**EarthTrends: Featured Topic**

Title: **Dirty Water: Pollution Problems Persist**
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The sight and smell of grossly polluted waterways provided some of the original impetus to the environmental movement in the 1970s. Nearly a century before that, the dangers of polluted water to human health drove what became known as the "sanitary revolution" in Europe and the United States, emphasizing clean water supplies and sewer systems in cities. Today, despite progress in cleaning up waterways in some areas, water pollution remains a serious global problem, with impacts on the health of freshwater ecosystems and the human communities that rely on them for water supply.

## The Changing Pollution Profile

Water pollution spans a wide range of chemical, physical, and microbial factors, but over the years the balance of major pollutants has shifted markedly in most industrialized countries (see Figure 1 for a summary of major pollution sources and their effects). One hundred years ago, the main water contamination problems were fecal and organic pollution from untreated human waste and the byproducts of early industries. Through improved treatment and disposal, most industrialized countries have greatly reduced the effects of these pollutants, with consequent improvements in water quality. Pollution laws and pollution control technologies have succeeded especially well in cutting emissions from concentrated "point sources" like factories and sewage treatment plants. For example, from 1972 to 1992 the amount of sewage treated at wastewater treatment plants in the United States increased by 30 percent, yet the organic pollution (measured as the Biological Oxygen Demand) from these plants dropped 36 percent (CEQ 1995:229).

Unfortunately, a new suite of contaminants from intensive agriculture and development activities in watersheds has kept the cleanup from being complete. In general, national water clean-up programs have not been effective in reducing "nonpoint" pollutants such as nutrients, sediments, and toxics that come in runoff from agriculture, urban and suburban stormwater, mining, and oil and gas operations (NRC 1992:47; EEA 1999:178).

Meanwhile, in most developing countries, the problems of traditional pollution sources like sewage and new pollutants like pesticides have combined to heavily degrade water quality, particularly near urban industrial centers and intensive agricultural areas. (Shiklomanov 1997:28; UNEP/GEMS 1995:6). An estimated 90 percent of wastewater in developing countries is still discharged directly to rivers and streams without any waste processing treatment (WMO 1997:11).

## Nutrient Pollution: The New Danger

The level of nutrients such as nitrates and phosphorous in freshwater ecosystems is a problem worldwide (Shiklomanov 1997:34–36). In most cases, the major cause of these contaminants is the increased use of manure and manufactured fertilizer in global agriculture. In the United States, for example, agriculture is the single greatest source of pollution degrading the quality of surface waters like rivers and lakes, with croplands alone accounting for nearly 40 percent of the nitrogen pollution and 30 percent of the phosphorous (Faeth 2000:6-7). (See Figure 2.)

Natural waters have very low concentrations of nitrates

**WIDE RANGE OF POLLUTANTS STILL DEGRADE WORLD'S WATER**

Figure 1: Common Water Pollutants and their Effects

| POLLUTANT | PRIMARY SOURCE | EFFECTS |
|---|---|---|
| Organic matter | Industrial wastewater and domestic sewage. | Depletes oxygen from the water column as it decomposes, stressing or suffocating aquatic life. |
| Excess nutrients (nitrates, phosphorous) | Runoff from agricultural lands and urban areas. | Overstimulates growth of algae (a process called eutrophication), which then decomposes, robbing water of oxygen, and harming aquatic life. High levels of nitrates in drinking water lead to illness in humans. |
| Heavy metals | Industries and mining sites. | Persists in freshwater environments, like river sediments and wetlands for long periods. Accumulates in the tissues of fish and shellfish. Toxic to both acquatic organisms and humans who eat them. |
| Microbial contaminants (e.g., cryptospori-dium, cholera, and other bacteria, amoebae, etc.) | Domestic sewage, cattle, natural sources. | Spreads infectious diseases through contaminated water supplies, causing millions of cases of diarrheal diseases and intestinal parasites, and providing one of the principal causes of childhood mortality in the developing world. |
| Toxic organic compounds (oil, pesticides, some plastics, industrial chemicals) | Wide variety of sources, from industrial sites, to automobiles, to farmers, and home gardeners. | Displays a range of toxic effects in aquatic fauna and humans, from mild immune suppression, to acute poisoning, or reproductive failure. |
| Dissolved salts (salinization) | Leached from alkaline soils by overirrigation, or drawn into coastal aquifers from overdrafting of groundwater. | Leads to salt build-up in soils, which kills crops or cuts yields. Renders freshwater supplies undrinkable. |
| Acid precipitation or acidic runoff | Deposition of sulfate particles, mostly from coal combustion. Acid runoff from mine tailings and sites. | Acidifies lakes and streams, which harms or kills aquatic organisms and leaches heavy metals such as aluminum from soils into water bodies. |
| Silt and suspended particles | Soil erosion and construction activities in watersheds. | Reduces water quality for drinking and recreation and degrades aquatic habitats by smothering them with silt, disrupting spawning, and interfering with feeding. |
| Thermal pollution | Fragmentation of rivers by dams and reservoirs, slowing water and allowing it to warm. Industrial uses such as cooling towers. | Affects oxygen levels and decomposition rate of organic matter in the water column. May shift the species compostion of a river or lake. |

Sources: Taylor and Smith 1997; Shiklomanov 1997; UNEP/GEMS 1995.

(a soluble from of nitrogen) and phosphorous, but nutrient levels increase with runoff from farm lands as well as from urban and industrial wastewater. Dissolved nutrients act as fertilizers, stimulating algal blooms and the eutrophication of many inland waters. This can rob the water column of dissolved oxygen, kill aquatic organisms, and degrade water quality. Dissolved nitrates in drinking water can also harm human health.

Data on nutrient trends in global waters are spotty and only give the most generalized picture of current conditions. The relevant water data from the UN's Global Environment Monitoring System (GEMS), for example, only cover 1976-1990. Of these globally monitored watersheds, the highest nutrient concentrations come from sampling stations in Europe. Nitrate concentrations are higher in

**AGRICULTURE IS PRIMARY SOURCE OF NUTRIENT POLLUTION IN U.S. WATERS**

Figure 2: Nitrogen and Phosphorous Discharges to U.S. Surface Waters from Point and Nonpoint Sources (in thousands of metric tons per year)

| SOURCE | NITROGEN | PHOSPHOROUS |
|---|---|---|
| **Nonpoint sources** | | |
| Croplands | 3,204 | 615 |
| Pastures | 292 | 95 |
| Rangelands | 778 | 242 |
| Forests | 1,035 | 495 |
| Other rural lands | 659 | 170 |
| Other nonpoint sources | 695 | 68 |
| **Total nonpoint discharges** | 6,663 | 1,658 |
| **Total point sources** | 1,495 | 330 |
| **Total discharge (point + nonpoint)** | 8,158 | 2,015 |
| **Nonpoint as a percentage of total** | 82% | 84% |

Source: Carpenter et al. 1998.

watersheds that have been intensively used and modified by human activity, such as the Weser, Seine, Rhine, Elbe, and Senegal. High levels are also found in such watersheds in China, South Africa, and the Nile and Mississippi basins (UNEP/GEMS 1995:33-35).

In South America, nitrate concentrations in the monitored watersheds are relatively low and follow human land use. The highest nitrate concentrations are found in the Uruguay watershed, where some of the most intensive agriculture on the continent is found. Nitrate concentrations are also greater in the Magdalena watershed of Colombia than in the less densely populated watersheds of the Amazon basin (UNEP/GEMS 1995:33–35). The nitrate concentrations in South America correspond to lower fertilizer application rates, compared to Europe.

More detailed and recent data available in Europe show distinct regional trends in the concentrations of nitrates and phosphorous in rivers. Nitrate loadings are highest in areas with intensive livestock and crop production, especially in the northern parts of western Europe. Nitrate concentrations are lowest in Finland, Norway, and Sweden. Overall nitrate concentrations in monitored European rivers have not changed significantly since 1980, despite lower nitrogen fertilizer application rates since the 1990s (EEA 1998:194–197; EEA 1999:176–177).

Similar regional patterns are also evident in phosphorous trends. Rivers in Finland, Norway, and Sweden have the lowest phosphorous concentrations, whereas areas from southern England across central and western Europe show the highest levels (EEA 1999:174). In general, phosphorous concentrations have decreased significantly since 1985, mostly due to improvements in wastewater treatment and the reduced use of phosphorous in detergents. However, phosphorus levels remain a problem in most regions of Europe (EEA 1999:174). Despite some positive trends, the overall state of many European rivers with respect to nutrient concentrations remains poor (EEA 1998:194-196).

Figure 3 shows water quality data for the United States for the 1980s. For the 1980–89 period, nitrate concentrations remained relatively stable, with most monitoring stations showing no discernable trend. This probably reflects the fact that nitrogen fertilizer use in the United States leveled off after steady increases in the 1970s. Fertilizer application rates increased for the period 1974–1981, and nitrate concentrations increased as well during that period. Average nitrate concentrations were greater in agricultural and urban areas than in forested areas (Smith et al. 1994:122).

Trends in phosphorous concentrations in the United States showed greater improvement, with five times more states showing downward trends than upward trends. Decreases were more likely to be found in the East, Midwest, and the Great Lakes regions, while the majority of increases occurred in the Southeast (Smith et al. 1994:124).

The decreased concentrations of phosphorous in streams and rivers in the United States is attributable to reduced phosphorous in laundry detergents and improved controls in wastewater treatment plants. The increased number of sewage treatment plants has also reduced the amount of nitrogen in the form of ammonium, which is toxic to fish. However, the sewage treatment process converts ammonium to nitrates that are still released into waterways. Thus, the greater number of sewage treatment facilities has not necessarily decreased the total amount of nitrogen flowing into waterways (Mueller and Helsel 1996).

**Groundwater Contamination**

Surface waters like streams and lakes are not the only water sources that suffer from pollution. Groundwater aquifers, which are critical sources of both drinking water and irrigation water, are also affected. The major causes of groundwater pollution are leaching of pollutants from agriculture, industry, and untreated sewage, as well as saltwater intrusion caused by overpumping.

Once pollutants enter a groundwater aquifer, the environmental damage can be severe and long lasting, partly because of the very long time needed to flush pollutants out of the aquifer (UNEP 1996:14). Because groundwater is primarily used for drinking water, pollution from untreated sewage, intensive agriculture, solid waste disposal, and industry can cause serious human health problems (Shiklomanov 1997:42).

Global data on the quality of groundwater resources are lacking. Even where available, data usually are not comparable because of the different measures and standards used, which vary by country (Shiklomanov 1997:42; Scheidleder et al. 1999:11; S. Foster, personal communication, 2000). However, there is evidence that groundwater contamination from fertilizers, pesticides, industrial effluents, sewage, and hydrocarbons is occurring in many parts of the world.

As with surface waters, nitrate pollution is one of groundwater's most serious threats. In general, the risk of nitrate pollution for groundwater supplies is directly related to the amount of fertilizers or other nitrogen inputs to the land, as well as the permeability of the soil. For example, half the groundwater samples in a heavily fertilized region of northern China contain nitrate levels above the safe limit for drinking water (Zhang et al. 1996:224). In the United States, where groundwater supplies drinking water for more than half the population, a preliminary analysis of nitrate contamination found that high nitrate concentrations are widespread in shallow groundwater aquifers in agricultural areas (USGS 1999:41). Groundwater

**NITRATE CONCENTRATION STABILIZE IN THE 1980s**

Figure 3: Trends in U.S. Stream Water Quality, 1980-89

| Water Quality Indicator | Number of Sampling Stations | Stations with Upward Trend in Concen-tration | Stations with Down-ward Trend in Concen-tration | Stations with No Concen-tration Trend |
|---|---|---|---|---|
| Dissolved Solids | 340 | 28 | 46 | 266 |
| Nitrate | 344 | 22 | 27 | 295 |
| Total Phosphorous | 410 | 19 | 92 | 299 |
| Suspended Sediments | 324 | 5 | 37 | 282 |
| Dissolved Oxygen | 424 | 38 | 26 | 360 |
| Fecal Coliform | 313 | 10 | 40 | 263 |

Source: Data are from the USGS National Stream Quality Accounting Network (NASQAN), quoted in CEQ 1995.

Note: Although data on stream water quality are continuously monitored, these are the latest aggregated figures published for all monitoring stations.

pollution in Europe is similarly widespread (Scheidleder et al.1999).

## Conclusion

Surface water quality has improved in most developed countries during the past 20 years, but nitrate and pesticide contamination remain persistent problems. Data on water quality in other regions of the world are sparse, but water quality appears to be degraded in almost all regions with intensive agriculture and rapid urbanization. Unfortunately, little information is available to evaluate the extent to which chemical contamination has impaired the health of freshwater ecosystems. However, incidents of algal blooms and eutrophication are widespread in freshwater systems all over the world—an indicator that these systems are profoundly affected by water pollution. In addition, the massive loss of wetlands at a global level has greatly impaired the capacity of freshwater systems to filter and purify water. Groundwater quality suffers from many of the same pollution problems as surface waters and faces the additional challenge of being very difficult to restore once the underlying aquifer is contaminated.

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