Lecture 21

Triple Superphosphate

Triple superphosphate is a fertilizer produced by the action of concentrated phosphoric acid on ground phosphate rock. The active ingredient of the product, monocalcium phosphate, is identical to that of superphosphate, but without the presence of calcium sulfate that is formed if sulfuric acid is used instead of phosphoric acid. The phosphorus content of triple superphosphate (17 - 23% P; 44 to 52% P$_2$O$_5$) is therefore greater than that of superphosphate (7 - 9.5% P; 16 to 22% P$_2$O$_5$). It is produced in granular and nongranular form and is used both in fertilizer blends (with potassium and nitrogen fertilizers) and by itself.

Chemical Properties

Chemical formula: Ca(H2PO4)2•H2O

Fertilizer analysis: 45% P2O5 (0-45-0)

15% Ca

Water-soluble P: Generally >90%

Solution pH 1 to 3

Agricultural Use

TSP has several agronomic advantages that made it such a popular P source for many years. It has the highest P content of dry fertilizers that do not contain N. Over 90% of the total P in TSP is water soluble, so it becomes rapidly available for plant uptake. As soil moisture dissolves the granule, the concentrated soil solution becomes acidic. TSP also contains 15% calcium (Ca), providing an additional plant nutrient.

A major use of TSP is in situations where several solid fertilizers are blended together for broadcasting on the soil surface or for application in a concentrated band beneath the
surface. It is also desirable for fertilization of leguminous crops, such as alfalfa or beans, where no additional N fertilization is needed to supplement biological N fixation.

Management Practices
The popularity of TSP has declined because the total nutrient content (N + P2O5) is lower than ammonium phosphate fertilizers such as monoammonium phosphate, which by comparison contains 11% N and 52% P2O5. Costs of producing TSP can be higher than ammonium phosphates, making the economics for TSP less favorable in some situations.

All P fertilizers should be managed to avoid losses in surface water runoff from fields. Phosphorus loss from agricultural land to adjacent surface water can contribute to undesired stimulation of algae growth. Appropriate nutrient management practices can minimize this risk.

The figure below shows the block flow diagram for manufacturing of triple superphosphate. This type of fertilizers is much more concentrated than the ordinary superphosphate, containing 45-46 % of available P2O5. Triple superphosphate is manufactured by the action of phosphoric acid on phosphate rock. The main reaction is:

\[
\text{CaF}_2 \cdot 3\text{Ca}_3(\text{PO}_4)_2 + 14\text{H}_3\text{PO}_4 \rightarrow 10\text{Ca(H}_2\text{PO}_4)_2 + 2\text{HF} \uparrow
\]

(Phosphate Rock) (Triple Superphosphate)

A process similar to single superphosphate production is used, in which pulverized phosphate rock is mixed with phosphoric acid in a two-stage reactor. The resultant slurry is sprayed into the granulator. The slurry is sprayed into the drum granulation co-current with flue gases of fired fuel (natural gas or fuel oil and air). The product is screened and off-size is recycled back to the granulator. The on-size product is cooled and stored ready for being bagged. The exhaust gases from the reactor, granulator and cooler are scrubbed to remove fluoric compounds.
Process Flow Diagram for Triple Superphosphate Manufacturing

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Operations</th>
<th>Outputs</th>
</tr>
</thead>
</table>
| Phosphate Rock | Crushing, Grinding & Screening | Noise
Dust & Particulates |
| Phosphoric Acid | Two-Stage Reaction | HF, SiF₄ emissions (to scrubber) |
| Water | Granulation | Water Vapor
Particulates
Emissions (HF, SiF₄) (to scrubber)
Combustion flue gases |
| Recycled over & under size Burners (direct heat) | Screening | Particulates |
| Cold Air | Cooling | Cooling water (to cooling towers) |
| Polyethylene bags | Storage & Bagging | Emissions (HF, SiF₄)
Particulates |

Granulated Triple Superphosphate