Minnesota Pollution Control Agency

Vegetative buffers for protecting and improving ground water quality

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Environmental Outcomes Division

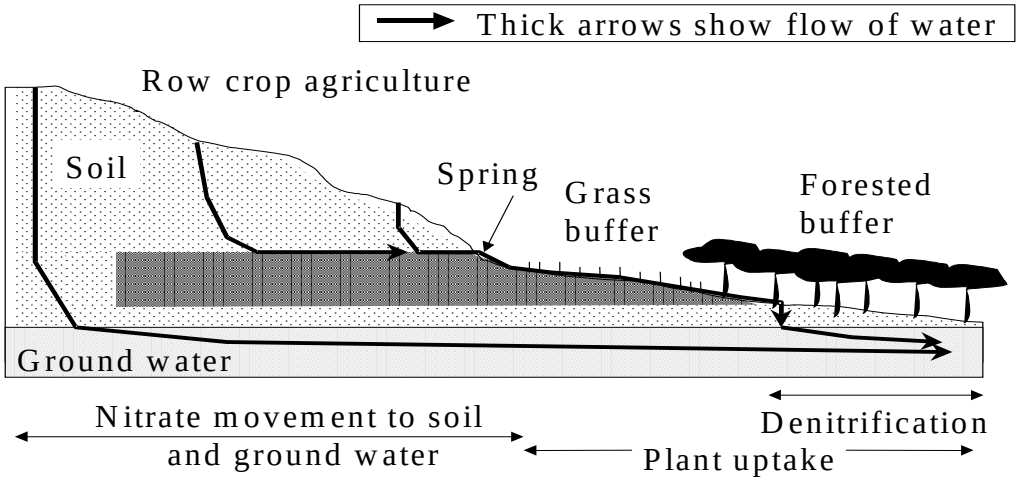
Ground Water Monitoring & Assessment Program

What is a vegetative buffer?

Vegetative buffers are areas of vegetation that provide a transition between different land uses. Vegetative buffers are most commonly associated with riparian zones, which are transition areas between uplands and lakes, rivers or wetlands. Riparian forests (those located along streams) have a high capacity to prevent the movement of nitrate and other nutrients in surface runoff and ground water flow from upland areas. Riparian zones are also well suited as farmland, as livestock grazing areas, for timber production or for commercial and residential development. If not properly managed, these uses diminish the value of vegetative buffers for protecting water quality.

How do vegetative buffers protect ground water quality?

The impacts of vegetative buffers upon ground water are not always obvious. Vegetation takes up nutrients from shallow ground water and produces conditions that are favorable for the breakdown of chemicals, such as nitrate and herbicides. The amount of water infiltrating through the soil and into the ground water is often higher in permanently vegetated areas than in agricultural areas, and this extra water may dilute chemical concentrations. Vegetative buffers also reduce runoff from upland areas. As this runoff water infiltrates the soil, nutrients and other chemicals are adsorbed, degraded or utilized by vegetation.



NOTE: Vertical scale greatly exaggerated. Arrows do not imply rates of flow.

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In a buffer area, ground water passes through or under the vegetated area. Water must interact with the vegetation to be impacted by it. Consequently, vegetated buffers will have their greatest impact in areas where ground water is close to the surface. In the diagram on the first page of this fact sheet, nitrates infiltrate through soil in the agricultural upland area. When this water emerges as a spring along an impermeable zone or in shallow ground water, grasses and trees take up some of the nitrate. Nitrate is also broken down in the forested area through a process called "denitrification."

Nitrate is typically the chemical of concern in ground water. Riparian forests retain up to 99 percent of nitrate, compared to about 85 percent in a zone vegetated with grass.

Vegetation removes about one-third of the nitrate in shallow ground water. The nitrogen taken up by plants is stored in their tissues. This occurs only during the growing season.

The most important mechanism of nitrate removal is denitrification. Microorganisms, such as bacteria, utilize nitrate during food production. The bacteria transform the nitrate to nitrogen gas, which is then released to the atmosphere. Microorganisms also need organic matter during this process, and vegetation is the source of this organic matter. Organic matter is released when leaves and other plant parts die and reach the soil surface. These plant parts are broken down and infiltrate through the soil, into the ground water, where they are used by microorganisms. Consequently, denitrification rates are highest and plants have their greatest impact in soil and in shallow ground water that is intercepted by plant roots. The effect of dilution on reducing nitrate concentrations in ground water is small compared to plant uptake and denitrification. Other chemicals, such as herbicides and trace metals, may be affected in ways similar to nitrate.

The following factors enhance removal of nitrate or other chemicals in a vegetated buffer zone:

- moderately permeable soils that allow infiltration but not excessively rapid flow;
- ground water within 1 to 3 meters (3 to 10 feet) of the land surface, thus allowing for plant uptake and removal in both soil and ground water;
- uniform flow in ground water, such as occurs in sand and gravel or sandstone aquifers;
- ground water with high concentrations of reduced sulfur, which can be used instead of organic matter during denitrification;
- increased plant production; and
- increased width of the buffer zone, which allows a greater area from which chemicals can be removed.

What are some guidelines for establishing vegetative buffers?

- Vegetative buffers should be used in conjunction with land-management systems that include nutrient management and sediment and erosion control.
- Buffers should be 18.3 meters (60 feet) or more wide and contain trees and shrubs.
- Bottomland hardwoods, such as cottonwood, silver maple, willow and green ash, are tolerant of water and remove large quantities of nutrients. Shrubs, such as dogwoods, ninebark, chokecherry and viburnum, provide additional cover beneath the tree canopy and are effective in removing nutrients from wet zones. Increasing the variety of trees and shrubs provides greater diversity in nutrient uptake and enhances uptake over long periods. Some plant species may be sensitive to herbicides present in ground water.
- An additional zone to enhance infiltration of water may include grasses. This grassy strip should be at least 6.1 meters (20 feet) wide. Recommended species include switchgrass or other native grasses.
- Forests are somewhat more effective at removing nutrients from shallow ground water.
- On permeable soils, utilize a tree density of about 35 percent of the total vegetative area to provide the most effective removal of nitrate.

References

The following Web sites are good starting points for gathering more information on riparian buffers and water quality. The second site provides a list of publications.

http://ink.yahoo.com/bin/query?p=riparian+buffer+nitrate+ground+water&hc=0&hs=0

http://www.serc.si.edu/SERC_web_html/pub_ripzone.html

http://affiliate.directhit.com/fcgi-bin/DirectHitWeb.fcg?alias=websrch&fmt=html&qry=Riparian&meta=rs&persrch=|||