AOM 3734: Irrigation Principles and Practices in Florida

CHEMIGATION – CHEMICAL INJECTION CONCENTRATIONS AND RATES

**Stock Chemicals**

Many chemicals used in agriculture are supplied as a percentage by weight of a dry or liquid mixture and initial calculations must be performed to determine how much of the mixture must be used to deliver a certain amount of a specific chemical to the crop.

**Fertilizer Nutrients**

For example, most of the fertilizers are supplied as a mixture of some form of nitrogen, potassium, and phosphorus. Very common ingredients of a mixture are: some form of nitrogen (N), phosphorus oxide (P\(_2\)O\(_5\)), and potash (K\(_2\)O).

Their approximate values are N (14), P (31), O (16), and K (39). Based on these, the equivalent gram molecular weight for each compound can be calculated.

44\% of the weight of P\(_2\)O\(_5\) is P, and 83\% of the weight of K\(_2\)O is K.

**Fertilizer Nutrients**

Atomic weight of P\(_2\)O\(_5\) is approx. 142.

Atomic weight of 2 P is approx. 62.

\[
\frac{62}{142} = 44\% 
\]

Atomic weight of K\(_2\)O is approx 94.

Atomic weight of 2 K is approx 78.

\[
\frac{78}{94} = 83\% 
\]

**N-P-K Analysis**

20-10-15

20\% is N, 10\% is P\(_2\)O\(_5\), 15\% is K\(_2\)O and 55\% is inert or other material.

N is 20\% of the total.

P is 44\% of P\(_2\)O\(_5\), which is 10\% of the total, so P

4.4\% of the total.

K is 83\% of K\(_2\)O which is 15\% of the total, so K

12.5\% of the total.
N-P-K Loading

Supply a field 100 lbs of N per acre using 
20-10-15 source.

\[
\frac{100 \text{ lbs-N/acre}}{0.20 \text{ N/source}} = \frac{500 \text{ lbs-source/acre}}{0.10 \text{ P/O}_2/\text{source}} \\
500 \text{ lbs-source/acre} \times 0.10 \text{ P/O}_2/\text{source} \\
* 0.44 \text{ P/P/O}_2 = 222 \text{ lbs-P/acre} \\
500 \text{ lbs-source/acre} \times 0.15 \text{ K/O}_3/\text{source} \\
* 0.83 \text{ K/K}_2\text{O} = 62 \text{ lbs-K/acre}
\]

Supply a field 50 lbs of P per acre using 
20-10-15 source.

\[
\frac{50 \text{ lbs-P/acre}}{0.10 \text{ P/P/O}_2} = \frac{1136 \text{ lbs-source/acre}}{0.20 \text{ N/source}} \\
1136 \text{ lbs-source/acre} \times 0.10 \text{ P/P/O}_2 \\
* 0.44 \text{ P/P/O}_2 = 227 \text{ lbs-N/acre} \\
1136 \text{ lbs-source/acre} \times 0.15 \text{ K/O}_3/\text{source} \\
* 0.83 \text{ K/K}_2\text{O} = 141 \text{ lbs-K/acre}
\]

Concentrations

Given in percent for solid materials. Typically given in ppm for liquid mixtures.

1 g-chemical / 1,000 L-water =
1 g-chemical / 1,000,000 mL-water =
1 g-chemical / 1,000,000 g-water =
1 ppm

Injection Rates

- The desired chemical concentration after injection into an irrigation is found from

\[
X = \frac{m_1}{m_2}
\]  
(32.1)

- Given that solutions can only be injected into an irrigation system directly (i.e., dry chemical must be mixed with a solvent before injection) the desired chemical concentration is

\[
X = \frac{m_1}{m_1 + m_2}
\]  
(32.2)

- The desired chemical concentration in terms of volumetric flow rate gives

\[
X = \frac{\rho_c Q_c}{\rho_a Q_a + \rho_b Q_b}
\]  
(32.3)

- Solving for the injection rate the equation becomes

\[
Q_c = \frac{\rho_c Q_a X}{\rho_b (C_a - X)}
\]  
(32.4)

- If the desired chemical concentration is given in terms of parts perm million the equation becomes

\[
Q = \frac{\rho_c Q_a X}{\rho_b (10,000 C_a - X)}
\]  
(32.5)
Injection Rates

What is the injection rate necessary to deliver 8 ppm through a irrigation system that deliver water at 1,200 gpm. The stock solution has a density of 10 lbs/gal at 20% concentration.

\[ Q_i = \frac{(8.3 \cdot 1,200 \cdot 8)}{10 \cdot 10,000 \cdot 8} = 0.04 \text{ gpm} \]

Injection Period

Given a chemical supply tank volume, and the injection rate the injection period is simply

\[ t = \frac{V_s}{Q_i} \] \hspace{1cm} (32.6)

Solution Volume – Rate Basis

How long would it take to empty 150 gallon tank when the injection rate is 6.67 gpm?

\[ V_s = Q_i \cdot t \]

\[ t = \frac{V_s}{Q_i} \]

\[ t = 150 \text{ gal} / 6.67 \text{ gpm} = 22.5 \text{ min} \]

Lateral Travel Time

The time the irrigation system should remain on after the supply tank has been emptied is given from

\[ T = \frac{\pi l^2}{4Q_i} \left( \frac{l}{Q_i} (0.577 + \ln n) \right) \] \hspace{1cm} (32.7)

Flushing velocity

- The flushing velocity must be a maintainable 1 fps at the end of an open lateral, in order to flush out any remaining chemical along the lateral. At 2 fps and all grit and sand would be removed through the lateral as well, though is harder to maintain.