Water quality: protecting our aquatic resources

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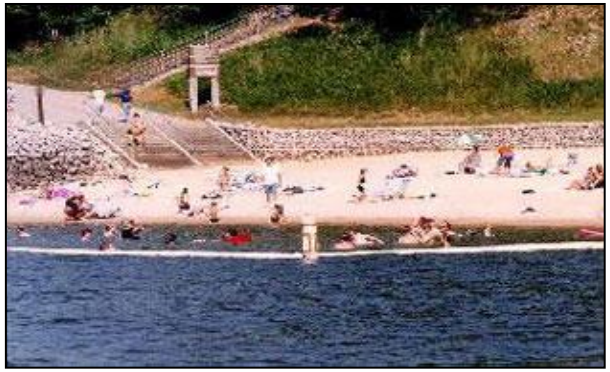
Water: our most precious natural resource

- Clean water is essential to human health and healthy aquatic ecosystems

Fisheries and Aquatic resources

- Highly valuable natural assets provide economic benefits, enhance quality of life



Protecting our aquatic resources

- Concern over effects of human activities on water quality and aquatic life
- Anthropogenic pollutants can have a profound effect on water quality and aquatic life
- Understanding how to prevent pollutants from entering our aquatic systems is necessary to protect our watersheds

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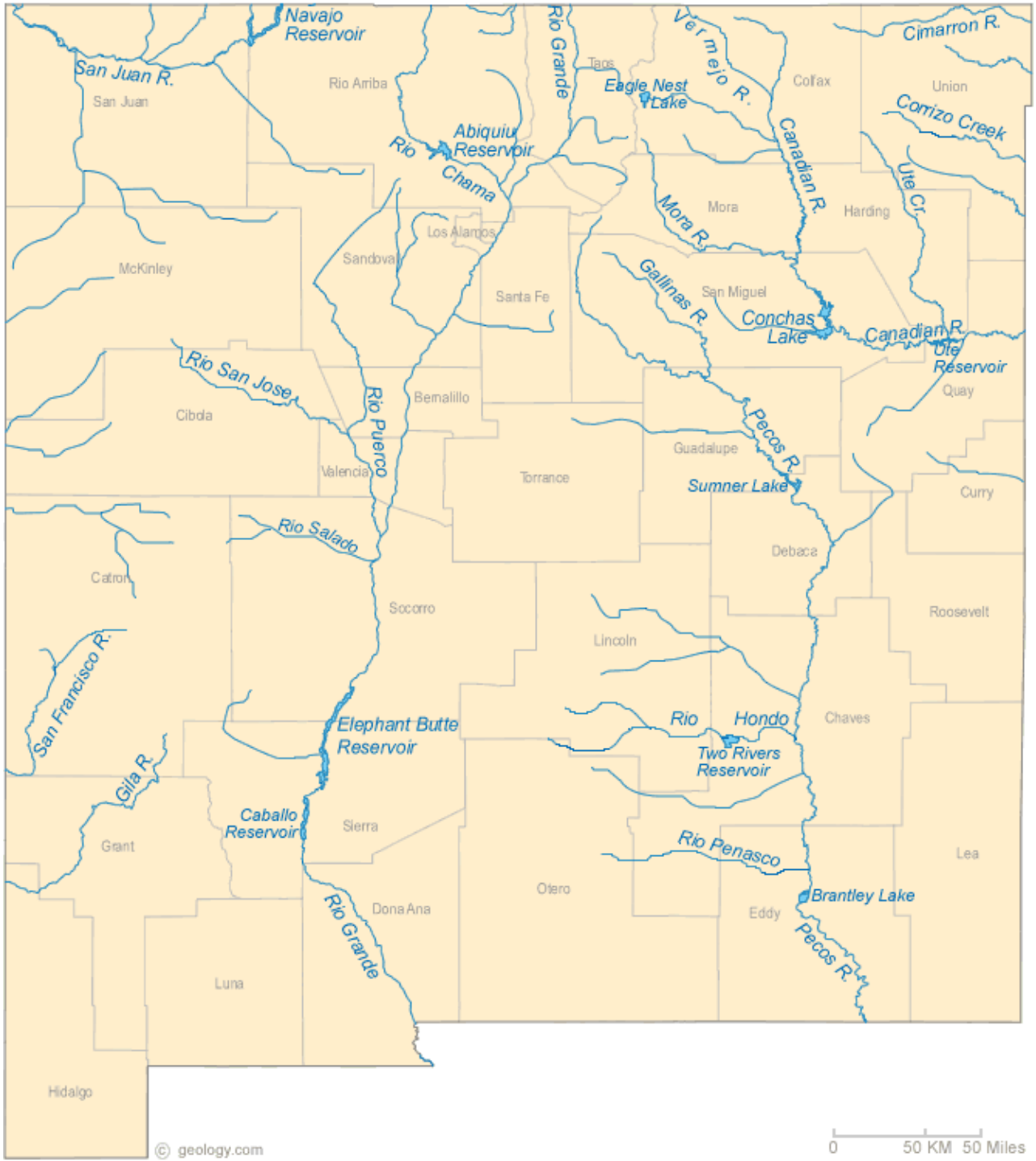
What is a watershed?

- **Watersheds** are the land area that contributes water to a specific water body, such as a pond, lake, wetland or catchment area
- Simply an area of land that drains the rainwater (or snow) into one location, such as a stream, lake, wetland, ocean

Photo taken by D.E. Cowley



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Surf your watershed

Sandoval County: covers 9 watersheds

13020101 Upper Rio Grande; state(s): CO, NM
13020102 Rio Chama; state(s): CO, NM
13020201 Rio Grande-Santa Fe; state(s): NM
13020202 Jemez; state(s): NM
13020203 Rio Grande-Albuquerque; state(s): NM
13020204 Rio Puerco; state(s): NM
13020205 Arroyo Chico; state(s): NM
14080103 Blanco Canyon; state(s): NM
14080106 Chaco; state(s): AZ, NM

Watersheds

- We ALL live, work and play in a watershed.
- As water travels over the land it is affected by how the land is used
- Land use affects <u>Water Quality</u>

Photo taken by D.E. Cowley

Water quality

- Assessed by measuring physical, chemical and biological parameters of the water

What water quality parameters are important to monitor?

Chemical Parameters

- pH*
- Total dissolved solids (TDS)
- Nutrients*
- Dissolved oxygen (DO)*
- Biochemical oxygen demand (BOD)
- Toxic substances*

Chemical parameters:
pH

- pH is an abbreviation for the Power of Hydrogen
- concentration of H^+ ions in the water
- Ranges from 0 to 14. Seven is neutral, below 7 is acidic, and above 7 is basic (alkaline).
- Most waters range from 6.5 to 8.5
- Most aquatic organisms exist within a range of 5.5 to 9.5.

Importance of pH

- Changes in pH can affect how chemicals dissolve in water and whether organisms are affected by them
- When acid waters come into contact with certain chemicals and metals, they often make them more toxic than normal.

pH and toxicity of chemicals

Examples:

- Mixing an acid water environment with small amount of aluminum, lead or mercury makes these compounds MUCH more toxic to fish
- Ammonia exists in 2 forms: NH_3 (toxic) and NH_4^+ (much less toxic). As pH increases, so does the proportion of toxic ammonia

Chemical parameters:
Dissolved Oxygen (DO)

- Tells how much oxygen is available in water for fish and other organisms to breathe
- DO is a product of *photosynthesis* and *diffusion*
- Water does not hold much oxygen (about 12 ppm or mg/L can dissolve in water)

Chemical parameters:
Dissolved Oxygen (DO)

- Affected by temperature, salinity, elevation, turbulence of water, time of day, pollution
- The warmer the water, the less oxygen it can hold

How much DO do organisms need?

- Most animals require at least 5 ppm

Trout require about 6.5 ppm

Chemical parameters:
Nutrients (particularly N and P)

- Critical to growth of plants and animals
- Too many nutrients can lead to over-fertilization, causing over-abundance of aquatic plants (Eutrophication)

Excessive Nutrients

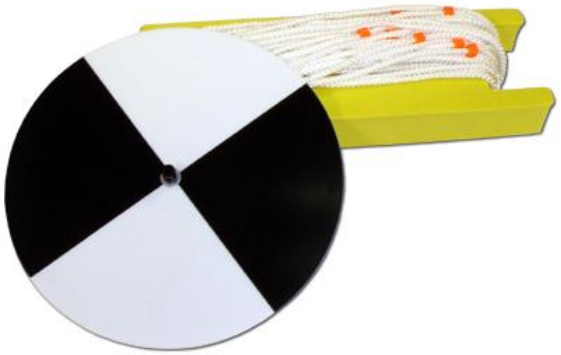
- When this excess of plants and/or algae die, they decompose, which leads to a depletion of O_2 (O_2 gets used up by bacteria)
- This can affect water clarity, temperature, smell
- Can lead to fish kills

Chemical parameters: ***Toxic chemicals***

- Usually come from industry and energy production
- The effects are often not known until years after they entered the environment
- Include heavy metals (lead, mercury), organic compounds (PCBs and DDT), inorganic compounds (arsenic), pesticides

Other important physical parameters:
Turbidity

- Measures water clarity or the ability of light to pass through water
- A measure of the amount of suspended solids and dissolved color suspended in the water
- Used to calculate the inputs from erosion and nutrients



What processes are affected by Turbidity?

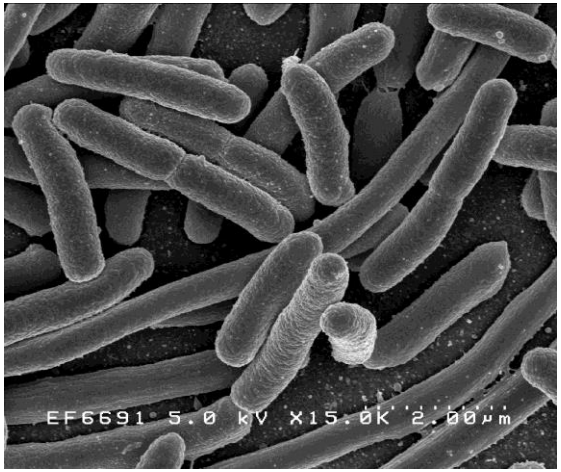
- Light penetration (turbidity blocks sunlight)
- Primary production (bottom of food chain)
- Will affect consumers of algae, such as insects and planktivorous fish

Water quality parameters
Biological parameters

- Another way to indirectly measure water quality is to use the organisms that live in the water as water quality indicators
- Some organisms can only live in excellent quality water, others do well in good quality water and some can even survive in polluted water
- Used for Biomonitoring programs

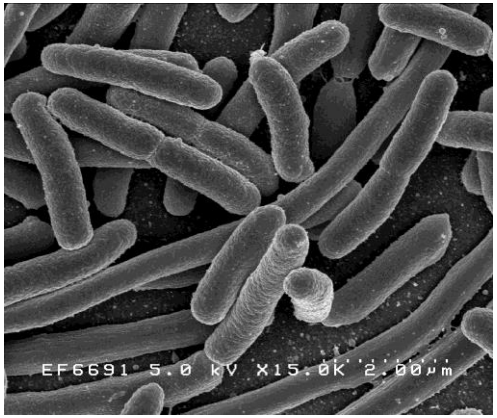
Water quality parameters:
Biological parameters

- Bacteria
- Benthic macroinvertebrates
- Aquatic vegetation
- algae



www.universityofcalifornia.edu

Biological parameters:
Bacteria



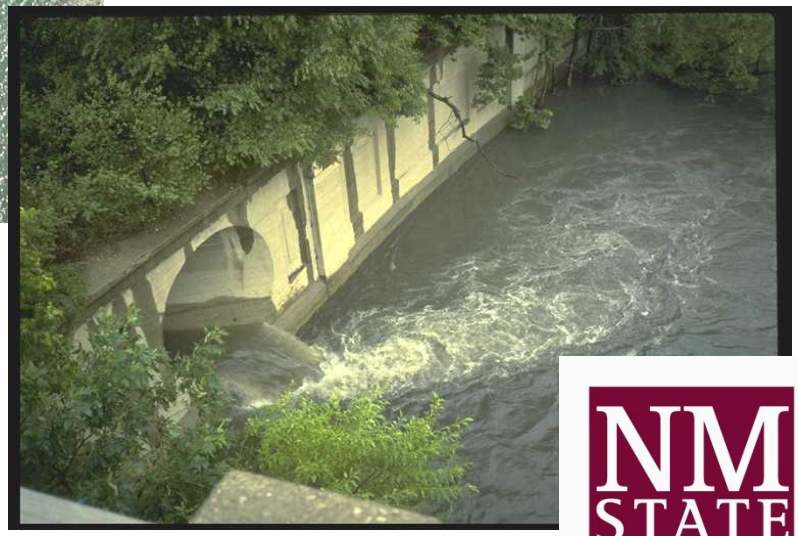
- Certain types like E.coli and fecal coliform are measured as indicators of more harmful bacteria and pathogens that cause disease
- Indicators of sewage or fecal contamination in water
- Most strains of E.coli are harmless but some can cause serious food poisoning

What are the sources of pollution to our waters ?

- Point Source Pollution
- Non-point source pollution

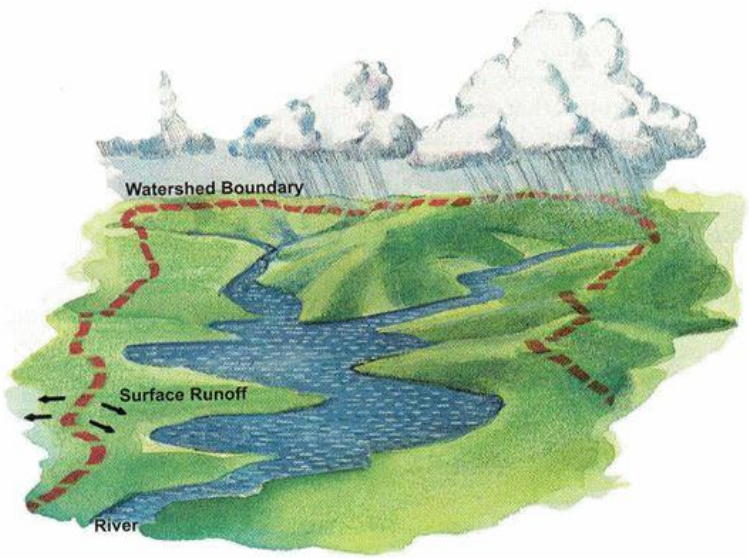
Point Source pollution

Pollution comes from a single source, pipe, such as an industrial plant, a sewage plant

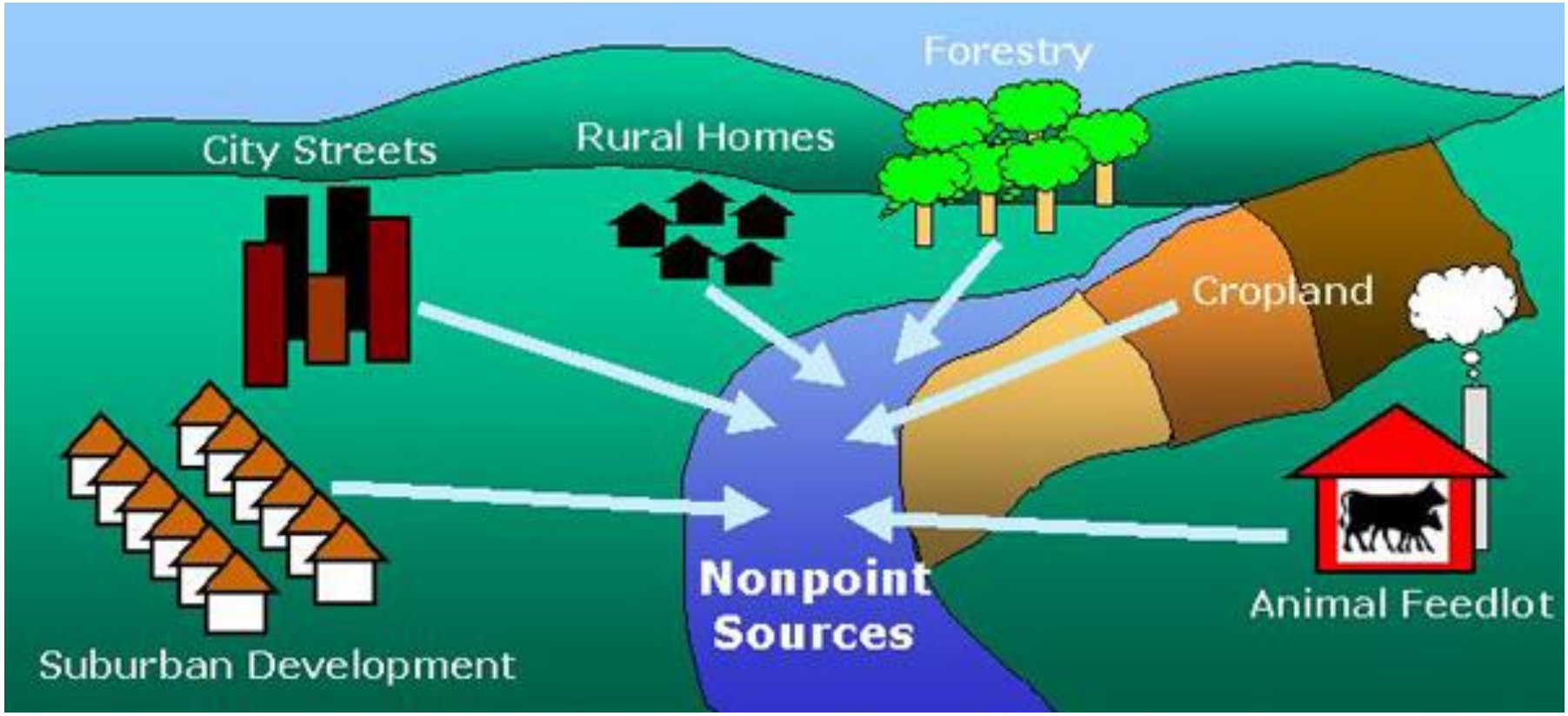


Nonpoint source pollution

- Unlike point source pollution NPS pollution comes from a wide area
- Caused by rainfall and snowmelt runoff moving over and through the ground, carrying natural and human-made pollutants into our waters



NPS pollution



This includes runoff from parking lots, roads, farms, yards, stream banks, air pollution and contaminated groundwater

Which produces most water pollutants ?

- MOST of the pollutants entering our waters come from Nonpoint source pollution

Sources of NPS pollution

- Agriculture (sediment, nutrients, pesticides, bacteria)
- Wastewater disposal (bacteria, nitrates, phosphates)
- Forestry (sediment, pesticides)
- Construction (sediment)
- Surface mining (sediment, minerals, acid drainage
- *Urban Storm runoff (oil, nutrients, pesticides)

Urban storm runoff

Associated activities:

- Automobile maintenance
- Painting
- *Lawn and garden care

Resulting pollutants:

- Oil
- Gas
- Antifreeze
- Nutrients
- Paint
- Pesticides

Urban runoff: What affects stream quality?

- Stream quality is related to impervious cover
- Impervious cover produces 16 times more stormwater runoff than runoff from a forest
- The more stormwater, the more urban polluted runoff (UPR) reaching our streams.
- 13% of environmental damage to streams comes from UPR, 21% of damage to impaired lakes comes from UPR

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Rainfall on an impervious surface

Rainfall on a permeable surface

What is the quality of our waters?

- For the US waterbodies sampled most recently, about 45% were rated as impaired for their <u>intended use</u>

There are many types of pollutants impairing our waters. These include:

- Petroleum products
- Nutrients
- Sewage
- Solid wastes
- Pesticides
- Toxic wastes
- Bacteria
- Sediment
- Heated water

What are the most widespread pollutants in US surface waters?

- <u>The top 3 pollutants causing problems are</u>:

  1. Soil (sediment) is the leading cause of pollution in streams / rivers
  2. Bacteria
  3. Nutrients (leading water quality problems in lakes, reservoirs and ponds, the two most common are N and P)

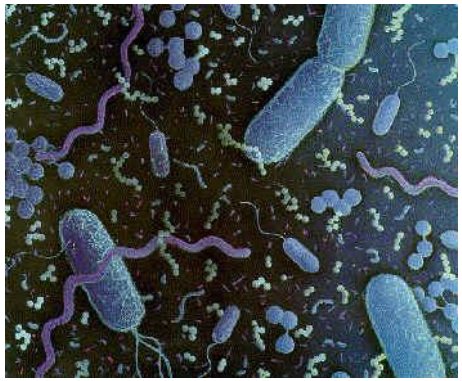
Soil/Sediment

- Erosion moves soil into waterways
- The soil creates suspended sediment that blocks sunlight, smothers aquatic life and adds contaminants

Photo by D. E. Cowley

Bacteria

- EPA ranks bacteria as the most widespread contaminant in our rivers and streams.
- Bacterial contamination is becoming a chronic problem in many waterways.
- The most prevalent sources are poorly treated sewage, and wildlife, pet and livestock waste.



Nutrients

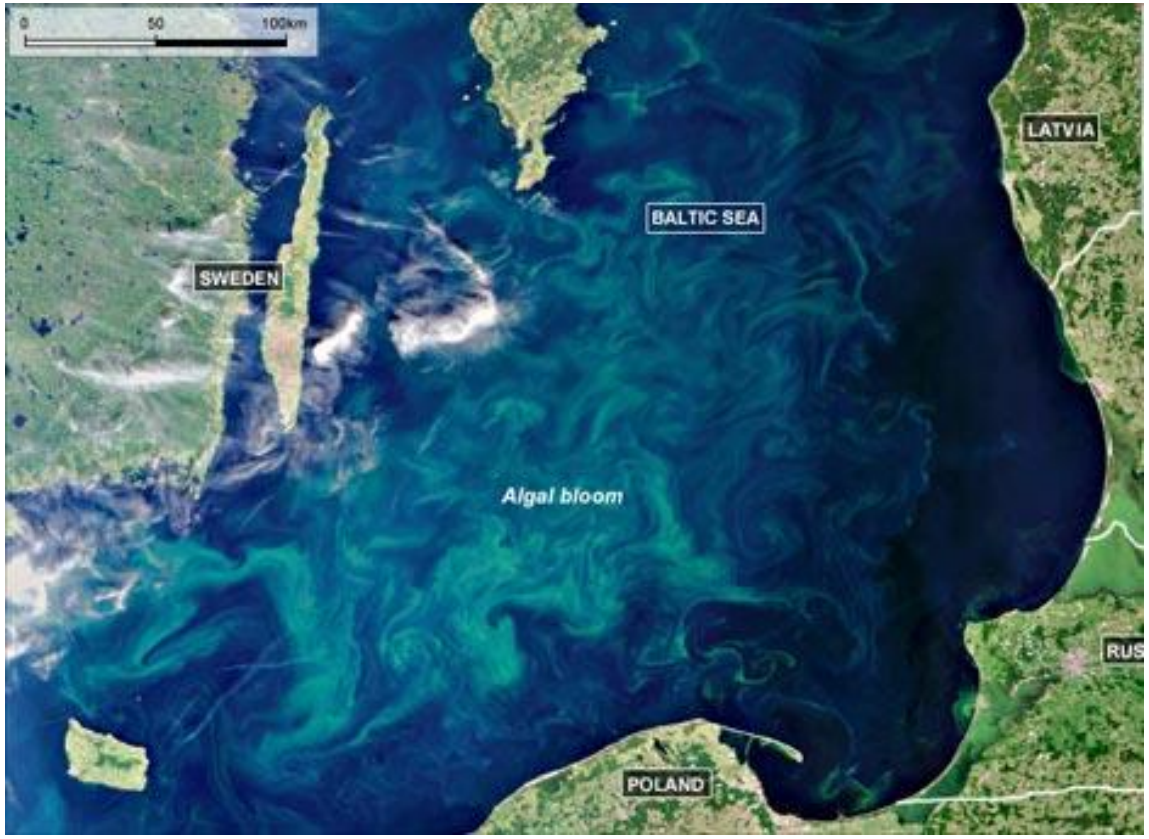
- Primary plant nutrients include nitrogen, phosphorus and other elements
- Excess nutrients increase algal growth. The algae die and the resulting decay consumes oxygen
- Sources include urban and farm fertilizers, animal wastes and partially treated sewage.

Link between nutrients and sediments

- Total nutrient concentration in surface water is affected significantly by suspended-sediment concentration because nutrients adsorb to suspended sediment and are transported by water

Over-fertilizaton of our waters

- Eutrophication remains one of the foremost problems in protecting freshwater and coastal ecosystems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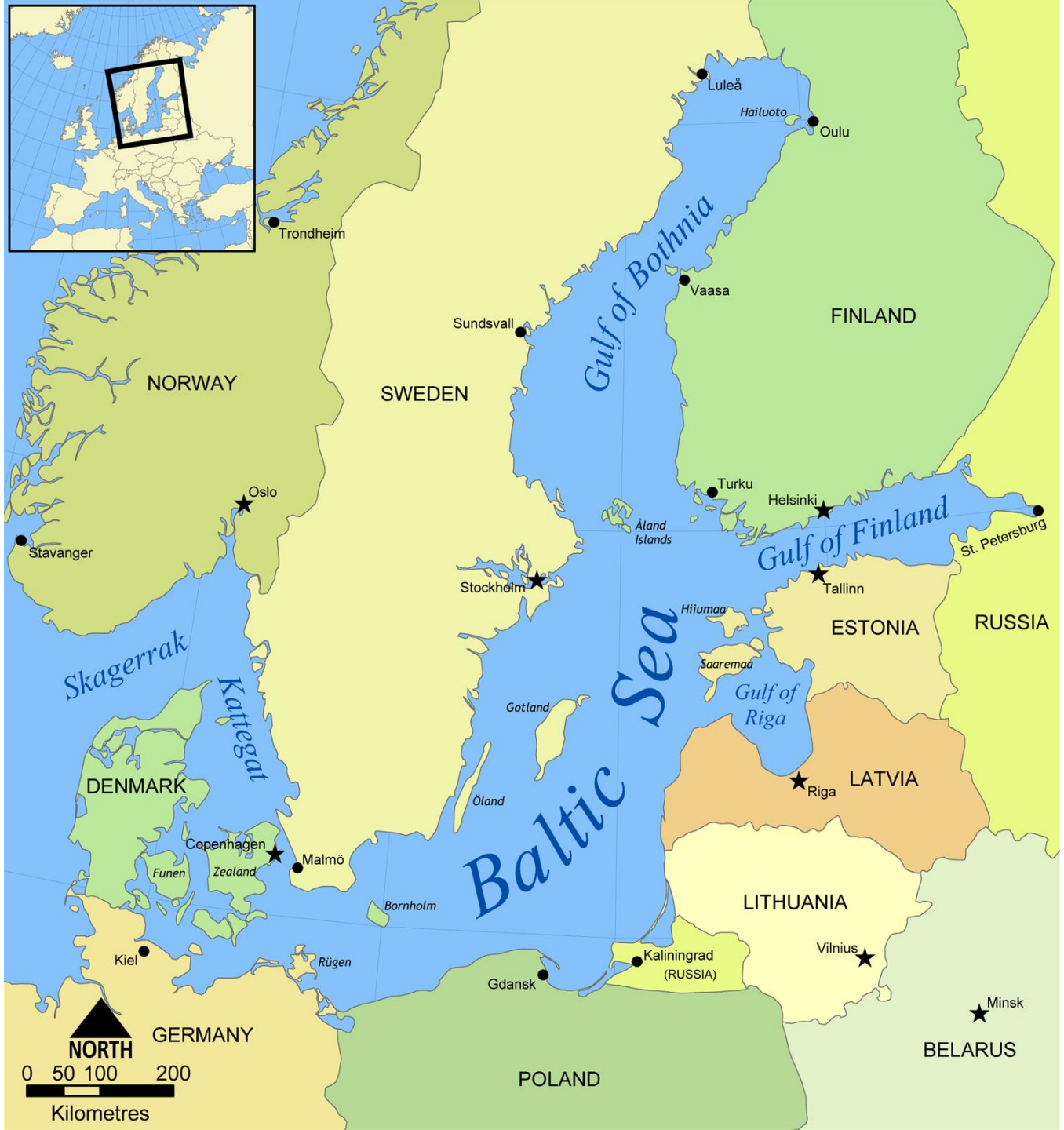
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- **Why Lake Erie is Under Attack from Algae Blooms**
- *By Douglas Main, OurAmazingPlanet Staff Writer*
- Lake Erie is under attack from noxious algae blooms, and the problem only looks likely to get worse if something isn't done to reverse the trend, new research suggests.
- In the summer of 2011, western Lake Erie turned a noxious green, as a massive algae bloom coated the surface and lapped up in mats along the shore. At its peak, the bloom covered an area 2.5 times larger than that of any Erie bloom on record, according to a study published today (April 1) in the Proceedings of the National Academy of Sciences.
- **Fertilizing the algae**

How does climate change affect water quality?

- Changes in the hydrological cycle:
  - Changes in seasonal distribution and amount of precipitation (more in tropics and high latitudes, decreases in sub-tropics)
  - Increased evapotranspiration and reduced soil moisture
  - Changes in vegetation cover
  - Increased melting of glacial ice
  - Increased risk of fire in many areas

Climate change and water quality

- In areas receiving more precipitation, increased runoff carrying nutrients, pollutants
- When drought persists, remaining water is of inferior quality due to concentration of contaminants (& increased loads of microbes)
- Increased water T° leads to microbial and algal blooms, reduced DO

Other common pollutants in surface waters and sediments

- Industrial contaminants
- Heavy metals
- Pesticides*

Pesticides use in U.S.

- Approx. 1,000,000,000 (1 billion) lbs of pesticides used each year in U.S. alone
- Currently there are 11324 pesticide products registered in New Mexico (NMDA website)
- 1572 products for controlling broadleaf weeds in NM alone

Urban Pesticide Use: Did you know?

- US EPA estimates that 70 million pounds of pesticides are applied to lawns every year.
- An <u>average</u> acre of maintained lawn receives an annual input of 5 to 7 lbs of pesticides per year.

Urban Pesticide Use: Did you know?

- Home gardeners use on average more pesticides per square foot in their gardens than farmers do on their fields
- Applied improperly, these chemicals can pollute local water resources
- As little as 1 teaspoon of certain pesticides rinsed down a storm drain is enough to show up in local streams

Where do pesticides end up?

- Estimated that often less than 0.1 percent of a pesticide that is applied reaches target pest
- 99.9 percent is an unintended environmental pollutant
- Ends up in soil, air, nearby vegetation and **water**
- Can pollute immediate area or move off site via drift, volatilization, leaching and runoff

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What the nation-wide studies show:

- Widespread contamination of water by pesticides and N and P
- Results of USGS studies on major river basins across country showed >90% of water and fish samples from all streams had 1, or more often, several pesticides
- Found in all samples from major rivers with mixed agricultural and urban land uses, and 99% of samples from urban streams

(Gilliom et al. 2006. The Quality of our Nation's Waters-Pesticides. U.S.G.S. Circular 1291)

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Frequently detected pesticides

- Among the 21 pesticides most often detected across the nation
  - Herbicides: atrazine, 2,4-D, diuron, and prometon
  - Insecticides: chlorpyrifos, diazinon, carbaryl, malathion
- Insecticides occur more frequently and at higher concentrations in urban streams than agricultural streams

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Concentrations greater than human health benchmarks (thresholds)

- Specifically, pesticide concentrations exceeded one or more human-health benchmarks in about 10 percent of agricultural streams, 7 percent of urban streams, and in 1 of the 65 mixed-land-use streams sampled by NAWQA.

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Concentrations greater than aquatic life benchmarks

- Of 186 stream sites sampled nationwide, 57 % of 83 agricultural streams, 83 % of 30 urban streams, and 42 % of 65 streams with mixed-land-use watersheds had concentrations of at least one pesticide (usually more) that exceeded one or more aquatic-life benchmarks

Water quality in the Rio Grande Valley: *Surface water*

- One or more pesticides were detected at 94% of the sites sampled in the Rio Grande and its tributaries, or drains.
- Include carbofuran, metolochlor, diazinon, dacthal
- No pesticide concentrations detected exceeded EPA drinking water standards or state or federal guidelines
- Concentrations of DDT and its metabolites in sediment and whole fish confirms the persistence of this pesticide in the environment

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Importance of groundwater

- Groundwater is an important water source for all of us (50% of drinking water in US)
- The US uses about 77,500 million gallons of groundwater each day for all kinds of uses
- Approximately 90% of NM population depends on groundwater for drinking water
- Once groundwater is polluted it may take years-decades for contamination to dissipate

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What is the quality of our groundwater?

- In general, the quality of NM groundwater is very good
- Unfortunately, many states, including NM have areas with polluted groundwater
- Most common pollutants are manufactured products (like gasoline) and nitrates
- Sources: fuel tanks buried underground, leaky septic systems, leaky landfills, leaky wastewater ponds, nutrients from farmland

Nitrate in Groundwater: nationwide and in here in NM

- Nitrate at concentrations greater than EPA MCL of 10 mg/L were found in 4.4 % of all wells and most frequently in wells in agricultural areas
- Shallow wells sampled from San Luis Valley, Rincon Valley contained nitrate concentrations greater than EPA MCL of 10 mg/L

Nitrate in well water

- Potential human-health effects.
- Excessive nitrate can result in the restriction of O_2 transport in the blood, of particular concern in infants who lack the enzyme needed to correct this condition (resulting in “blue baby syndrome”).
- Nitrate occurs naturally, but concentrations greater than 1 mg/L usually are indicative of human activities, such as fertilizer application, animal production, and septic systems.

Pesticides in Groundwater in the Rio Grande Valley

- Pesticides were detected in ground water samples from shallow wells
- Samples from deeper groundwater (more typically used as drinking water source) contained one pesticide (prometon)
- Prometon and metolochlor were most frequently detected, although neither exceeded EPA drinking water standards.

(Gilliom et al. 2006. The Quality of our Nation's Waters-Pesticides. U.S.G.S. Circular 1291)

Recap: Percentage of samples taken from urban areas across the US that contained 1 or more pesticides (USGS 2006)

- Fish: 100%

- Streams: 99%

- Shallow groundwater: 40%

Some Environmental Problems associated with Pesticides in water

- Aquatic microorganisms affected
- Pyrethroids and stream sediments
- Fish and endocrine (hormone) disruption
- Decline of amphibians
- Fish kills (insecticides directly, herbicides indirectly)

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How do we measure effects? Aquatic Toxicology

- The study of the effect of environmental contaminants on aquatic organisms
- A pesticide's capacity to harm fish & other aquatic organisms is a function of:
  1. Toxicity
  2. Exposure time
  3. Dose /concentration
  4. Persistence

Toxic effects

Lethal: cause death

LC50 = Concentration which causes death in 50% of the test organisms (mg/L or ppm)

- **Minimal : > 100**
- **Slight: 10 - 100**
- **Moderate: 1 - 10**
- **High: 0.1 - 1.0**
- **Extreme: 0.01 - 0.1**

Toxic effects

Sublethal effects: Does not cause immediate death, but repeated exposure can reduce survival by:

- Reduced egg production and hatching
- Nest and brood abandonment
- Lower resistance to disease
- Decreased body weight
- Hormonal changes
- Reduced avoidance of predators

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Effects of pesticides on non-target aquatic organisms - fish

- Of the 30 commonly used lawn pesticides, 24 are toxic to fish and aquatic organisms
- Ex. Trifluralin (Snapshot) is highly to very highly toxic to both cold and warm-water fish and causes vertebral deformities in fish
- Ex. Chlorpyrifos, a common contaminant in urban streams, is very highly toxic to fish

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Additional considerations

- **Mixtures** and **breakdown products** of pesticides occur in environment
- Additive or synergistic effects unknown
- “inert ingredients” in formulations protected by trade secrets and as such not tested
- Sometimes are more toxic than active ingredients, include carcinogens, teratogens, neurotoxins
- Some pesticides are known, probable or suspected **Endocrine disruptors** (hormone disruptors).

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Example of importance of formulation

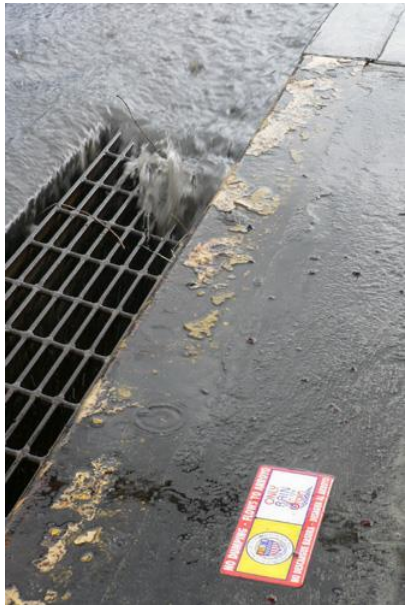
<u>Glyphosate and Roundup</u>

- Roundup surfactant (POEA) approx. 3X as toxic as glyphosate (on a weight basis)
- LC50 (Glyphosate) fathead minnow: 97 mg/L
- LC50 (Roundup) fathead minnow: 2.3 mg/L
- LC50 (POEA) fathead minnow 1.4 mg/L

What can we do to protect our watersheds from NPS pollution??

Homeowners, gardeners, landscapers

- Keep litter, pest wastes, leaves and debris out of street gutters and storm drains (these outlets drain directly to waterbodies)



What can we do to protect our watersheds from NPS pollution??

Homeowners, gardeners, landscapers

- Clean up spilled brake fluid, oil, grease, etc. Do not hose them into the street where they can eventually reach local streams and lakes
- Plant trees, shrubs and ground cover to reduce soil erosion and surface runoff
- Maintain your septic tank and fill line, and pump out solids periodically

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What can we do to protect our watersheds from NPS pollution??

Homeowners, gardeners, landscapers

- Dispose of used oil, antifreeze, paints and other household chemicals properly, NOT in storm sewers or drains

What can we do to protect our watersheds from NPS pollution??

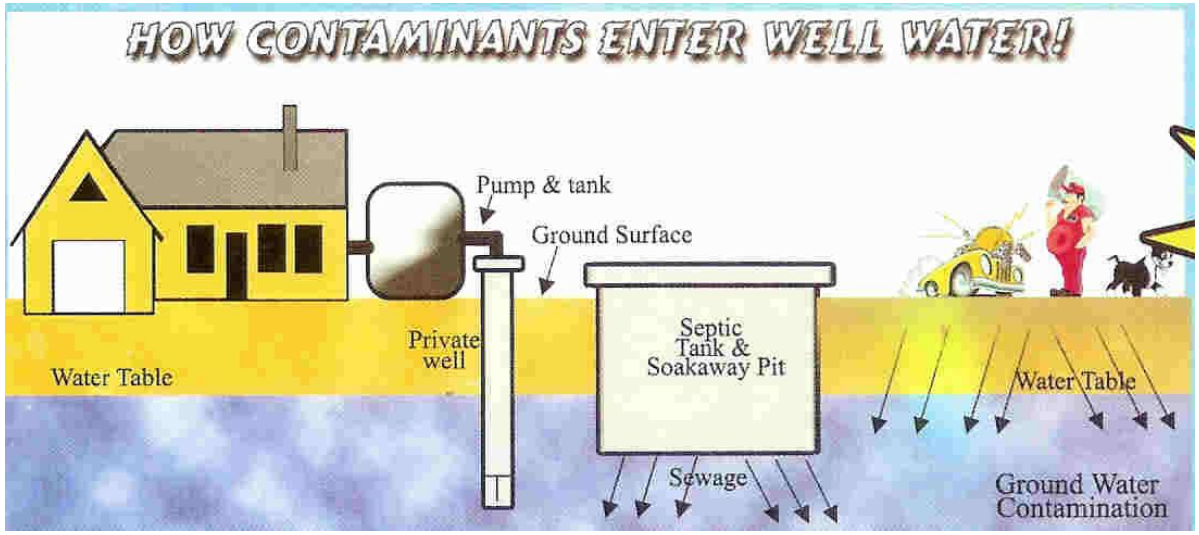
Homeowners, gardeners, landscapers

- Purchase household detergents and cleaners that are low in phosphorus to reduce the amounts of nutrients discharged into waters

What can we do to protect our watersheds from NPS pollution??

Homeowners, gardeners, landscapers

- Rural homeowners should protect private wells by keeping chemicals away from the wellhead and by keeping the septic tank and fill line downhill from the well



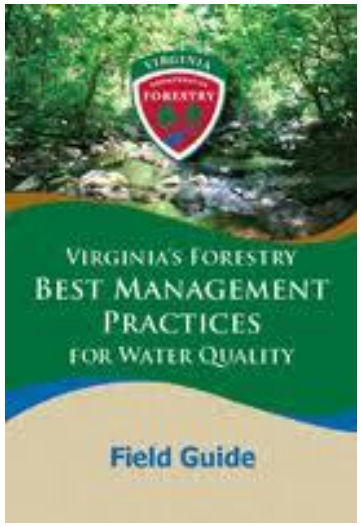
What can we do to protect our watersheds from NPS pollution??

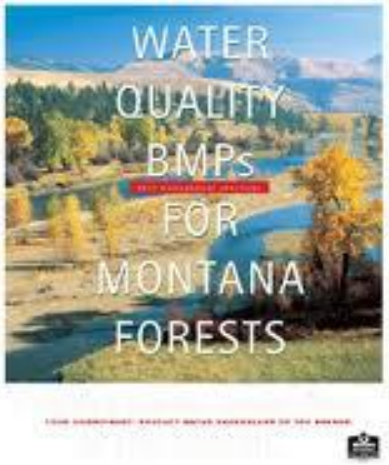
Homeowners, gardeners, landscapers

- Apply lawn and garden chemicals sparingly and according to directions

Best Management Practices (BMPs)

- Science-based holistic environmental management approaches aimed at reducing the possibility of pesticides and other chemicals and sediments of moving off treated areas into receiving water bodies





BMPs: cultural practices

- Establish and maintain untreated buffer strips (10 to 50 ft) between treated areas and receiving surface waters to help prevent runoff of pesticides and fertilizers

- Weed control and tolerance: use of alternative control methods such as cultivation, and allowing some weed growth

BMPs: Pesticide and fertilizer use: Reducing the Risk

Control the rate, method, timing and type of chemicals being applied

In other words…

1. Use only when necessary
2. Use less toxic pesticides
3. Use safe/sensible application methods

Rate of pesticide application

- Use the appropriate (not excessive) pesticide rates. Use <u>as needed only</u> and eliminate routine maintenance programs.
- Adopt an integrated pest management (IPM) approach to use the least amount and least toxic of pesticides possible to achieve acceptable pest control.

Type of pesticide

When possible, select pesticide based on:

- Lowest toxicity to humans, mammals, fish, birds and other invertebrates (bees)
- Rapid degradation and low leaching potential (e.g. higher soil adsorption, lower water solubility, shorter half-life)
- Lowest persistence (the more persistent, the greater chance of off-site movement via leaching or runoff)

Characteristics of pesticides that influence how they act once in soil

- Water solubility – refers to the ability of the chemical to dissolve in water. Affects mobility.
- Half life – refers to the length of time it takes for half of the pesticide to degrade. Affects persistence. Influenced by soil moisture, soil T^o, microbial population, etc.
- Soil adsorption coefficient (Koc) – refers to the tendency of pesticides to bind to soil particles. The more they bind, the less likely to leach into groundwater. Also affects mobility

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Useful websites to learn about pesticide properties

- National Pesticide Information Center (NPIC) (http://npic.orst.edu/)
- Crop Data Management System (CDMS) database (http://www.cdms.net/)
- Extension Toxicology Network (http://extoxnet.orst.edu/)

Type of formulation

- Develop management programs that use pesticide and fertilizer formulations that have LOW runoff potential (e.g. liquid applications rather than granular formulations of pesticides)

Method and Timing

- Avoid pesticide applications just before anticipated rainfall events or when soil moisture conditions are high, or when very windy
- Prevent run-off by managing irrigation so application rates do not exceed infiltration capacity of the soil (i.e. water according to evapotranspiration and soil moisture)
- Do not apply pesticides in an area that is greater than can be quickly and efficiently watered in

Where can I get more information?

- Adopt your watershed (www.epa.gov/adopt)
- Surf your watershed (http://cfpub.epa.gov/surf/locate/index.cfm)
- Earth Force (www.earthforce.org)
- The GLOBE Program (www.globe.gov)
- Project WET (www.ProjectWET.org)
- The Groundwater Foundation (www.groundwater.org)
- EPA groundwater and drinking water site (www.epa.gov/ogwdw)

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Thank you!