Cooperative Extension Service
College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

*Soil and Crop Management*
**Jan. 2004**
**SCM-6**

# Testing for Soil Nitrogen and Phosphorous for Environmental Pollution Monitoring

Michael Robotham[1], Chris Smith[1], and Hector Valenzuela[2]
[1]Natural Resources Conservation Service, U.S. Department of Agriculture; [2]CTAHR Department of Tropical Plant and Soil Sciences

Concerns over environmental pollution of groundwater and surface water bodies by nitrogen and phosphorous have increased in recent years. Landowners, farmers, ranchers, nursery operators, and personnel of the Cooperative Extension Service (CES), the Natural Resources Conservation Service (NRCS), and other agencies need to determine whether or not excess nutrients are present that could cause pollution.

Nitrogen and phosphorus can come from many sources, including animal manures, organic fertilizers, and commercial fertilizers. Nutrient pollutants can also move from various locations, including cropped fields, pastures, and lawns in urban settings. Soil testing is a way to find out whether or not excessive amounts of nitrogen and phosphorus are present at a particular site. If excessive amounts are found in the soil, there is a greater chance that these nutrients might move off the site and cause pollution unless practices are undertaken that lessen the risk.

### *Some types of Hawaii soils*

Hawaii's soils are often different from the temperate-zone soils of the U.S. mainland, and these differences affect their susceptibility to cause environmental N and P pollution. Following are explanations of the soil terms used in this publication.

Oxidic soils are very old, highly weathered soils that contain large amounts of iron. They are red or reddish-brown. The "pineapple" soils of Oahu, Molokai, and Maui are typical oxidic soils.

Andic soils are relatively young soils that have formed from volcanic ash. They are found on the Big Island and in a few locations on Maui.

Montmorillonitic soils are very dark brown or black soils that shrink and swell. They get very sticky when wet and form noticeable cracks when dry. These soils are most commonly found in gently sloping areas near the ocean.

Thin organic soils over lava are primarily found in the Kona, Ka'u, and Puna districts of the island of Hawaii.

Sandy soils are usually found near the ocean.

## Primary environmental pollution problems from agricultural nutrients

### *Nitrogen*

Nitrogen (N) in streams, lakes and the ocean, especially in protected areas like bays and lagoons, can adversely affect their aquatic life and use for recreation. The presence of nitrate-nitrogen in excess in drinking water is related to the occurrence of a harmful condition called blue-baby syndrome in small children. Nitrogen can move from a particular site to ground and surface waters either through leaching (downward flow through the soil) or runoff (water running off the ground surface, usually during and after a rain).

Nitrogen leaching potential is highest under these conditions:
- sandy soils
- thin organic soils underlain by *'a'ā* lava or highly fractured rock
- soils with montmorillonitic or mixed mineralogies and good drainage
- soils with a water table near the surface
- shallow soils where there are fractures in the bedrock.

Nitrogen movement in runoff is more likely under these conditions:
- when commercial fertilizer or manure is applied to eroded sites and other areas with low organic matter in surface layers.
- when excessive fertilizer or manure is applied on the soil or vegetation surface and this is followed by a hard rain or excessive irrigation that causes water runoff.

Published by the College of Tropical Agriculture and Human Resources (CTAHR) and issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Andrew G. Hashimoto, Director/Dean, Cooperative Extension Service/CTAHR, University of Hawaii at Manoa, Honolulu, Hawaii 96822. An Equal Opportunity / Affirmative Action Institution providing programs and services to the people of Hawaii without regard to race, sex, age, religion, color, national origin, ancestry, disability, marital status, arrest and court record, sexual orientation, or veteran status. CTAHR publications can be found on the Web site <http://www.ctahr.hawaii.edu> or ordered by calling 808-956-7046 or sending e-mail to ctahrpub@hawaii.edu.

- when the ability of water to move down into the soil is restricted at a shallow depth by bedrock or the presence of a tillage pan.

### *Phosphorous*

Phosphorus (P) is known for being tightly bound to oxidic and particularly andic clays, regardless of pH. When these soils erode, they can carry significantly more P than sediments from loamy or clayey soils in the Midwest USA.

Many soil test results in Hawaii have shown extremely high soil P levels in areas where manure or commercial fertilizers have been applied for many years. Experimental measurements have shown that P, when present at these very high levels, can be released from the soil and move in significant amounts in runoff, not only in runoff carrying sediment but even in clear runoff.

There also are conditions where P can leach, such as in sandy soils and thin organic soils.

## Sampling guidelines

### *When to sample for environmental purposes*

The situations when sampling for environmental purposes is appropriate are often high-risk situations—areas where landscape, soil, or climatic characteristics make pollution more likely—including

- steep slopes
- shallow soils or soils with bedrock or a hardpan near the surface
- sandy soils
- soils with a high water table
- fields located near streams or other water bodies
- locations with a history of intensive agriculture
- high-rainfall areas or areas that are extensively irrigated.

Other reasons to sample for environmental purposes might be to meet regulatory requirements or for NRCS management plan development, including

- Comprehensive Nutrient Management Planning, especially when application of manures or effluents is a component
- Nutrient Management Planning for crop production, especially under intensive conditions and in potentially high-risk situations.

### *How to sample for environmental purposes*

Sampling soils for N and P analysis because of environmental concerns differs slightly from sampling for nutrient sufficiency. It should be done in addition to a regular program of soil and tissue sampling for fertility management. The goal of any sampling program should be to develop a nutrient management plan that provides the appropriate nutrients to produce healthy and productive plants while minimizing the risk of pollution.

Collection of soil samples should follow the standard protocol outlined in CTAHR publication AS-4, *Testing Your Soil—Why and How to Take a Soil-Test Sample,* except that the procedure described under "How deep to sample" needs to be modified by using Table 1, which provides general guidelines on how deep to

**Table 1. Recommended sampling depth when collecting soil samples to monitor environmental N and P levels.**

| | | | Depth of soil to sample (inches) | |
|---|---|---|---|---|
| Past use | Present use | Planned use | for N | for P |
| Cropland | Cropland | Cropland | 0–6, 10–16 | 0–6, 10–16** |
| Cropland | Fertilized pasture* | Fertilized pasture* | 0–4, 10–16 | 0–2, 10–16** |
| Range, pasture | Range, pasture | Cropland | 0–6, 10–16 | 0–6 |
| Range, pasture | Range, pasture | Fertilized pasture* | 0–4, 10–16 | 0–2 |
| Orchard | Orchard | Orchard | 0–4, 10–16 | 0–2 |
| Forest | Forest | Forest | 0–4, 10–16 | 0–2 |

*Fertlized pasture includes both effluent irrigation and application of other organic or commercial fertilizer materials.
**Deeper subsamples are recommended for P only if the field has been subsoiled (deep-ripped) in the past.

sample depending on past, present, and planned land use practices.

## Special circumstances

Table 1 provides sampling depth guidelines that will apply in most situations. However, there are special circumstances that may require different sampling approaches to accurately assess pollution risk.

### *Thin organic soils over* ʻaʻā *or* pahoehoe *lava*

In these thin soils, leaching is the most likely source of both N and P pollution. Sample the entire depth of the soil to the underlying lava layer for both nutrients.

### *Sandy soils*

In sandy soils where fertilizers or manures have been applied, leaching is the most likely source of both N and P pollution. Sample both the surface layer (0–6 inches) and the subsurface layer (10–16 inches).

### *Soils with a shallow water table*

In soils with a shallow water table (less than 24 inches below the surface), sample the soil surface layer to the depth shown in Table 1. Collect an additional sample in the 4–6 inches of soil immediately above the saturated soil boundary.

## Management options

If you have sampled your soil and determined that there may be a high risk of environmental contamination, there may be management options available that will help you to reduce these risks.

In cropped conditions, excess N or P can be dealt with by changing your fertilizer program. This may include greatly reducing or eliminating application of some types of fertilizer or by using other fertilizer products, such as slow-release formulations. Special care must be taken in some situations, such as with shallow-rooted vegetable crops (e.g. leaf lettuce), to ensure that new plantings have adequate available nutrients. Care must also be taken in high-rainfall areas. Soil nutrient levels, particularly nitrate levels, can decrease significantly after a heavy rain as nutrients are leached below the root zone or flow off the field in runoff. Consult with your CES extension agent or your crop consultant to develop an appropriate nutrient management plan for your specific situation.

If leaching of either N or P is the primary concern, appropriate water management is extremely important. Water management can be difficult in high rainfall areas. In drier areas, however, minimizing the amount of water leaving the root zone through good irrigation management will greatly reduce the risk of nutrients leaching into groundwater. More accurate water and nutrient management often have the added benefit of reducing the cost of production.

Where manure or effluent is applied to pastures, there may be few options available to the land-owner if N or P soil tests results show excessive amounts. All available land may be taken, and disposing of the effluent at another site may not be a viable option. If soil N is too high, it may be possible to remove much of the N from effluent before applying it to the field by using waste management practices that encourage N losses through volatilization. Removing P is much more difficult. In certain situations where P levels are high in the surface layer but lower in deeper layers, inversion of the field through deep tillage may be a possibility. If this is not an option, there may be no alternative but to stop applying P to the site. Removal of vegetative material through repeated hay harvests can bring P levels down over time.

## References

Hue, N.V., R. Uchida, and M.C. Ho. 1997. Testing your soil—Why and how to take a soil-test sample. CTAHR publication AS-4.

Moore, P., and B. Joern. 1997. Improvements needed for environmental soil testing for phosphorus. Chapter 3 in SERA-17, Minimizing phosphorus losses from agriculture, accessed 8/7/2003, http://www.soil.ncsu.edu/sera17/publications/sera17-1/Chapter3-97.htm.

Robotham, M.P., J. Hart, and E.H. Gardner. 2002. Soil sampling for home gardens and small acreages. Oregon State University Extension Service publication EC 628.