the Rain events

COMPOST:
A SOURCE OF NUTRIENTS?

Finding the root cause behind elevated Total Nitrogen numbers when using compost BMPs.

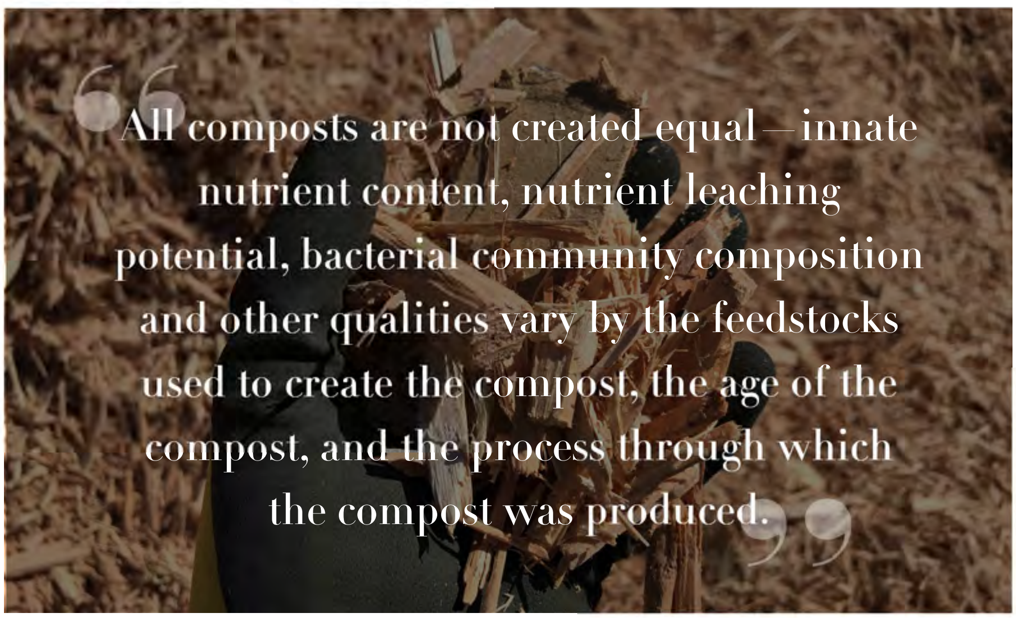
Compost is used by gardeners to create healthy, nutritious soil. But industrial sites all over California use compost to filter storm water runoff. Could this be a problem?

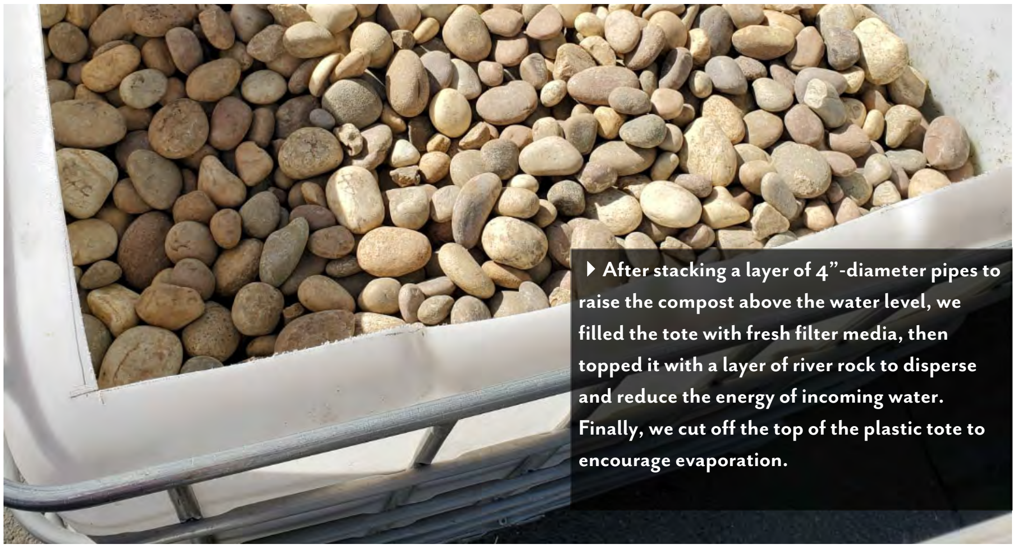
We've used compost socks successfully at many industrial and construction sites to help correct a variety of tough pollution issues. At one particular metal fabrication shop, all storm water is impounded in a series of 10,000 gallon tanks. So to combat elevated metals and nitrates, our team came up with the idea of installing compost socks inside a flow-through tote near the facility outfall. It seemed like a great idea—the compost sock wouldn't impede facility operations, and storm water runoff would be forced through the tank, where pollutants could be removed by the compost filter media. For the first year, that's exactly what happened. But we weren't prepared for the tremendous spike in nitrates that occurred during the second storm season. Not only was the compost failing to remove any nitrates, it appeared to be <u>adding</u> nitrates to our storm water runoff! What is going on, anyway? That's the question we set out to answer.

▸ **What is compost?** Compost is a mixture of organic matter, usually organic waste, that has been decomposed through a process called composting. The end result is a dark brown or black humus-like material that can range in texture from fine dirt to coarse wood chips. Fortunately for us, our friend Craig Kolodge at San Pasqual Valley Soils presented an informative workshop during Storm Water Awareness Week about myths associated with compost nutrient release. After watching the workshop (which you can too at www.stormwaterawareness.org) and talking with Craig, we got a better idea of what is going on.

As an "organic" material, compost is dependent on two natural processes called the carbon cycle and the nitrogen cycle. All living organisms are built out of carbon-based compounds, or in scientific terms, "organic" compounds. Carbon is the most abundant element in compost, while nitrogen is usually present in low percentages. Carbon to nitrogen ratios in finished compost should range between 12:1 and 20:1 (C:N), with the ideal balance lying between 14:1 and 18:1. When making compost, care must be taken to mix raw compost materials to the proper carbon to nitrogen ratio.

But, as Craig reminded us, it's imperative to understand the term "compost" is a generic term, and applies to a variety of decomposed organic materials. All composts are not created equal—innate nutrient content, nutrient leaching potential, bacterial community composition and other qualities vary by the feedstocks used to create the compost, the age of the compost, and




After stacking a layer of 4”-diameter pipes to raise the compost above the water level, we filled the tote with fresh filter media, then topped it with a layer of river rock to disperse and reduce the energy of incoming water. Finally, we cut off the top of the plastic tote to encourage evaporation.

the process through which the compost was produced (e.g., in windrows, static pile, vermicompost, etc). Feedstocks can range from sewage sludge, municipal solid waste, animal excrement, food waste, landscape trimmings, and other green waste. Not all types of compost are suitable for storm water treatment—companies that sell compost for storm water applications use carefully selected feedstocks and a controlled composting process. But even with such a carefully monitored composting process, due to the ever-changing nature of feedstocks, it’s nearly impossible to predict nutrient levels in a batch of compost.

But isn’t compost a fertilizer? No. As shown in the last paragraph, compost doesn’t contain a predictable or guaranteed amount of nutrients so it cannot be classified as a fertilizer. Most commercially-available compost contains an organic form of nitrogen which is not immediately biologically available, and therefore contributes little by way of nutrient pollution in storm water. Compost is typically used as a soil additive, by providing soil aeration and feeding and supporting a healthy soil microbiome, which in turn provides nutrients to plant life. In contrast, most fertilizers are inorganic nutrients—synthetic, water soluble forms of nutrients which are designed to be readily available to plants and often result in ground water and storm water contamination due to over-application and leaching.

OK, so where are all these nutrients coming from? Well, for the most part, these nutrients are “leaching out” of the compost. “Leaching” refers to the chemical process by which a solute (nutrients) is extracted from a carrier substance (compost) by way of a solvent (storm water). But let’s back up a bit. Because compost is made of decomposing organic material, it *does* inherently contain nutrients such as nitrates and phosphates, but these nutrients are typically insoluble and carbon-bound. Since the nutrients are insoluble, they can’t dissolve and leach out into the storm water runoff. That is, until the microbial organisms living in the compost convert them into inorganic, soluble forms. But this microbial process is said to **only cause an issue when the compost is saturated in water for an extended period of time**—like in our tote at the metal shop!

But there’s more to the story. Saturated compost can cause pollutant spikes due to its use as a filtration and sorption media. The word “filtration” describes the act of separating particles and fluids in a suspension using a filter medium through which only the fluid can pass. Solid particles which can’t pass through the filter medium are described as “oversize,” and are “filtered out.”

Is compost a filter? Sometimes. Sediment particulates are large enough to be filtered out by the compost filter bed. But pollutants that are fluid (hydrocarbons), dissolved (metals, nutrients), or in very small particulates are captured by compost through a physiochemical process called **adsorption**, which is the adhesion of atoms, ions, or molecules to a surface. An everyday example of adsorption would be dry Swiffer pads, which use electrostatic attraction to pick up dust and pet hair which in turn clings to the **outside surface** of the pad (the similarly-spelled *absorption* could be compared to a sponge, which soaks up your spilled soda *into* the sponge material). For fluid or dissolved pollutants, compost performs much like a Swiffer pad—pollutants adhere to the surface of the compost mulch. And just like a dirty Swiffer won’t keep adsorbing pet hair forever, compost won’t keep adsorbing pollutants indefinitely. But to our point, water has been described as the “universal solvent” for its ability to dissolve a wide range of substances. By halting the flow of water through compost media, we created the perfect conditions for this “universal solvent” to extract nutrients and pollutants which had been adsorbed or filtered out by the compost, and even nutrients from the compost media itself.

So, how did we fix our nutrient problem? After researching the issue, and talking with chemists and a compost expert, we decided the first and most important step was to reduce or remove the ability for water to pond within our filtration tote and saturate the compost for a long period of time. Secondly, we removed all of the filtration media from the tote and replaced it with fresh media (we’re experimenting with different kinds of compost and filtration media to see what works best for our situation). We installed a layer of 4”-diameter perforated ABS pipe sections on the bottom of the tote, which helped us raise the filtration media above the working water level of the tote. We also spread a layer of river rock on top of the filtration media to distribute and spread the energy of incoming water. Finally, we cut off the top of the tote to create an open-air environment which allowed for evaporation. Since the rain season isn’t quite here yet, it’s too early to know if these changes will work. But we’ll keep you posted on our results! - ***RE***

To view the Storm Water Awareness Week workshop on “Myths Associated with Compost Nutrient Release in Storm Water Runoff,” visit www.stormwaterawareness.org.

Need industrial storm water support? Give us a call.

The Rain Events
Lead Editor: **John Teravskis**
QSD/QSP, QISP, CPESC, ToR, IGPTT Participant
jteravskis@wgr-sw.com
(209) 334-5363 ext. 110 or (209) 649-0877

Supporting Editors:
Aaron Ortiz, QISP, ToR, aortiz@wgr-sw.com
(209) 334-5363 ext. 114

Chelsea Dreyer, QISP, cdreyer@wgr-sw.com
(562) 799-8510 ext. 1003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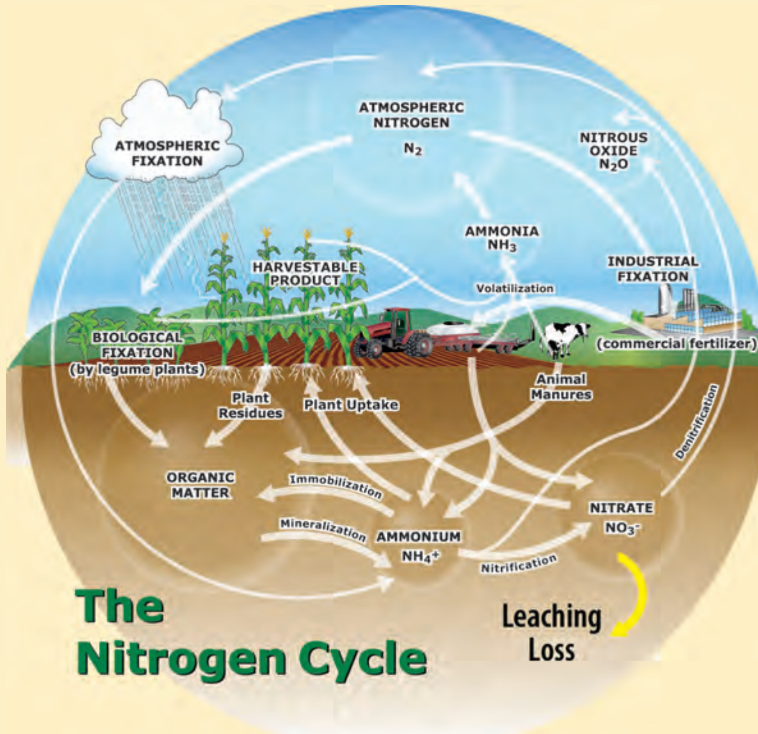
IPNI
Nitrogen NOTES
NUMBER 3

Nitrate Leaching

Nitrate is critical for supporting plant growth, but it is vulnerable to leaching through soil. For nitrate leaching to occur, (1) nitrate must be present in the soil, (2) the soil must be permeable for water movement, and (3) water must be moving through the soil.



Nitrate (NO_3^-) is present to some degree in almost all cropland, except flooded soils. Water added in excess of the soil's water-holding capacity will carry nitrate and other salts downward. Controlling nitrate leaching can be a challenge for farmers because it requires simultaneous management of two essentials of plant growth; nitrogen (N) and water.

Any factor influencing soil moisture (such as rainfall, irrigation, evaporation and transpiration) will impact nitrate movement. In general, more water infiltration results in nitrate moving deeper in the profile. Soil properties also have a major impact on the extent of nitrate movement. However, the extent of nitrate movement to groundwater depends on the underlying soil and bedrock conditions, as well as depth to groundwater.

Presence of Nitrate

Nitrate is the primary form of leached N. Ammonium (NH_4^+) is the other major form of inorganic N in soils, but it does not generally move far in soil. Nitrate in a field may originate from many sources, including manures, composts, decaying plants, septic tanks, or from fertilizer. Geologic sources of fossil N can add significant amounts of nitrate to water in some regions. Nitrate behavior does not depend on the source of N. The simple fact is that any nitrate available for plant uptake is vulnerable to leaching loss.

One key practice for reducing leaching losses is to minimize the amount of nitrate present in the soil at any given time. This goal can be difficult to achieve because rapidly growing crops require adequate N and may take up as much as 5 lbs N/A/day (22 lbs NO_3^-/A/day).

While plant roots are acquiring nitrate dissolved in water, other reactions are simultaneously occurring, including:

- Immobilization (converting nitrate to organic compounds)

Nitrogen Notes is a series of bulletins written by scientific staff of the International Plant Nutrition Institute (IPNI). This series was supported by a grant from the California Department of Food & Agriculture and through a partnership with the Western Plant Health Association. This series is available as PDF files at www.ipni.net/publications.

IPNI International Plant Nutrition Institute
WPHA Western Plant Health Association
cdfa California Department of Food & Agriculture
FREP Fertilizer Research and Education Program

- Denitrification (converting nitrate to N gases)
- Leaching (loss below the root zone)
- Erosion and runoff (loss with surface water during rain events or irrigation)

Since nitrate is susceptible to many transformations and loss pathways, nitrate concentrations should ideally be no more than is required to meet plant nutritional needs. Soil nitrate should be depleted as much as possible by the time harvest occurs to minimize loss between crops. The use of non-legume winter cover crops to recover residual soil nitrate can be effective in some situations.

Soil temperatures in the major crop-growing regions of California are warm enough to support mineralization of organic matter throughout the year. This process continues to contribute soil nitrate all year.

Soil Properties

Soil properties influence nitrate leaching because they determine how water moves. Farmers can not change some soil properties (such as texture), but can profoundly influence others (such as structure).

Soil Texture: The proportion of small (clay), medium (silt), and large (sand) particles in a soil. The textural triangle is used to determine the textural class.

Soil Structure: The arrangement of soil particles into stable units (aggregates). Soil structure can range from loose and friable, to blocky, plate like, or massive (without structure). Water takes the easiest path through soil and primarily flows around aggregates, rather than through them.

Water-Holding Capacity: The maximum amount of water that can be stored in the soil is important in estimating the potential for nitrate leaching. Sandy-textured soils cannot retain as much water as loam-textured soils.

Soil Porosity: The space between soil particles that is occupied with ever-changing amounts of air and water. Porosity is determined by soil texture and soil structure. Compaction reduces the number and size of soil pores. (**Figure 1**)

Soil Permeability: This property is determined by the soil texture and the structure. The size and arrangement of the pores determines the rate of infiltration (movement of water into the soil) and the rate of percolation (movement of water through the soil). Permeability is a measure of water moving through the pores of a saturated soil (also called the saturated hydraulic conductivity).

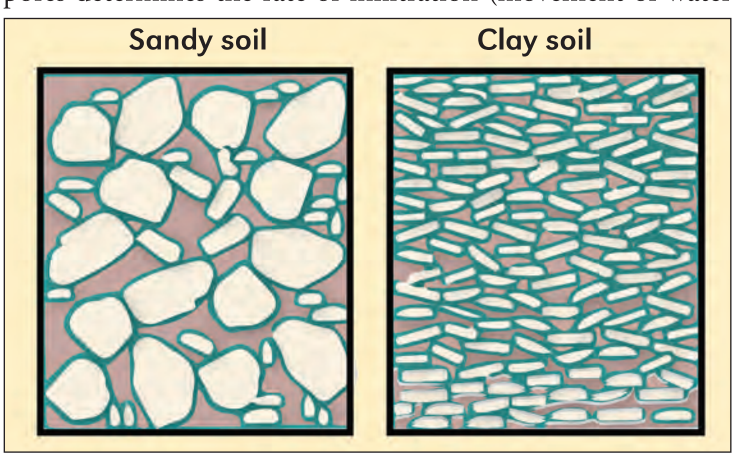


Figure 1. Water permeability and nitrate leaching are influenced by the soil texture and the arrangement of pores.

Vadose Zone: This region consists of the unsaturated zone beyond the roots and above the groundwater. It is common for the vadose zone to extend to a depth from 25 feet (shallow groundwater) to several hundred feet or more (deep groundwater). This zone links agricultural practices occurring at the soil surface and the groundwater below. The N transformations occurring within the zone are not always well understood (**Figure 2**).

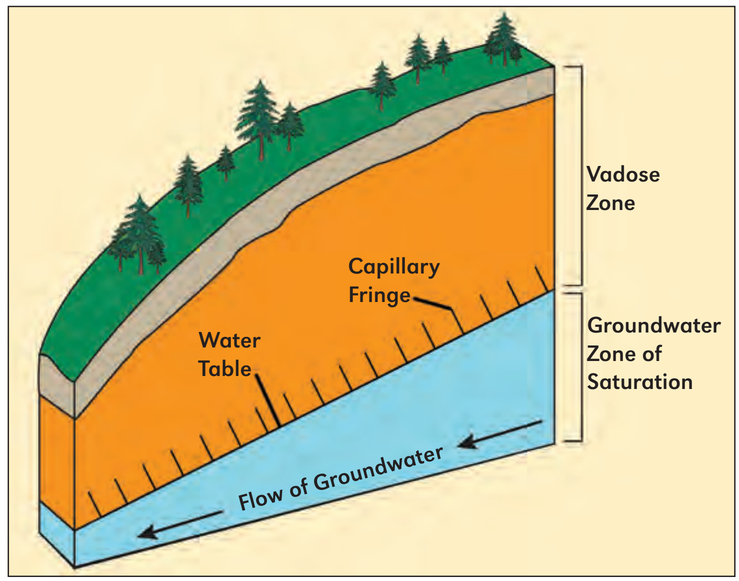


Figure 2. The vadose zone is between the root zone and the groundwater. Nitrate movement through the vadose zone can be rapid or very slow depending on site characteristics.

Leaching occurs when the air spaces in soil become filled with water and gravity begins to move water downward. The percolating water carries any soluble salts that are present in the soil and is not specific for nitrate.

Fine-textured soils (high clay) are generally less susceptible to nitrate movement than sandy-textured soils because water permeability is much lower. However, fine-textured soils are more prone to denitrification losses of nitrate.

A large portion of water percolation and nitrate leaching occurs in the large soil pores. These pores develop from shrinking and swelling of clays, as channels remaining from decomposed roots, and by insect and animal activity. Water movement through soil cracks and macropores (preferential flow) can be as much as twenty times higher than in the same soil without cracks. This movement can allow nitrate to flush through soil more rapidly than might be expected.

Examination of the soil texture at the soil surface may not reflect the soil properties deeper in the profile. Downward-moving water will likely encounter many features such as perched water tables, geologic discontinuities, restrictive layers, and other barriers to nitrate movement.

Artificially drained fields (tile-drained) allow water to bypass the natural hydrology. A large portion of the nitrate-containing water that would otherwise continue to the groundwater is instead directed to buried drainage pipes and flows to surface water.

Soil Moisture

Nitrate leaching only occurs when water is passing through the soil, so the extent of nitrate leaching is related to the amount of water percolation. Any water management practice that limits percolation can limit nitrate loss.

In much of the western U.S., water loss through evaporation and plant transpiration (ET) far exceeds the amount of rainfall on an annual basis (**Figure 3**). But there are times of the year when rainfall exceeds ET and leaching will occur

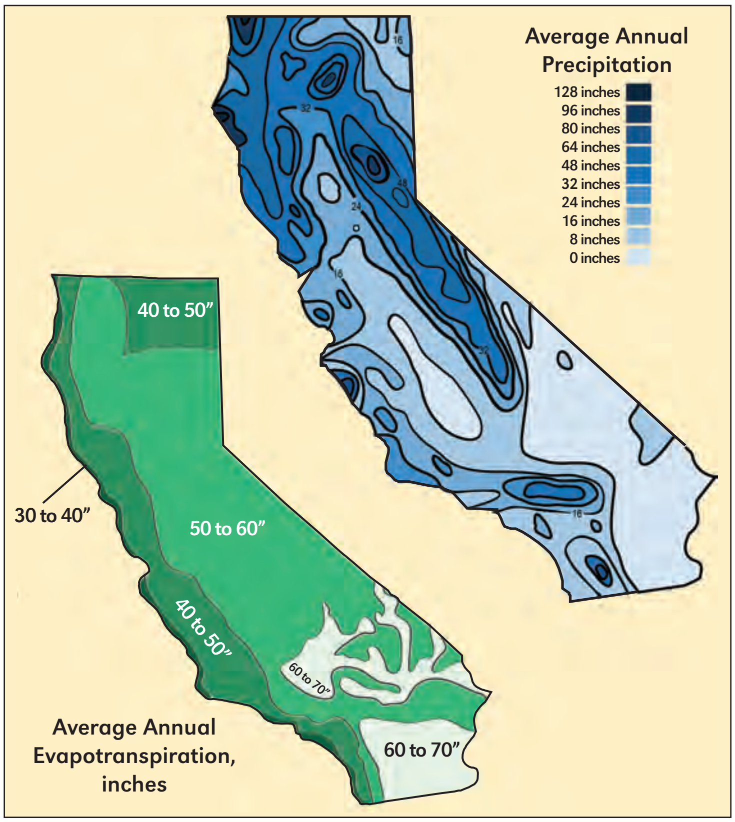


Figure 3. Yearly evapotranspiration greatly exceeds average annual precipitation in most of California. Adding supplemental irrigation water raises the risk for nitrate leaching.

Irrigated lands receive water in addition to rainfall so the potential for nitrate leaching is increased. When careful irrigation practices are followed, the risk of nitrate leaching can be minimized. These practices include:

Irrigation uniformity: The appropriate amount of water is distributed across the field, without areas in the field of excess or deficit water application.

Irrigation scheduling: Water is not added until the crop has used the available moisture previously in the root zone.

Water placement: Water is added where plant roots can access it. Drip irrigation and micro sprinklers are good examples of targeted placement of water.

Irrigation quantity: Water is added only until the water-holding capacity is achieved. Water added in excess of the holding capacity may result in leaching or surface runoff.

Irrigated fields require periodic leaching to remove accumulated soluble salts. Some leaching takes place as a result of seasonal rains, but additional irrigation water is often needed to reduce the soil salinity. This salt management technique will leach any nitrate present in the soil.

Nitrogen Management Practices

Appropriate nutrient management can greatly reduce the risk of nitrate leaching loss. This includes consideration of:

Source: Using an ammonium source of N fertilizer can temporarily limit initial N movement. Nitrification inhibitors can temporarily delay the appearance of nitrate. Controlled-release fertilizers are also effective at limiting nitrate loss.

Rate: Growing crops need a constant supply of N nutrition, but this must be balanced with the goal of minimizing nitrate losses. This requires an understanding of the plant N requirement for maximum yield or economic return. Nitrate leaching losses substantially increase when fertilizer applications are in excess of the crop need (**Figure 4**). Nitrate present in the soil and the irrigation water should be accounted for.

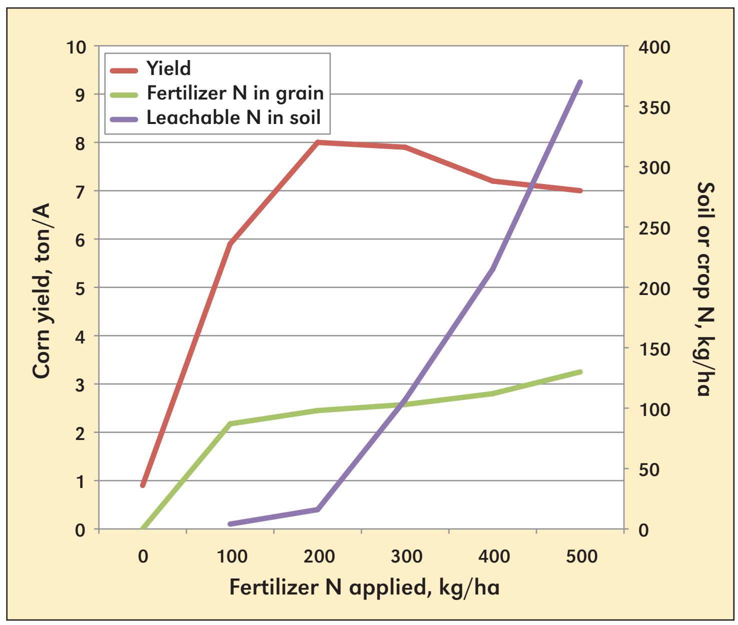


Figure 4. Nitrogen fertilizer added beyond the capacity of crops to recover it increases the risk for nitrate leaching. Broadbent and Rauschkolb, 1977.

Time: Understanding the N demand of growing crops allows farmers to synchronize fertilizer application with nutrient uptake (**Figure 5**). Increasing fertilizer recovery results in less nitrate that is vulnerable to leaching loss.

Place: Nitrogen needs to remain in the root zone to be useful as a nutrient. Nitrogen added through fertigation also needs careful management to avoid losses through deep percolation or surface runoff.

Concentration vs. Load

Discussions of nitrate leaching loss generally assume that lower nitrate concentrations are always desirable for ground-

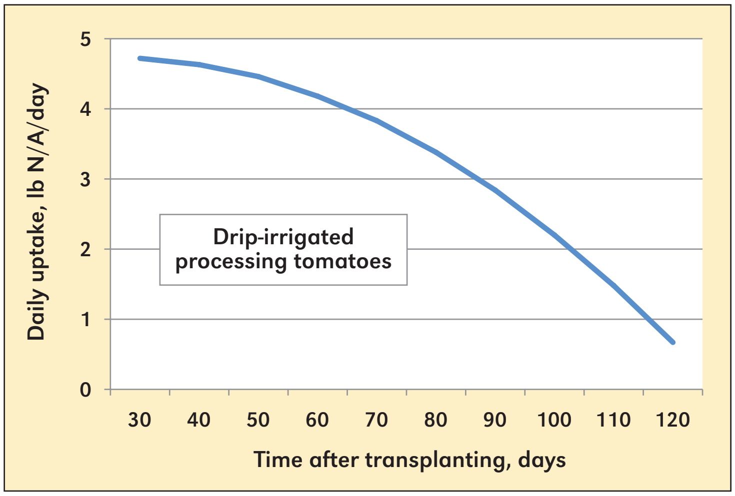


Figure 5. The daily N uptake of drip-irrigated processing tomatoes changes through the growing season, declining after fruit set has occurred. (Hartz and Bottoms, 2009)

water quality. Excessive amounts of irrigation water will dilute the nitrate concentration, but may increase the total pounds of N lost to leaching.

For example Broadbent and Rauschkolb (1977) measured nitrate losses from an irrigated cornfield in Davis, CA that received three rates of irrigation water.

- In the water-deficit treatment (1/3 ET), crop yields were depressed and the stressed plants recovered less of the N fertilizer, compared with the fully irrigated treatment. Not enough water was applied to leach nitrate below the root zone, but there was a large accumulation of nitrate remaining in the root zone due to the poor plant growth.
- In the intermediate irrigation treatment (1-ET), there was some nitrate loss due to leaching or denitrification, especially at the high rate of applied N, but crop yields were maximized
- With the excess irrigation treatment (5/3 ET), water moved a large quantity of the N below the root zone and there was minimal nitrate remaining in the root zone following crop harvest.

If only the soil nitrate concentrations had been measured in this study, misleading conclusions could have been reached. Higher nitrate concentrations were measured in the root zone of the 1-ET irrigation treatment than the 5/3 ET treatment. But the 5/3 ET treatment received additional irrigation water that diluted the "concentration" (ppm), but had a larger total loss of nitrate (pounds leached).

Summary

There are a variety of management options that should be implemented for improved nitrate management, depending on local conditions.

Nutrient Management

- Use appropriate N sources (including soluble fertilizers, controlled-release fertilizers and inhibitor additives).
- Properly use organic materials, know their N content, and the expected rate of N release.
- Adjust the N application rate to meet realistic crop yield goals.
- Analyze soils and irrigation water for the presence of nitrate.
- Place N as near to plant roots as feasible.
- Synchronize N applications with periods of peak plant demand.
- Calibrate fertilizer application equipment to deliver the desired N rate.

Water Management

- Consider soil properties in the delivery of water.
- Add irrigation water to match plant demand, as measured by evapotranspiration.
- Apply the appropriate quantity of irrigation water to minimize nitrate leaching.
- Target irrigation water delivery to the plant roots as much as practical.

Crop and Soil Management

- Consider how tillage and crop residue influence water penetration and leaching.
- Use non-legume cover crops to recover residual nitrate following harvest.
- Use soil and tissue testing to guide the need for additional N fertilizer.
- Adopt crop rotation where deep-rooted crops can be used to recover nitrate from deeper in the soil.
- Give close attention to crops that require high N fertilizer application rates and frequent irrigation since they may be vulnerable to nitrate loss.
- Consider that for many high-value crops, the cost of N fertilizer may be relatively small compared to potential revenue. However there are "environmental costs" of nitrate lost to groundwater that may not be apparent for many years.

The goal of minimizing nitrate leaching requires maintaining only enough nitrate in the root zone to meet the nutrient demands of the crop and applying the lowest volume of water to meet crop transpiration demands. These goals are generally achieved by (1) using high-yielding crops that remove a significant amount of N in the harvested portion; (2) using the right source of fertilizer, applied at the right rate, at the right time, and added at the right place; (3) careful water management to retain nitrate in the root zone during the growing season; (4) crop protection from weeds, pest, and disease; and (5) eliminating any other factors that might limit crop growth and nutrient removal in the harvest. ❖

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Hartz, T.K. and T.G. Bottoms. 2009. HortSci 44: 1988-1993

Storm Water Contest…

Each month, we invite our readers to participate in a contest to test their knowledge of the Industrial General Permit and show their storm water compliance program. We enter all submittals to our monthly newsletter question into a drawing and one person is selected at random to receive a $25 gift card. Last Month's question was:

Are you required to collect storm water samples during the COVID-19 pandemic?

OK, we know … we have been delinquent in sending out our monthly newsletters, mostly due to the pandemic, an extremely large workload, and having to work from home … and we probably can come up with a few more excuses. But, back in May, Angelina answered the contest question correctly. If any permit required activities (such as sampling) cannot be performed safely because of the pandemic, the reasons for not performing the permit-required activities must be documented and included in the Annual Report. Of course, now that we have been living for nearly 9 months under this pandemic, we are learning how to get things done safely in spite of the virus. Remember to wear a mask!

Angelina wins a $25 gift card to Doordash for a lunch treat brought straight to her office!

This Month's Contest Question:

ARE ALL COMPOSTS CREATED EQUAL? WHAT ARE SOME OF THE DIFFERENT FEEDSTOCKS FOR COMPOSTS?

We need industrial storm water sleuths to help us with this month's question. Submit your answers by Friday, November 30th. Email your answer to jteravskis@wgr-sw.com . One winner will be selected by a random drawing to receive a $25 gift card to The Honeybaked Ham Company.

THE HONEYBAKED HAM COMPANY

Need sampling ideas?

The State Water Board provides guidance on how to obtain representative samples from industrial discharge points that are sometimes complicated.

https://www.youtube.com/watch?v=sNjcU4iNvTI&feature=youtu.be

stormwater HOLIDAY GIFT GUIDE

Need Christmas shopping ideas? Check out these awesome finds!

1. Waterproof Rainslicker Jacket - HIS & HERS
2. WGR's Customizable Storm Water Inspection App (contact jteravskis@wgr-sw.com for more information)
3. Frogg Toggs Water-Resistant Pants - HIS & HERS
4. Free Storm Water Newsletter Subscriptions
5. FORGE - Online Learning Subscription
6. Flannel Lined Work Jeans - HIS & HERS
7. Rain Boots - HIS & HERS
8. Bullard 4 Point Pinlock Suspension Hard Hat
9. Leather Briefcase - HIS & HERS
10. Company Logo Blazer - HIS & HERS
11. Water/Tea/Cold Brew Coffee Insulated Infuser Bottle
12. Safety Vest
13. Fleece Lined Flannel Shirt - HIS & HERS
14. pH Meter
15. Rite In The Rain Waterproof Notebook and Pen
16. Deerskin Work Gloves
17. HydroFlask Insulated Coffee Mug

Original artwork by Julia's Watercolors 2020