

## 9.4: Water Pollution

Water receives a number of different kinds of pollutants and moving water is one of the main pathways of pollutant transport. Water pollutants are of concern for a variety of effects. These include general water quality, toxicity, effects on aquatic organisms, esthetics, eutrophication, and water oxygen levels. Some of the main categories of water pollutants are discussed here.

Several kinds of pollutants are detrimental to water that is a source of water supply. **Taste, odor, and color** are caused by a variety of impurities. **Sediments** require removal and sometimes special measures are needed to coagulate and settle colloidal suspended matter. Acidity, alkalinity, and salinity at excessive levels are water pollutants.

Some pollutants are picked up by water as a natural consequence of its use in municipal water systems, which take in potable water fit to drink and discharge wastewater. One of the main ones of these consists of sewage including human wastes, food wastes, and other substances that get into water through bathrooms and kitchens. A major component of these water pollutants consists of biodegradable organic matter, abbreviated here as  $\{\text{CH}_2\text{O}\}$  and commonly called **biochemical oxygen demand, BOD**, which rapidly depletes receiving water of its dissolved oxygen by the following microbially-mediated process:



Another class of pollutants picked up in municipal water systems and produced in the biodegradation of sewage is composed of **algal nutrients**, primarily nitrogen ( $\text{NH}_4^+$ ,  $\text{NO}_3^-$ ), phosphates ( $\text{H}_2\text{PO}_4^-$ ,  $\text{HPO}_4^{2-}$ ), and potassium ( $\text{K}^+$ ). Rather than being toxic, these materials cause algae to grow in excess in receiving waters producing too much biomass which degrades as shown in Reaction 9.4.1 and depletes the dissolved oxygen in the water, a process called **eutrophication**. **Detergents** are common pollutants in municipal wastewater and can be harmful because of their content of **surfactants** (basically, the ingredient that lowers water surface tension making it “wetter”) and **builders** added to assist detergent action, formerly a major source of phosphates in wastewater.

A variety of trace **inorganic compounds** can be water pollutants. These include algal nutrients and salts responsible for excess acidity, alkalinity, and salinity mentioned above. Other inorganic pollutants include odorous hydrogen sulfide ( $\text{H}_2\text{S}$ ), oxygen-demanding sulfite ( $\text{SO}_3^{2-}$ ), and, in rare cases from mineral processing waste, highly toxic cyanide,  $\text{CN}^-$ . Trace levels of a variety of elements can be undesirable pollutants. Especially significant of these are toxic **heavy metals** including lead, cadmium, and mercury and metalloid arsenic. **Organically-bound metals** are undesirable. As noted in Section 9.3, iron bound with humic substances causes water color and is particularly difficult to remove. **Methylated forms** of mercury and arsenic (those containing a  $-\text{CH}_3$  group bound to the element) can be mobilized from sediments and get into water. Dimethylmercury,  $\text{Hg}(\text{CH}_3)_2$ , is particularly toxic and undergoes biomagnification through the food chain, accumulating in fish tissue. In addition to the methylated compounds, other **organometallic compounds** made synthetically can be troublesome toxic water pollutants. Until it was banned, tetraethyl lead used as a gasoline additive could get into water and more recently organotin compounds used in biocidal paints to prevent growth of organisms on ship hulls have been toxic to sediment-dwelling organisms.

In some cases **radionuclides** occur as water pollutants. Leakage of radioactive tritium, a form of hydrogen, has gotten into water from reactors. The radionuclide of most concern usually is radium from natural sources and a number of groundwater sources of water have been discontinued because of the presence of radium.

A variety of **organic compounds** occur as water pollutants. These include industrial chemicals, petroleum products (especially significant in light of the notorious 2010 leak from the Deepwater Horizon oil spill that dumped as much as 5 million gallons of crude oil into the Gulf of Mexico and caused billions of dollars in pollution damage to the Gulf and its shore areas), polychlorinated biphenyls (PCBs, now banned from manufacture but still sometimes encountered, especially in sediments), and dioxin. **Pesticides** are common water pollutants of which **herbicides** such as atrazine are a concern because of their widespread application to land. Some organic water pollutants call for particular attention because of their potential biological activity and toxicity. **Carcinogens** are an obvious case. **Pharmaceuticals** and their metabolites have emerged as a concern and are currently one of the “hottest” areas of water pollution research. A wide variety of these get into wastewater and sometimes into water supplies, though in minuscule quantities.

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