contains many of the nutrients that are needed for a good fertiliser. Unfortunately, it also contains certain substances such as lead, cadmium, and mercury in concentrations which would be harmful to plants.

Efforts are underway to remove the unwanted elements, making this material a viable fertiliser. Another source that is being developed is manures. The first fertilisers were manures, however, they are not utilised on a large scale because their handling has proved too expensive. When technology improves and costs are reduced, this material will be a viable fertiliser once again.

## Organic fertilisers

In organic fertilisers, the word 'organic' refers to the fact that the nutrients contained in the product are derived solely from the remains or a by-product of an organism. Some examples of organic fertilisers are chicken manure, blood & bone, guano, mineral fertilisers, lime, fish emulsions, fish hydrolytes, kelp products, humic products, sulfate of potassium, plus many different blends using compost as their base.

In comparison to synthetic ('inorganic') fertiliser, organic fertilisers contain lower levels of nutrients, but they perform important functions which the synthetic fertilisers do not. They increase the organic content and consequently the water-holding capacity of the soil. They improve the physical structure of the soil which allows more air to get to plant roots. If you apply organic fertilisers, the bacterial and fungal activity increases in the soil. Mycorrhizal fungi which make other nutrients more available to plants thrive in soil where the organic matter content is high. Organically derived plant nutrients are slow to leach from the soil making them less likely to contribute to water pollution than synthetic fertilisers.

***This material was obtained from the website www.organicfarmingsolutions.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Organic farming solutions.com. 2010. Organic Fertiliser. [Online]. Available: http://www.organicfarmingsolutions.com/organicfertiliser.php [1 July 2010].***

Cow dung cakes and heap set out for drying

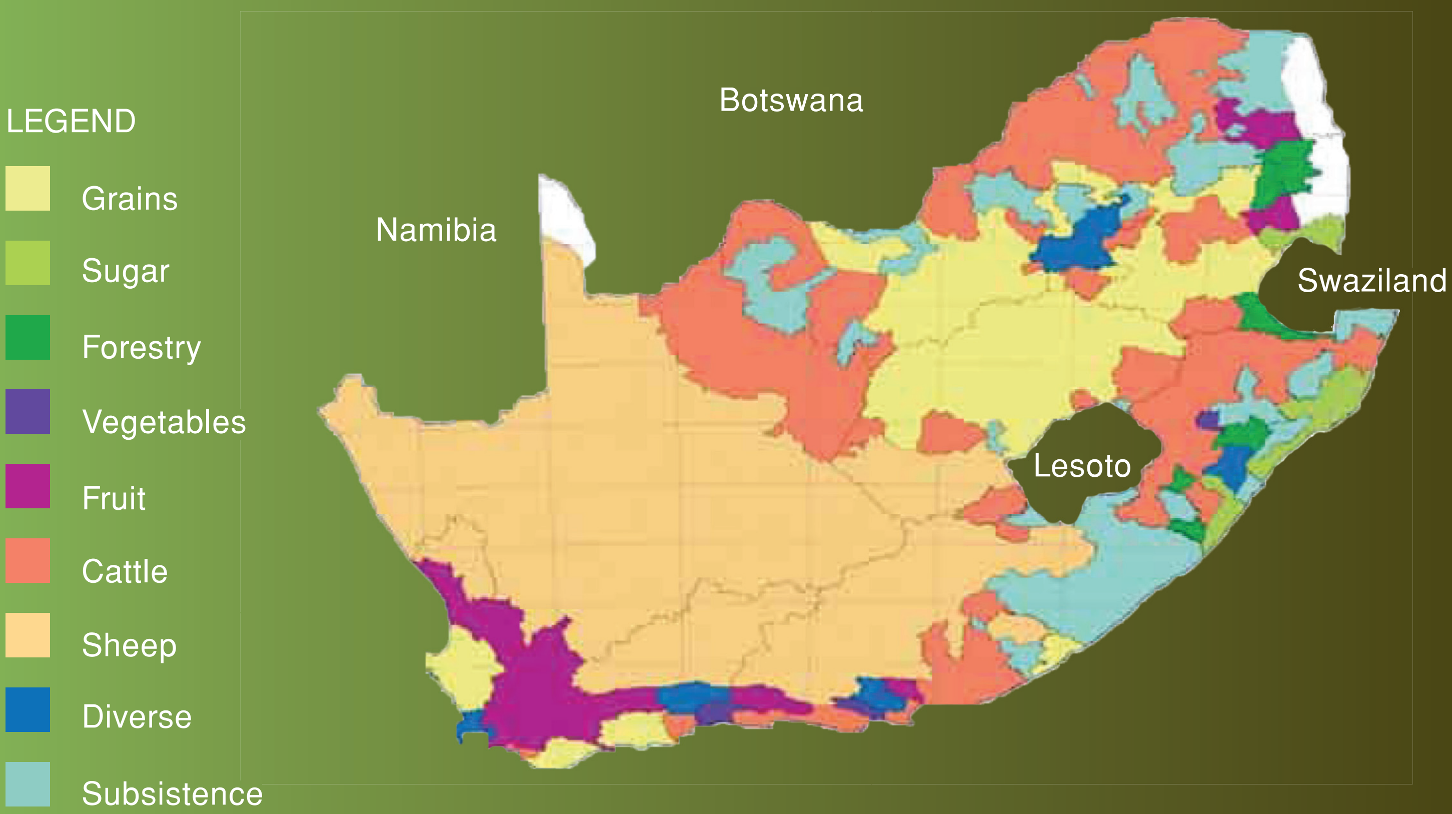
*Source: Wikimedia Commons*

## DID YOU KNOW?

*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The decisions our grandparents made about how to farm the land continue to affect agricultural practice today; and the economic policies we endorse today will have an impact on urban poverty when our children are adults.*

*Source: International Institute for Sustainable Development (IISD)*

Fertiliser use by crop in South Africa



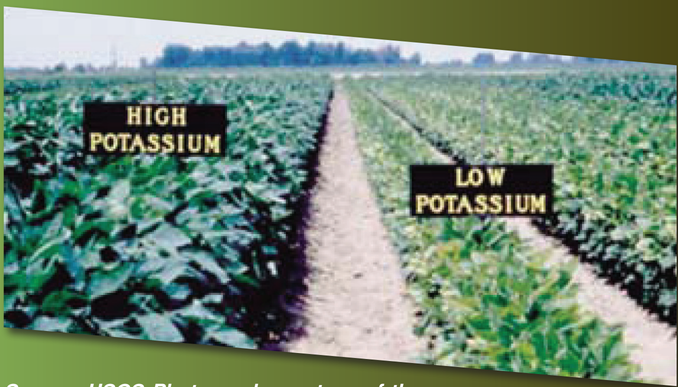

*This map was obtained from the Food and Agricultural Organization of the United Nations. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: FAO. 2005. Fertilizer use by crop in South Africa. [Online]. Available: ftp://ftp.fao.org/agl/agll/docs/fertusesouthafrica.pdf [1 July 2010.]*

# F10 FERTILISERS

## GROWING SMART



*Photograph showing a soybean test plot demonstrating the improved growth obtained with the addition of potash.*




*Source: USGS Photograph courtesy of the Potash and Phosphate Institute.*


*Photograph: Elvera Viljoen*

*Ginger, prickly pear, sweet potato, cherries, oranges, kiwi, tomato, onion, leek and other fruits & vegetables*

## Technological developments

Research is constantly being conducted to improve crop yields and the efficiency of fertiliser usage. Precision agriculture uses Global Positioning System technology, intensive soil testing, and computer-controlled fertiliser application equipment to determine nutrient requirements and to apply precisely those materials as determined by the data. This reduces excess application of fertilisers and minimises nutrient deficiencies that may be neglected in a less rigorous fertiliser application plan.

Genetic research has developed crop varieties that increase yields without requiring comparable increases in fertiliser requirements. New strains of crops are also being developed that are resistant to insects and specific herbicides and have increased nutritional value for people and animals.

### DID YOU KNOW?

***Nitrogen is an essential element which is needed in large quantities for plant growth. It is required for the formation of proteins, chlorophyll and nucleic acids. Plants suffering from nitrogen deficiency become stunted with yellow leaves.***

# General suggestions for applying lime and fertiliser

***Soil pH***

There is a correct soil pH range for all plants. When the soil pH is either below or above this range, nutrient uptake is reduced and plant performance is hurt. Therefore apply only the recommended amounts of lime (to increase the soil pH) or sulfur (to lower the soil pH).

***Nitrogen***

1. Do not apply much more than is recommended. Excess N makes plants more succulent and susceptible to disease.

2. Too little N reduces plant vigour and growth, and reduces the uptake of most other nutrients.

3. Grasses (don't forget that maize is also a grass) tend to need more N than other plants. However, where possible, it is usually best to split the total N recommendation into multiple, smaller applications spaced throughout the growing season.

***Potassium, magnesium, and calcium***

1. These three elements tend to compete with each other for uptake by the plant. An excess of one can suppress the uptake of the others.

2. Calcium (Ca) and magnesium (Mg) are contained in lime, so most soils with a pH between 6.0 and 7.0 will have adequate amounts for plant growth. However, acid-loving plants such as rhododendrons, azaleas, some conifers, blueberries, and others may need Ca or Mg from fertiliser sources, since lime may not be an option.

3. Application rates that are significantly higher than the recommended dosage have the potential for causing salt damage to the plants. This is true especially for potassium fertilisers.

***This material was obtained from the website www.spectrumanalytical.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Spectrumnanalytical. com. 2010. Fertiliser and lime applications. [Online]. Available: http://www. spectrumanalytic.com/support/library/ff/Fertiliser _ lime _ calculations.htm [1 July 2010].***

## DID YOU KNOW?

***Foliar feeding is the spraying of a water soluble fertiliser onto the leaves of a plant and is an alternative source of nutrition for the plant.***

***Healthy cabbage plants***

***Peaches***

The acidifying effect of fertilisers can be neutralised through the application of lime. Some fertilisers, such as urea, initially raise the pH of the soil, but the longer term effect is an increase in soil acidity.

***Liquid vs Solid?***

Liquid and solid fertilisers serve different purposes so you need to know what you want to achieve before your select your fertiliser.

The purpose of liquid fertilisers is to provide direct nourishment for your plants, not to provide the soil with micro organisms. Types of potent liquid fertilisers include fish, kelp, or seaweed emulsion and compost or manure 'tea'. Liquid fertilisers provide a quick nutrient boost and stimulate fast plant growth, but they are a temporary measure.

The purpose of solid fertilisers is to provide nourishment for the microherd, the soil organisms that drive your soil's life processes, not the plants. Consequently, solid organic fertilisers are called 'slow release' because it is the action of the microherd that breaks them down and releases the nutrients in a form the plants can use. Solid fertilisers provide slow, steady growth, which is the best kind for sturdy, healthy plants.

***This material was obtained from the website www.bettergardeningtips. com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Rossi, C. 2009. Hydroponics gardening. [Online]. Available: http://www.examiner.com/x-49165-SF-East-Bay-Organic-Gardening-Examiner~y2010m6d8-Fertiliser-facts-liquid-or-solid [1 July 2010].***

# F11 FERTILISERS

## FROM ROCKS TO FERTILISERS

CHEMICAL INDUSTRIES
RESOURCE PACK

## Nitrophosphate process

The nitrophosphate process (also known as the Odda process) was a method for the industrial production of nitrogen fertilisers invented by Erling Johnson in the city of Odda, Norway, around 1927.

The process involves acidifying phosphate rock with nitric acid to produce a mixture of phosphoric acid and calcium nitrate.

$Ca_3(PO_4)_2 + 6HNO_3 \rightarrow 2H_3PO_4 + 3Ca(NO_3)_2$

The mixture is cooled to below zero degrees Celsius, where the calcium nitrate crystallises and can be separated from the phosphoric acid.

The resulting calcium nitrate is used as nitrogen fertiliser. The filtrate is composed mainly of phosphoric acid with some nitric acid and traces of calcium nitrate, and this is neutralised with ammonia to produce a compound fertiliser.

$Ca(NO_3)_2 + 4H_3PO_4 + 8NH_3 \rightarrow CaHPO_4 + 2NH_4NO_3 + 3(NH_4)_2HPO_4$

If potassium chloride or potassium sulfate is added, the result will be NPK fertiliser. The process was an innovation at the time, requiring neither the expensive sulfuric acid nor producing gypsum waste.

As already mentioned, the calcium nitrate can be worked up as calcium nitrate fertiliser, but often it is converted into ammonium nitrate and calcium carbonate using carbon dioxide and ammonia.

$Ca(NO_3)_2 + 2NH_3 + CO_2 + H_2O \rightarrow 2NH_4NO_3 + CaCO_3$

Both products can be worked up together as straight nitrogen fertiliser. Although Johnson created the process while working for the Odda Smelteverk, his company never employed it. Instead, it licensed the process to Norsk Hydro, BASF, Hoechst, and DSM. Each of these companies used the process, introduced variations, and licensed it to other companies. Today, only Yara (Norsk Hydro), BASF, AgroLinz, and GNFC still use the Odda process. Due to the alterations of the process by the various companies who employed it, the process is now generally referred to as the nitrophosphate process.

***This material was obtained from Wikipedia. Learners - if you use any part ofit you need to write it in your own words and include the following in yourreference list: Wikipedia. 2010. Nitrophosphate process. [Online]. Available:http://en.wikipedia.org/wiki/Nitrophosphate _ process. [1 July 2010].***

## Sulfur

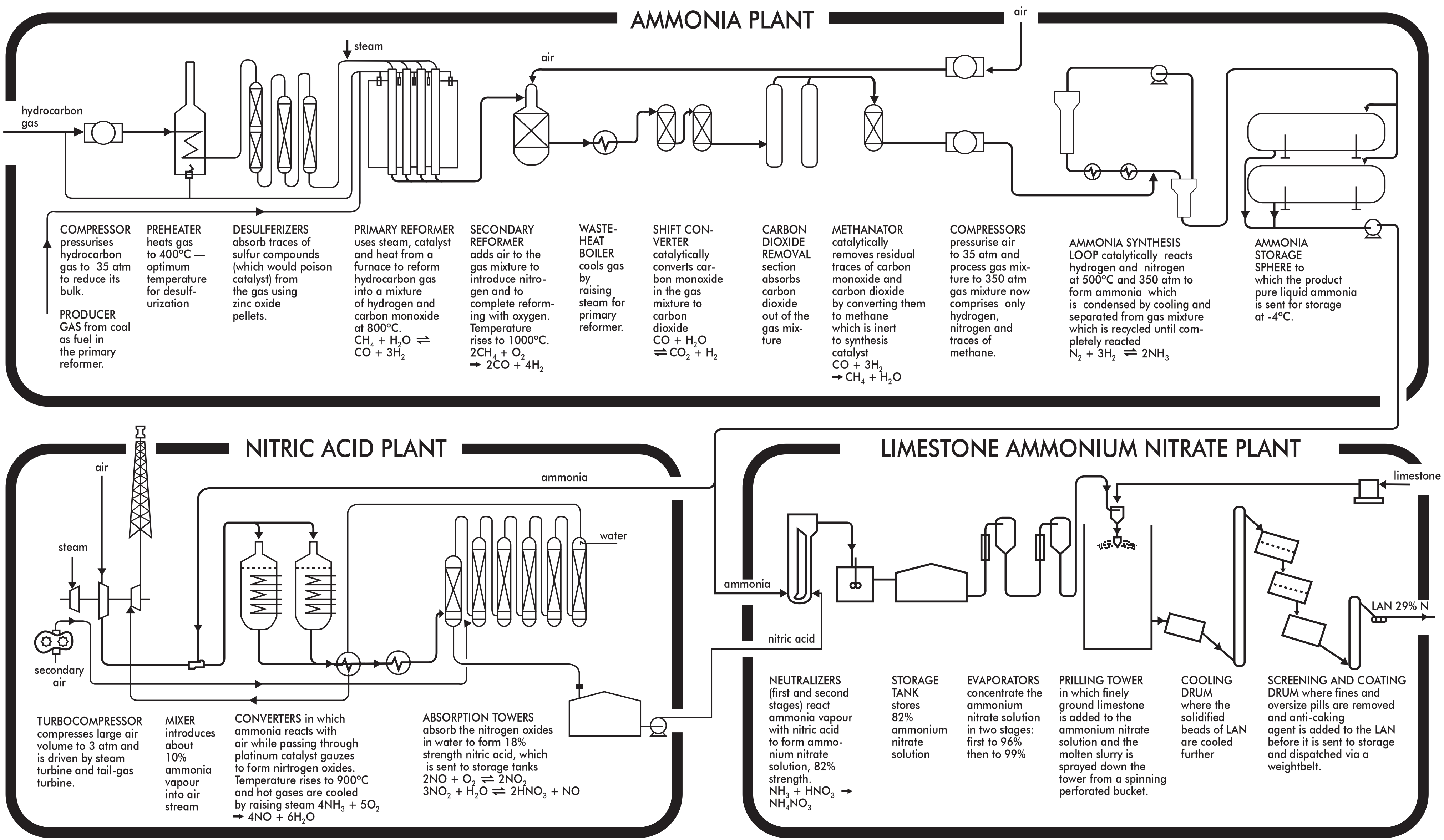
Sulfur is significant to agriculture in two ways - as a plant nutrient and for its importance to the processing of phosphate rock into phosphate fertilisers. In the past 20 years, sulfur has been increasingly recognised as an essential ingredient for plant nutrition because it is a component of amino acids, proteins, fats, and other compounds found in plants. The increased use of fertilisers that contain little or no sulfur and the decrease in atmospheric sulfur deposition from industrial emissions have resulted in lower soil sulfur content and increasing soil sulfur deficiencies worldwide. Sulfur for plant nutrition can be applied directly as elemental sulfur, sulfur-bentonite mixes, ammonium sulfate, potassium sulfate, or superphosphates. Nearly 60 percent of all sulfur consumption is in the production of phosphate fertilisers. Nearly 10 percent of additional consumption is used in other agricultural applications, including the production of nitrogenous fertilisers and plant nutrient sulfur. The largest sources of elemental sulfur are petroleum refining and natural gas processing at numerous facilities.

***This material was obtained from the United States Geological Survey Fact Sheet 155-99. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Jasinski, S. M.; Kramer, D. A.; Ober, J. A.; Searls, J. P. 1999. Fertilizers ▯ Sustaining Global Food Supplies. [Online]. Available: http://pubs.usgs.gov/fs/fs155-99/fs155-99.html [1 July 2010].***

### Sulfur powder

### Roll sulfur

*Source: Serpens & Wikimedia Commons*


AMMONIA PLANT
hydrocarbon gas
steam
air
air
COMPRESSOR pressurises hydrocarbon gas to 35 atm to reduce its bulk.
PRODUCER GAS from coal as fuel in the primary reformer.
PREHEATER heats gas to 400°C — optimum temperature for desulf-urization
DESULFERIZERS absorb traces of sulfur compounds (which would poison catalyst) from the gas using zinc oxide pellets.
PRIMARY REFORMER uses steam, catalyst and heat from a furnace to reform hydrocarbon gas into a mixture of hydrogen and carbon monoxide at 800°C. $CH_4 + H_2O \rightleftharpoons CO + 3H_2$
SECONDARY REFORMER adds air to the gas mixture to introduce nitro-gen and to complete reform-ing with oxygen. Temperature rises to 1000°C. $2CH_4 + O_2 \rightarrow 2CO + 4H_2$
WASTE-HEAT BOILER cools gas by raising steam for primary reformer.
SHIFT CON-VERTER catalytically converts car-bon monoxide in the gas mixture to carbon dioxide $CO + H_2O \rightleftharpoons CO_2 + H_2$
CARBON DIOXIDE REMOVAL section absorbs carbon dioxide out of the gas mix-ture
METHANATOR catalytically removes residual traces of carbon monoxide and carbon dioxide by converting them to methane which is inert to synthesis catalyst $CO + 3H_2 \rightarrow CH_4 + H_2O$
COMPRESSORS pressurise air to 35 atm and process gas mix-ture to 350 atm gas mixture now comprises only hydrogen, nitrogen and traces of methane.
AMMONIA SYNTHESIS LOOP catalytically reacts hydrogen and nitrogen at 500°C and 350 atm to form ammonia which is condensed by cooling and separated from gas mixture which is recycled until com-pletely reacted $N_2 + 3H_2 \rightleftharpoons 2NH_3$
AMMONIA STORAGE SPHERE to which the product pure liquid ammonia is sent for storage at -4°C.
NITRIC ACID PLANT
air
steam
secondary air
ammonia
water
TURBOCOMPRESSOR compresses large air volume to 3 atm and is driven by steam turbine and tail-gas turbine.
MIXER introduces about 10% ammonia vapour into air stream
CONVERTERS in which ammonia reacts with air while passing through platinum catalyst gauzes to form nirtrogen oxides. Temperature rises to 900°C and hot gases are cooled by raising steam $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
ABSORPTION TOWERS absorb the nitrogen oxides in water to form 18% strength nitric acid, which is sent to storage tanks $2NO + O_2 \rightleftharpoons 2NO_2$ $3NO_2 + H_2O \rightleftharpoons 2HNO_3 + NO$
LIMESTONE AMMONIUM NITRATE PLANT
limestone
ammonia
nitric acid
LAN 29% N
NEUTRALIZERS (first and second stages) react ammonia vapour with nitric acid to form ammo-nium nitrate solution, 82% strength. $NH_3 + HNO_3 \rightarrow NH_4NO_3$
STORAGE TANK stores 82% ammonium nitrate solution
EVAPORATORS concentrate the ammonium nitrate solution in two stages: first to 96% then to 99%
PRILLING TOWER in which finely ground limestone is added to the ammonium nitrate solution and the molten slurry is sprayed down the tower from a spinning perforated bucket.
COOLING DRUM where the solidified beads of LAN are cooled further
SCREENING AND COATING DRUM where fines and oversize pills are removed and anti-caking agent is added to the LAN before it is sent to storage and dispatched via a weightbelt.

# F12 FERTILISERS

ENVIRONMENTAL ISSUES

## Eutrophication

Eutrophication is the enrichment of an ecosystem with chemical nutrients, normally by compounds that contain nitrogen or phosphorus. Eutrophication is considered a form of pollution because it promotes plant growth, favouring certain species over others. Health-related problems can also occur if eutrophic conditions interfere with the treatment of drinking water.

When a system is enriched with nitrogen, plant growth is rapid. When the number of plants increases in an aquatic system, they can block light from reaching deeper. Plants also consume oxygen for respiration, and if the oxygen content of the water decreases too much, this can cause other organisms such as fish to die.

Agricultural runoff which makes its way into the water supply of an area results in eutrophication, which may cause the uncontrollable growth of algae. This is called an algal bloom. These blooms can discolour the water, clog fish gills, or even be toxic, and can accumulate in the food chain. Despite the impacts, there are a number of ways of preventing eutrophication from taking place. Cleanup measures can directly remove the excess nutrients such as nitrogen and phosphorus from the water. Creating buffer zones near farms, roads and rivers can also help. These act as filters and cause nutrients and sediments to be deposited there instead of in the aquatic system. Laws relating to the treatment and discharge of sewage can also help to control eutrophication.

A final possible intervention is nitrogen testing and modelling. By assessing exactly how much fertiliser is needed by crops and other plants, farmers can make sure that they only apply just enough fertiliser. This means that there is no excess to run off into neighbouring streams during rain. There is also a cost benefit for the farmer as unnecessary fertilisers are not added.

***This material was obtained from the Free High School Science Text (FHSST) project. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: FHSST. 2008. Chapter 23 The Chemical Industries. [Online]. Available: www.fhsst.org. [1 July 2010].***

## Eutrophication of fresh water

***Source: Research Group of Wastewater Treatment and Purification***

# Soil degradation

Soil degradation is when soil deteriorates because of human activity and loses its quality and productivity. It happens when soil loses its nutrients, or its organic matter. It also happens when the soil structure breaks down, or if the soil becomes toxic from pollution. Simply, it is the breakdown of soil particles.

Degradation is not the same as soil erosion, which is when the soil is washed or blown away by water or wind. Soil erosion is common when trees are cut down, and then it rains, so the soil is moved somewhere else (sometimes to the sea/ocean/river). Trees and their root systems keep the soil in place and thus prevent soil erosion.

***This material was obtained from Wiki Answers. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: Wiki.Answers.com. 2010. What is soil degradation? [Online]. Available: http://wiki.answers.com/Q/What _ is _ soil _ degradation. [1 July 2010].***

***Topsoil as well as farm fertilisers and other potential pollutants run off unprotected farm fields when heavy rains occur.***

***Source: Wikimedia Commons***

# Studying Fertilisers to Cut Greenhouse Gases

**November 18, 2009 By Dennis O'Brien**

Agricultural Research Service (ARS) scientists have found that using alternative types of fertilisers can cut back on greenhouse gas emissions, at least in one part of the country. They are currently examining whether the alternatives offer similar benefits nationwide.

Nitrogen fertilisers are often a necessity for ensuring sufficient crop yields, but their use leads to release of nitrous oxide, a major greenhouse gas, into the atmosphere. Fertiliser use is one reason an estimated 78 percent of the nation's nitrous oxide emissions come from agriculture, according to Ardell Halvorson, a soil scientist at the ARS Soil Plant Nutrient Research Laboratory.

Halvorson compared nitrous oxide emissions from maize fields treated with either a conventional nitrogen fertiliser (urea) or either of two specially formulated urea fertilisers—one with "controlled release" polymer-coated pellets, and the other with inhibitors added to "stabilise" the urea to keep more of it in the soil as ammonium for a longer period.

In a two-year experiment at Fort Collins, he collected the emissions using static vented chambers, similar to small "pillbox" structures placed over the soil. He chose a "no-till cropping system" because it is known to reduce carbon dioxide emissions. He found that the controlled-release fertiliser cut nitrous oxide emissions by a third, and that the stabilised fertiliser cut them almost in half.

***This news article was obtained from the website www.physorg.com. Learners - if you use any part of it you need to write it in your own words and include the following in your reference list: O'Brian, D. 2009. Studying fertilisers to cut greenhouse gases. [Online]. Available: http://www.physorg.com/news177778629.html. [1 July 2010].***