

TNPSC Chemistry Study Material Fertilizers

A **fertilizer** is any material of natural or synthetic origin (other than liming materials) that is applied to soils or to plant tissues to supply one or more plant nutrients essential to the growth of plants. Many sources of fertilizer exist, both natural and industrially produced.

Three main macronutrients:

1. **Nitrogen (N):** leaf growth
2. **Phosphorus (P):** Development of roots, flowers, seeds, fruit;
3. **Potassium (K):** Strong stem growth, movement of water in plants, promotion of flowering and fruiting;

Three secondary macronutrients:

1. **Calcium (Ca)**
2. **Magnesium (Mg)**
3. **Sulfur (S)**

Micronutrients:

- **Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Zinc (Zn), Boron (B).** Of occasional significance are **Silicon (Si), Cobalt (Co), and Vanadium (V).**

Plants are made up of four main elements:

- **Hydrogen, oxygen, carbon, and nitrogen.** Carbon, hydrogen and oxygen are widely available as water and carbon dioxide.
- Although **nitrogen** makes up most of the **atmosphere**, it is in a form that is unavailable to plants.

Nitrogen

- **Nitrogen** is the most important fertilizer since nitrogen is present in **proteins, DNA and other components (e.g., chlorophyll).**
- To be nutritious to plants, nitrogen must be made available in a "fixed" form.
- Only some bacteria and their host plants (notably legumes) can fix **atmospheric nitrogen(N₂)** by **Converting it to ammonia.**

Phosphate:

- **Phosphate** is required for the production of **DNA** and **ATP**, the main energy carrier in cells, as well as certain lipids.
- **Micronutrients** are consumed in smaller quantities and are present in plant tissue on the order of parts-per-million (ppm), ranging from **0.15 to 400 ppm DM**, or less than **0.04% DM**.

Fertiliser	Formula	Essential elements	Acid	Alkali
Ammonium nitrate	NH_4NO_3	nitrogen	nitric acid	ammonia
Ammonium phosphate	$(\text{NH}_4)_3\text{PO}_4$	nitrogen and phosphorus	phosphoric acid	ammonia
Ammonium sulfate	$(\text{NH}_4)_2\text{SO}_4$	nitrogen	sulfuric acid	ammonia
Urea	$(\text{NH}_2)_2\text{CO}$	nitrogen		
Potassium nitrate	KNO_3	potassium and nitrogen	nitric acid	potassium hydroxide

Classification:

- Fertilizers are classified in several ways.
- They are classified according to whether they provide a **Single Nutrient** (e.g., **K, P, or N**), in which case they are classified as "**Straight Fertilizers**", "**Multinutrient Fertilizers**" (or "**complex fertilizers**") provide two or more nutrients, for example N and P.

Single nutrient fertilizers:

- The main nitrogen-based straight fertilizer is **ammonia** or its solutions.
- Ammonium nitrate** (NH_4NO_3) is also widely used.
- Urea** is another popular source of nitrogen, having the advantage that it is solid and non-explosive, unlike ammonia and ammonium nitrate, respectively.
- A few percent of the nitrogen fertilizer market (4% in 2007) has been met by **calcium ammonium nitrate** ($\text{Ca}(\text{NO}_3)_2 \cdot \text{NH}_4\text{NO}_3 \cdot 10\text{H}_2\text{O}$).
- The main straight **phosphate fertilizers** are the **superphosphates**.
- "**Single superphosphate**" (SSP) consists of **14–18% P_2O_5** , again in the form of **$\text{Ca}(\text{H}_2\text{PO}_4)_2$** , but also **phosphogypsum** ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$).
- Triple superphosphate** (TSP) typically consists of **44-48% of P_2O_5** and no gypsum.

Multinutrient fertilizers:

- These fertilizers are the most common. They consist of two or more nutrient components.

Binary (NP, NK, PK) fertilizers:

- Major two-component fertilizers provide both nitrogen and phosphorus to the plants. These are called **NP fertilizers**.
- The main NP fertilizers are **monoammonium phosphate (MAP)** and **diammonium phosphate (DAP)**.
- The active ingredient in **MAP** is **$\text{NH}_4\text{H}_2\text{PO}_4$** .
- The active ingredient in **DAP** is **$(\text{NH}_4)_2\text{HPO}_4$** .
- About 85% of MAP and DAP fertilizers are soluble in water.

NPK fertilizers:

- NPK fertilizers are three-component fertilizers providing **nitrogen, phosphorus, and potassium**.
 - NPK rating is a rating system describing the amount of nitrogen, phosphorus, and potassium in a fertilizer.
 - **NPK ratings consist of three numbers**(e.g., 10-10-10 or 16-4-8) describing the chemical content of fertilizers.
1. The first number represents the percentage of **nitrogen** in the product
 2. The second number, **P₂O₅**.
 3. The third, **K₂O**.
- Fertilizers do not actually contain P₂O₅ or K₂O, but the system is a conventional shorthand for the amount of the phosphorus (P) or potassium (K) in a fertilizer.
 - Most fertilizers are labeled according to this **N-P-K convention**, although **Australian convention, following an N-P-K-S system**, adds a fourth number for **sulfur**, and uses elemental values for all values including P and K.

Micronutrients:

- The main micronutrients are **molybdenum, zinc, and copper**.
- These elements are provided as **water-soluble salts**.
- Iron presents special problems because it converts to insoluble (bio-unavailable) compounds at moderate soil pH and phosphate concentrations.
- The micronutrient needs depend on the plant.
- **For example**, sugar beets appear to require boron, and legumes require cobalt.

Country	Total Nitrogen use	Amt. used for feed/pasture
China	18.7	3
India	11.9	N/A
U.S.	9.1	4.7
France	2.5	1.3
Germany	2	1.2
Brazil	1.7	0.7
Canada	1.6	0.9
Turkey	1.5	0.3
UK	1.3	0.9
Mexico	1.3	0.3
Spain	1.2	0.5
Argentina	0.4	0.1

- **Nitrogen fertilizers** are made from ammonia (NH_3), which is sometimes injected into the ground directly. The ammonia is produced by the **Haber-Bosch process**.
- In this energy-intensive process, **natural gas** (CH_4) usually supplies the hydrogen, and the **nitrogen** (N_2) is derived from the air.
- This ammonia is used as a feedstock for all other nitrogen fertilizers, such as **anhydrous ammonium nitrate** (NH_4NO_3) and **urea** ($\text{CO}(\text{NH}_2)_2$).

Phosphate fertilizers:

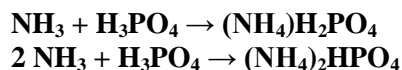
- The most popular phosphate-containing minerals are referred to collectively as phosphate rock.
- The main minerals are **fluorapatite** $\text{Ca}_5(\text{PO}_4)_3\text{F}$ (CFA) and **hydroxyapatite** $\text{Ca}_5(\text{PO}_4)_3\text{OH}$.
- These minerals are converted to **water-soluble phosphate salts** by treatment with **sulfuric** (H_2SO_4) or **phosphoric acids** (H_3PO_4).

Potassium fertilizers:

- **Potash** is a mixture of **potassium minerals** used to make potassium (chemical symbol: K) fertilizers.
- Potash is soluble in water, so the main effort in producing this nutrient from the ore involves some purification steps; e.g., to remove **sodium chloride** (NaCl) (**common salt**).
- Sometimes **potash** is referred to as K_2O , as a matter of convenience to those describing the potassium content.
- In fact potash fertilizers are usually **potassium chloride**, **potassium sulfate**, **potassium carbonate**, or **potassium nitrate**.

Compound fertilizers:

- **Compound fertilizers, which contain N, P, and K**, can often be produced by mixing straight fertilizers.
- In some cases, chemical reactions occur between the two or more components. For example, **monoammonium and diammonium phosphates**, which provide plants with both N and P, are produced by neutralizing phosphoric acid (from phosphate rock) and ammonia :



Organic fertilizers:



- **“Organic fertilizers”** can describe those fertilizers with an organic — biologic — origin—that is, fertilizers derived from living or formerly living materials.
- The **“organic fertilizer”** products typically contain both some organic materials as well as acceptable additives such as **nutritive rock powders, ground sea shells (crab, oyster, etc.), other prepared products such as seed meal or kelp, and cultivated microorganisms and derivatives.**