Incorporating Micronutrients to NPK Fertilizers

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How Plants Obtain Nutrients

- Nutrients Obtained from Air and Water
  - Water, CO_2
- Primary Nutrients Obtained from the Soil
  - Nitrogen, Phosphorus, Potassium
- Secondary Nutrients from the Soil
  - Calcium, Magnesium, Sulfur
- Micronutrients Mostly from the Soil
  - Zinc, Boron, Manganese, Iron, Copper, Molybdenum, Selenium, Chlorine, Nickel

Different Origins of Micronutrients Used by Plants

- Naturally occurring in the soil
- Recycled plant residue
- Industrial pollution (acid rain, for example)
- Airborne dust from volcanoes
- Industrial byproducts and wastes
- Present in water
- Industrially manufactured from minerals or basic elements
- Produced from seaweed

Application of Micronutrients to Crops

- Directly applied to plants or soil
- Premixed with manure or mulch
- Premixed with fertilizers
- Applied on seeds

Typical Sources of Boron and Copper

Boron:

H_3BO_3 $Na_2B_4O_7 \bullet 5H_2O$ $Na_2B_4O_7 \bullet 10H_2O$

$Ca_2B_6O_{11} \bullet 5H_2O$ $Na_2B_8O_{13} \bullet 4H_2O$

Copper:

$CuSO_4 \bullet 5H_2O$ CuO $CuCO_3$

Soluble Slightly Soluble Variable Insoluble

Typical Sources of Iron and Manganese

Iron:

$FeSO_4 \bullet 7H_2O$ $FeSO_4 \bullet H_2O$ $FeCO_3$

FeHEDTA FeEDDHA

Manganese:

$MnSO_4 \bullet 4H_2O$ MnO $MnCO_3$ Mn oxysulfate

Soluble Slightly Soluble Variable Insoluble

Typical Sources of Molybdenum and Zinc

Molybdenum:

$Na_2MoO_4 \bullet 2H_2O$ $(NH_4)_2MoO_4$ MoO_3

$(NH_4)_6Mo_7O_{24} \bullet 4H_2O$

Zinc:

$ZnSO_4 \bullet H_2O$ $ZnSO_4 \bullet 7H_2O$ $ZnSO_4 - NH_3$ complex

ZnO $ZnCO_3$ Zn oxysulfate ZnEDTA

Soluble Slightly Soluble Variable Insoluble

Synthetic Chelates

- Formed by combining a chelating agent with a metal through coordinating bonds.
- They maintain the micronutrient in chelated form and impede their reaction with other cations in the soil.
- Mostly used in fluid fertilizers for direct application, drip irrigation, and foliar application.

Main Chelating Agents

- EDTA – ethylene diamine tetraacetic acid
- DTPA – diethylene triamine pentaacetic acid
- EDDHA [o,o] – ethylene diamine-di-(o-hydroxy phenil acetic acid
- EDDHA [o,p] – ethylene diamine-N-(o-hydroxy phenil acetic acid)-N'-(p-hydroxy phenil acetic acid)
- HEEDTA – 2-hydroxyl ethyl ethylene diamine triecetic acid
- EDDHMA [o,o] – ethylene diamine-di-(o-hydroxy-o-methylphenyl acetic acid)
- EDDHMA [o,p] – ethylene diamine-di-(o-hydroxy-p-methylphenyl acetic acid)
- EDDHMA [p,o] – ethylene diamine-di-(p-hydroxy-o-methylphenyl acetic acid)
- EDDCHA [2,4] – ethylene diamine-di-(2-hydroxy-4-carboxyphenyl acetic acid)
- EDDCHA [2,5] – ethylene diamine-di-(2-carboxy-5-hydroxyphenyl acetic acid)
- EDDCHA [5,2] – ethylene diamine-di-(5-carboxy-2-hydroxyphenyl acetic acid)

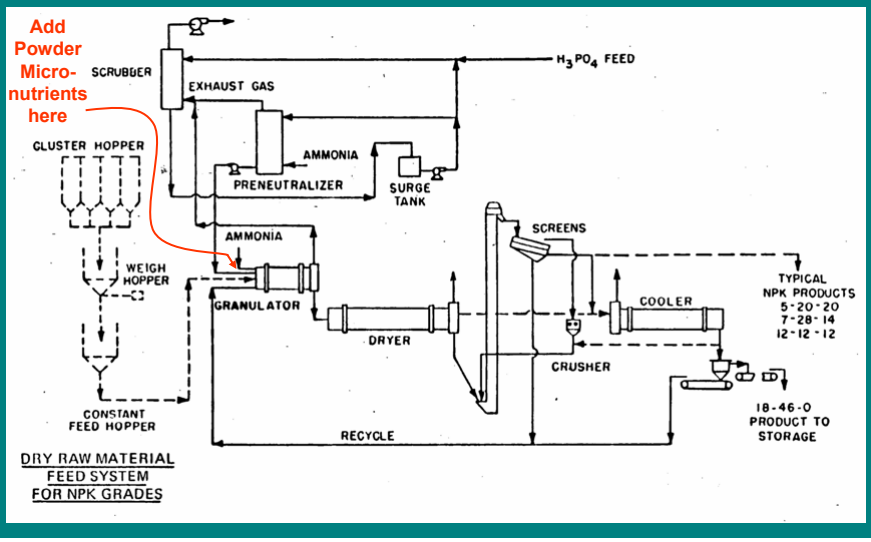
Relative Cost of Micronutrients

- Powdered oxides are usually the least expensive form of micronutrients.
- Granular oxides are usually about 20% more expensive as powdered oxides.
- Granular sulfates are somewhat over twice as expensive as powdered oxides.
- Organic chelates are about 10 times as expensive as powdered oxides.
- EDTA and other chelates are up to 20 to 40 times as expensive as powdered oxides.

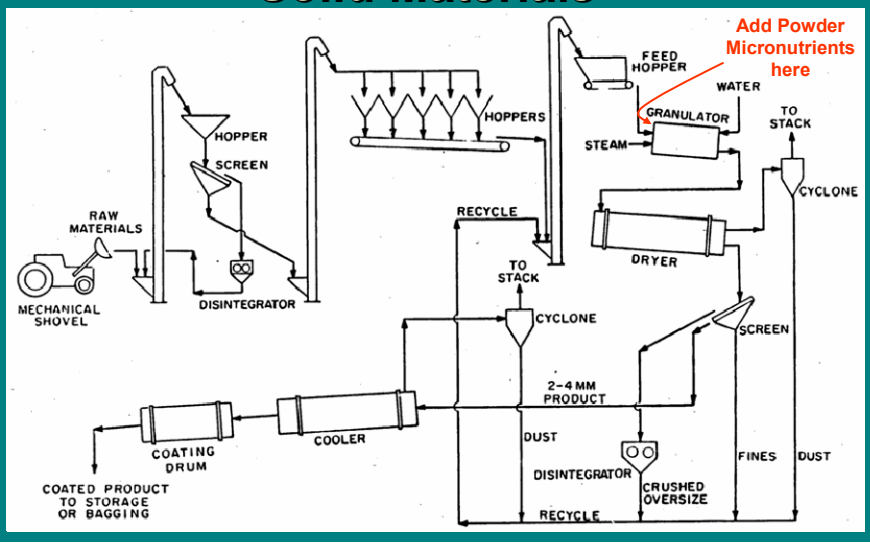
Incorporation of Micronutrients into Solid NPK Fertilizers

- Introducing the micronutrients into the NPK material before it is granulated.
- Blending a granular form of the micronutrients with the rest of the NPK materials.
- Preparing an intermediate product with high content of micronutrients, and blending it with the NPK materials.
- Coating the finished blended NPK materials with a liquid or solid form of the micronutrients.

Unit for Granulating NPKs Through Chemical Reactions



Unit for Granulating NPKs from Solid Materials



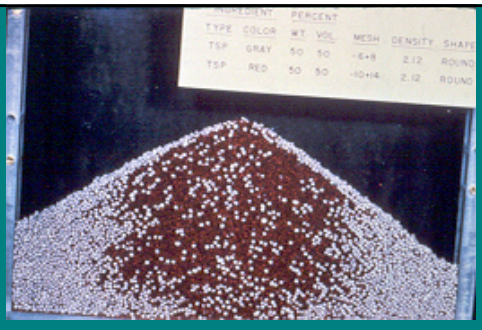
Care Should Be Taken To Avoid Reactions During Production

Some reactions between the micronutrient components added and the acids or other materials present may render some of the nutrients or micronutrients unusable.

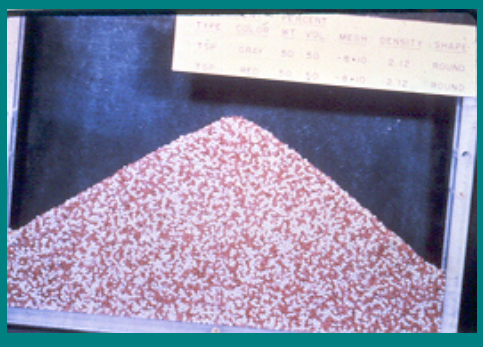
Making Bulk Blends With Micronutrients

It is important, and necessary, that the micronutrients be incorporated in granules of the same size as that of the fertilizer materials. If not, segregation will take place and separate the materials.

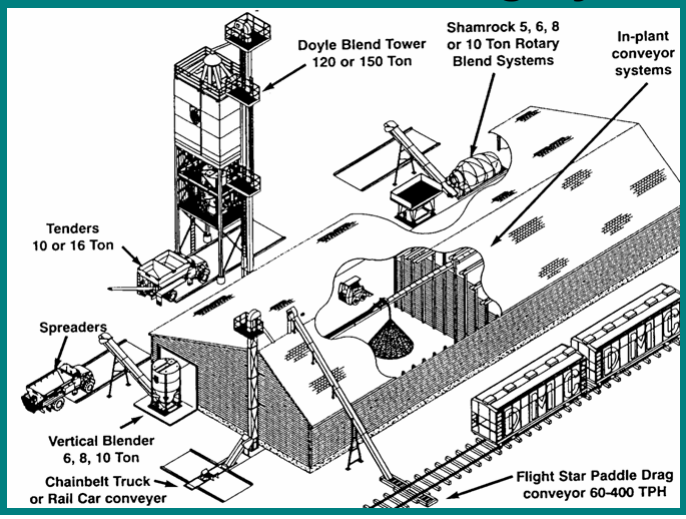
Segregation due to different particle size of materials (the dark material is smaller)



No segregation takes place when all particles have a similar size



Plant Using a Vertical Tower Blending System



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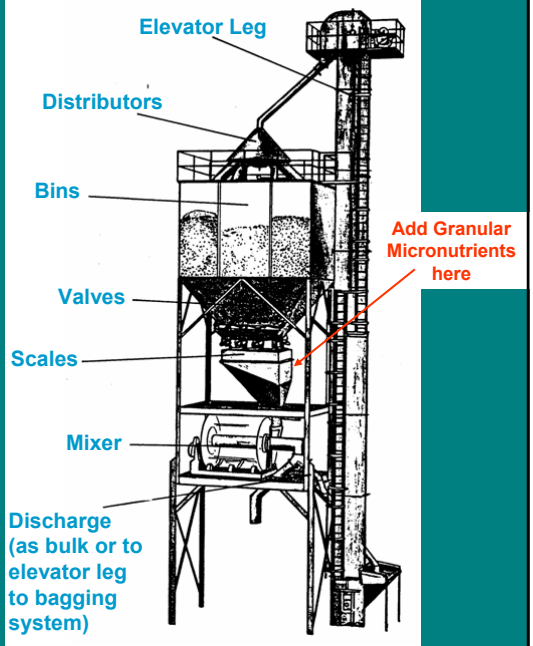
Vertical Tower Blending System



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Vertical Tower Blending Systems

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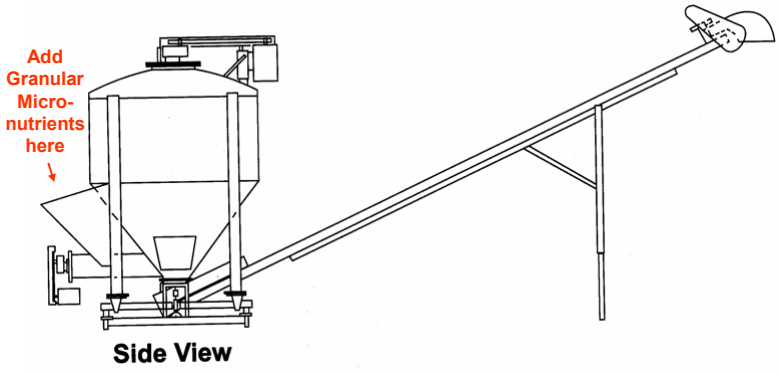
Horizontal Blending System With Vertical Auger Blender



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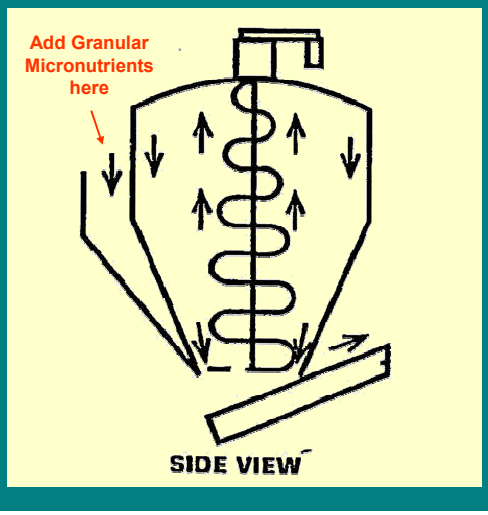
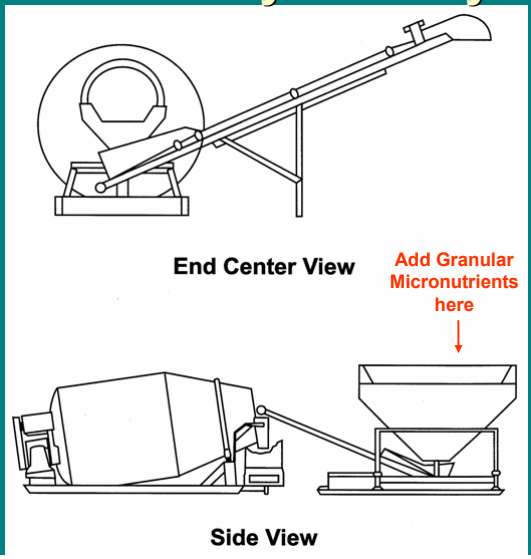
Vertical Auger Blender



Tapered Vertical Auger Blender

Horizontal Blend System With Concrete Mixer-Style Rotary Blender



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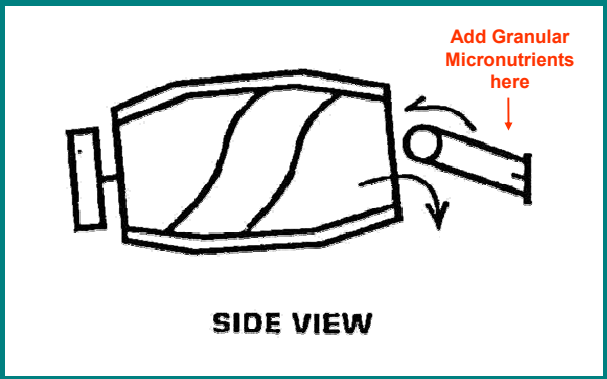
Concrete Mixer-Style Rotary Blender



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Concrete Mixer-Style Rotary Blender

Another Possible Problem in Making Blends with Micronutrients

If the proportion of granules containing micronutrients is small, even if the fertilizer is well distributed when applied, only a small portion of the plants in the field will have access to the micronutrients and a large portion of the plants in the field will not. Because of this, in many cases it is best to coat all the granules.

Coating of the Fertilizer Granules

Coating the fertilizer granules provides an even distribution of the micronutrient material on all the granules.

The sources of micronutrients are usually substances classified as harmful or marine pollutants

Many of the materials used are classified as:

- Corrosive
- Carcinogenic
- Dangerous for the Environment
- Harmful

According to the EC Directive 67/548/EC

When working with micronutrient substances, it is highly recommended to use:

- Gloves
- Protective Clothing
- Suitable masks to avoid inhaling these materials