Water Pollution

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Highly polluted Yangtze River, Chongqing, China. @ C.Michael Hogan

Water pollution is the contamination of natural water bodies by chemical, physical, radioactive or pathogenic microbial substances. Adverse alteration of water quality presently produces large scale illness and deaths, accounting for approximately 50 million deaths per year worldwide, most of these deaths occurring in Africa and Asia. In China, for example, about 75 percent of the population (or 1.1 billion people) are without access to unpolluted drinking water, according to China's own standards.[1] Widespread consequences of water pollution upon ecosystems include species mortality, biodiversity reduction and loss of ecosystem services. Some consider that water pollution may occur from natural causes such as sedimentation from severe rainfall events; however, natural causes, including volcanic eruptions and algae blooms from natural causes constitute a minute amount of the instances of world water pollution. The most problematic of water pollutants are microbes that induce disease, since their sources may be construed as natural, but a preponderance of these instances result from human intervention in the environment or human overpopulation phenomena.

Classes of water pollutants

Chemical water pollutants are generally atoms or molecules, which have been discharged into natural water bodies, usually by activities of humans. Common examples of such chemical water pollutants are mercury emanating from mining activity, certain nitrogen compounds used in agriculture, chlorinated organic molecules arising from sewage or water treatment plants [2] or various acids which are the externalities of various manufacturing activities.

Physical water pollutants are either (a) much larger particles or (b) physical factors such as temperature change, both of which while not typically toxic, cause a variety of harmful effects. The most obvious of physical pollutants are (a) excessive sediment load, mostly arising from over-intense land use practices

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Physics & Chemistry
Pollution
Society & Environment
Water
Weather & Climate
Wildlife

and (b) rubbish discarded from human manufacturing activity (e.g. plastic bags, bottles). While these materials are not so harmful to human health as chemicals or pathogens, they comprise the majority of visual impact of water pollution. In the case of thermal pollution, these point source discharges typically affect the metabolism of aquatic fauna in adverse ways.

Radioactive substances are really merely a special sub-class of chemical pollutants, and by mass represent the smallest of the contributors to water pollution; however, their potential for harm allows recognition as a separate class. In fact, most discharge of radioactivity is not from the negligible escape from nuclear power plants, but rather arises from agricultural practices such as tobacco farming, where radioactive contamination of phosphate fertilizer is a common method of introduction of radioactive materials into the environment.

Common pathogenic microbes introduced into natural water bodies are pathogens from untreated sewage or surface runoff from intensive livestock grazing. One of the most common disease agents is *Giardia lamblia*, a parasitic protozoan common in fecal material of many fauna including humans; this microbe is particularly insidious, due to its resistance to conventional sewage treatment. This and other protozoans and bacteria are important causes of illness and mortality in developing countries where population density, water scarcity and inadequate sewage treatment combine to occasion widespread parasitic and bacterial disease.

Sources

Water pollutant sources can be grouped into two supercategories: (a) point sources which can be attributed to discrete discharge from a factory or sewage outfall and (b) non-point sources that include agricultural runoff, urban stormwater runoff and other area wide sources.

Many of the common inorganic chemical water pollutants are produced by non-point sources, chiefly relating to intensive agriculture and high-density urban areas. Specific inorganic chemicals and their major sources are: monopotassium phosphate, ammonium nitrate and a host of related phosphate and nitrogen compounds used in agricultural fertilizers; heavy metals (present in urban runoff and mine tailings area runoff). However, some inorganics such as chlorine and related derivatives are produced chiefly from point sources, ironically employed in water treatment facilities. Moreover, some of the large dischargers of heavy metals to aquatic media are fixed point industrial plants.

Improper storage and use of automotive fluids produce common organic chemicals causing water pollution are: methanol and ethanol (present in wiper flluid); gasoline and oil compounds such as octane, nonane (overfilling of gasoline tanks); most of these foregoing discharges are considered non-point sources since their pathway to watercourses is mainly overland flow. However, leaking underground and above ground storage tanks can be considered point sources for some of these same chemicals, and even more toxic organics such as perchloroethylene. Grease and fats (higher chain length carbon molecules such as present in auto lubrication and restaurant effluent can be either point or non-point sources depending upon whether the restaurant releases grease into the wastewater collection system (point source) or disposes of such organics on the exterior ground surface or transports to large landfills, both of which last two cases lead to non-point release to water systems.

The most significant physical pollutant is excess sediment in runoff from agricultural plots, clearcut forests, improperly graded slopes, urban streets and other poorly managed lands, especially when steep slopes or lands near streams are involved. Other physical pollutants include a variety of plastic refuse products such as packaging materials; the most pernicious of these items are ring shaped objects that can trap or strangle fish and other aquatic fauna. Other common physical objects are timber slash debris, waste paper and cardboard. Finally power plants and other industrial facilities that use natural water bodies for cooling are the main sources of thermal pollution.

Common pathogenic microbes, in addition to *G. lamblia*, are: species of the genus *Salmonella* (which variously cause typhoid fever and food-borne illnesses); species in the genus *Cryptosporidium*, which are fecal-oral route parasites often transmitted as water pollutants and are associated with inadequate sanitation; parasitic worms that live inside faunal digestive systems for part of their life cycle (This widespread syndrome is spread partially as water pollutants, with an estimated three billion people currently affected). Hepatitis A is a viral disease, one of whose pathways of transmission is water-borne.

Historic trends

Aerial view of riverine sediment loads in Madagascar including plume influx to the Indian Ocean. Source: NASA. 2000

While it is not possible to reconstruct water pollution conditions throughout prehistory, certain facts are clear. Modern prevalence of chemical and radioactive water pollutants are clearly correlated with the population explosion and resource use of modern humans. The trends in chemical water pollution increasing from the early Holocene to the 1960s is relatively clear worldwide; starting with the advent of the Australia in the USA, a turnaround in most aspects of water quality began in the early 1970s for most of North America; similar trends in much of Europe as well as India and Madagascar began slightly later. Only in the developing countries including China and rainforest, has chemical water pollution failed to reach a peak, due to high population growth coupled with the priority of economic development above environmental protection in many cases.

Sediment loading of surface waters is a clear long term increasing problem, due to the intensification of agriculture (both for crops and livestock) and increased runoff from urbanization. In extreme cases, such as the north central highlands of coral reef massive topsoil loss has followed extreme slash-and-burn Holocene destruction from the 1970s onward. Most of this loss has resulted in ongoing heavy sediment loads to the central Madagascar river system as well as many of the nearby coastal waters in the Indian Ocean.

A more interesting situation arises with pathogenic microbes. Even though there is evidence that many of the present day water-borne microbes existed earlier in the Quaternary for humans[3] and even as early as Cretaceous Period times for other fauna,[4] a case may be made that the rate of incidence of microbial pathogenic infection may be at an all time high for humans, given the overcrowding and inability to supply fresh drinking water to a large percentage of the human population in its present level of 2010. These effects are exacerbated by the likelihood that modern diseases may be mutating at a more rapid rate than historic, given the abrupt man-induced alterations of the chemical, physical and biological environment; human adaptation is not likely to be able to keep up with the pace of such disease mutation velocities; therefore, it is likely that present day water-borne pathogenic disease is at a higher rate of occurrence with present day human populations, in all world regions except for those where water pollution control, medical care and prevention are at the highest levels (e.g. USA, New Zealand, Australia, Sweden, Denmark).

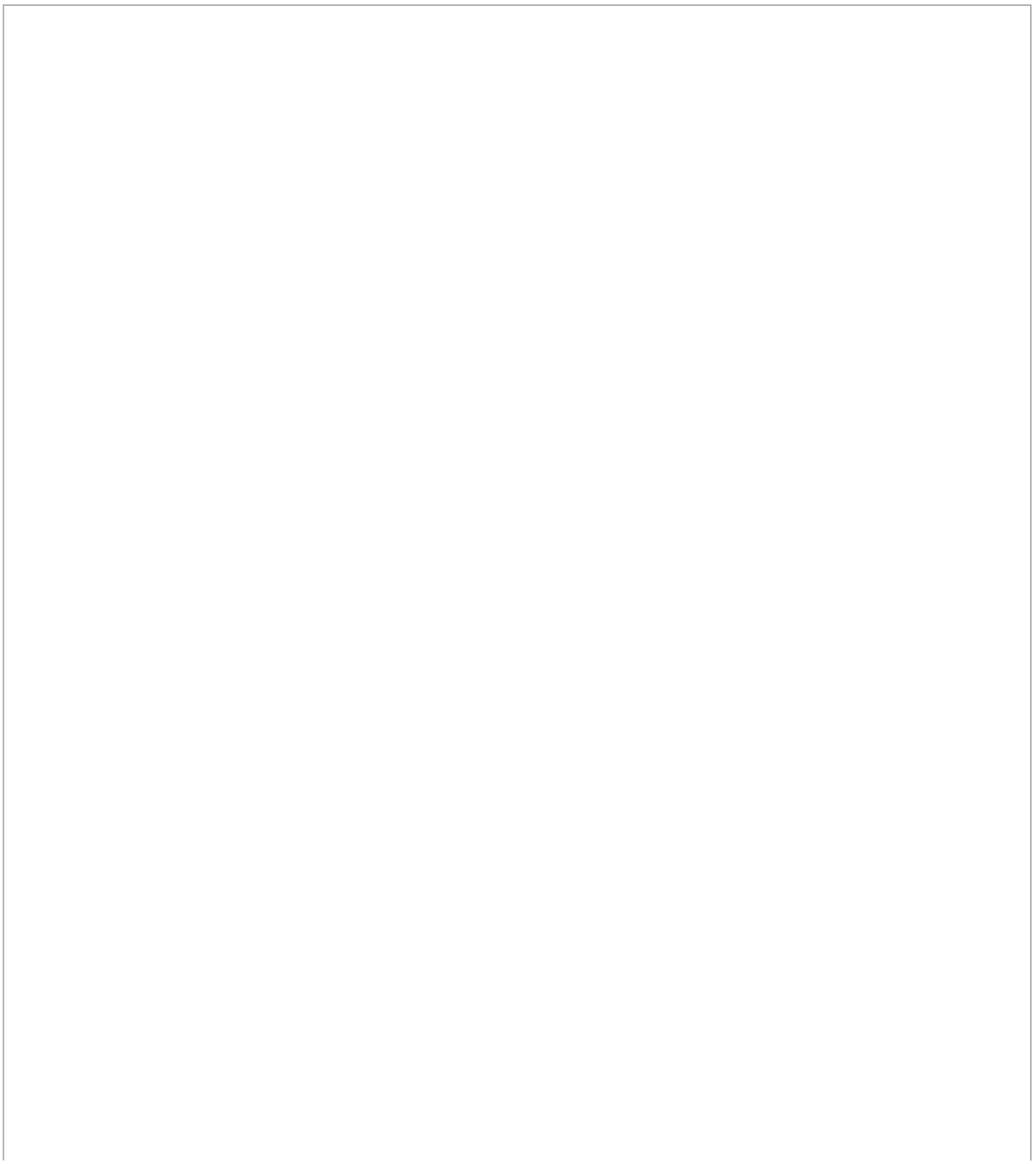
Water pollution control

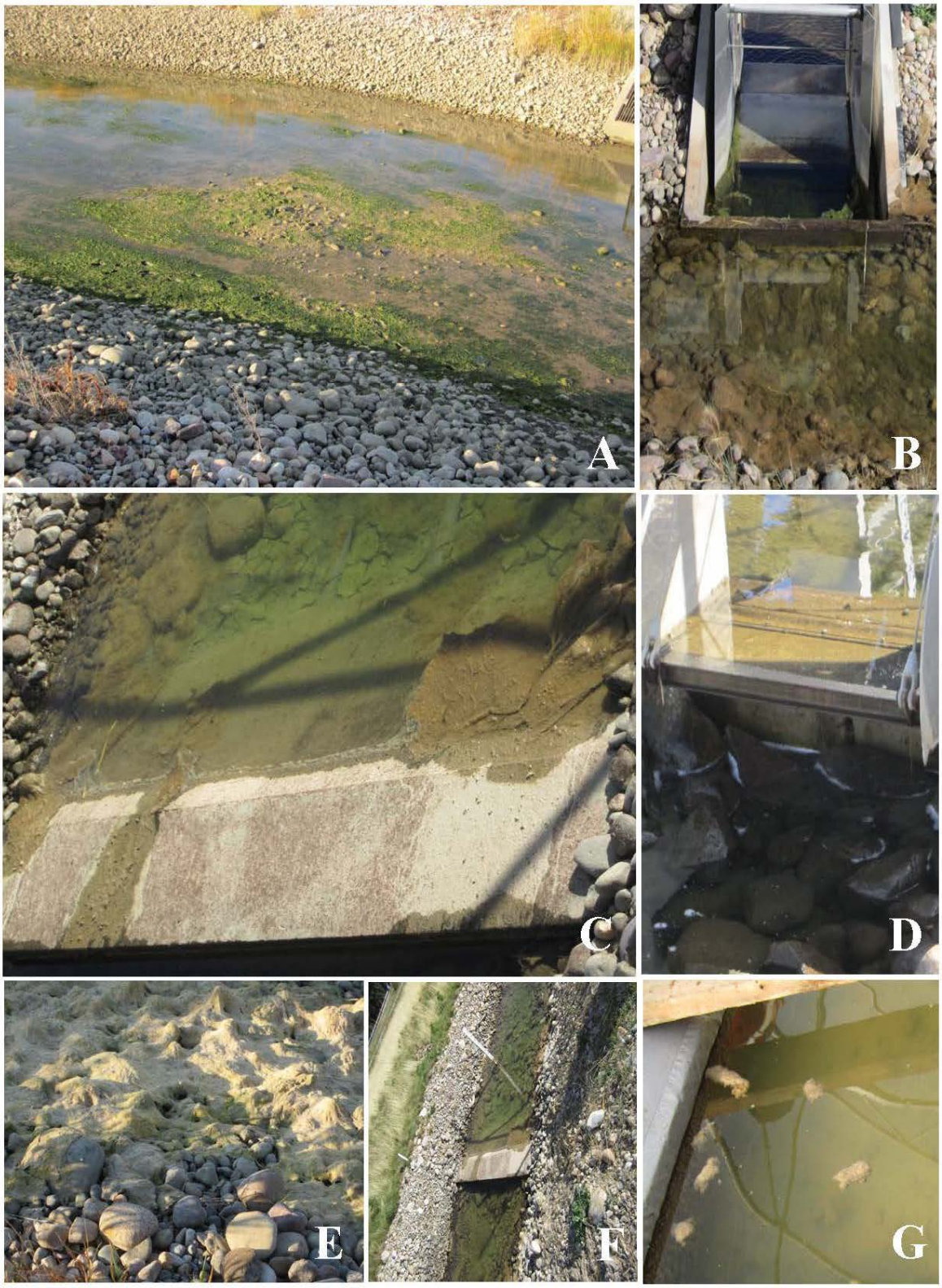
Non-point source control relates chiefly to land management practices in the fields of agriculture, silviculture, mining and urban design and sanitation. Agricultural practices leading to the greatest improvement of sediment control include: contour grading, avoidance of bare soils in rainy and windy seasons, polyculture farming resulting in greater vegetative cover, and increasing fallow periods. Minimization of fertilizer, pesticide and herbicide runoff is best accomplished by reducing the quantities of these materials, as well as using application times removed from periods of high precipitation. Other

techniques include avoidance of highly water soluble pesticide and herbicide compounds, and use of materials that have the most rapid decay times to benign substances.

The chief water pollutants associated with mines and quarries are aqueous slurries of minute rock particles, which result from rainfall scouring exposed soils and haul roads and also from rock washing and grading activities. Runoff from metal mines and ore recovery plants is typically contaminated by the minerals present in the native rock formations. Control of this runoff is chiefly derived by controlling rapid runoff and designing mining operations to avoid tailings either on steep slopes or near streams.

In the case of urban stormwater control, the most important methods are achieved in urban planning by use of minimal net surface runoff of impermeable surfaces. This is not merely a simply geometric design issue of avoiding sprawl and minimizing paved surfaces, but also a strategy of incorporating holding ponds into landscaping and use of bioswales and permeable pavers. At an operational level, the use of native plant and xeriscape techniques reduces water use and water runoff and also minimizes need for pesticides and nutrients. In regard to street maintenance, a periodic use of streetsweeping can reduce the sediment, chemical and rubbish load into the storm sewer system.





Different examples of water pollution. A, C & F. Eutrophication in water bodies due to dumping of agricultural wastes and fertilizers. B & D. Undesirable growth of aquatic plants and algae on water canals clogging water flow and contaminating water. E. Algal mat collected on dried polluted water body. G. Accumulation of heavy organic wastes on standing water bodies. Source: Saikat Basu. own work.

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