Chapter 11

Sources of Groundwater Pollution

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ABSTRACT

In many regions in the world, groundwater represents an important source of fresh water. It is now established that several contaminants enter groundwater from a number of sources and pathways. These sources are both natural and anthropogenic. Contamination of groundwater resources by a variety of anthropogenic pollutants from both point and nonpoint sources represents a key global environmental problem. The most frequently identified contaminant sources are industrial manufacturing, agricultural activities, municipal landfills, and wastes. Frequently detected contaminants included nitrates, volatile organic compounds, arsenic, and fluorides. Other contaminant species include solvents, fuel hydrocarbons, heavy metals, pesticides, disinfectants, detergents, and radionuclides. In this chapter, the main sources and pathways for contaminants in groundwater are reviewed. It identifies challenges that need to be met to minimize risk to drinking water and ecosystems. Particular attention is paid to the occurrence of known and potential endocrine disrupting substances in groundwater.

1. INTRODUCTION

Water is an essential component of life. Almost all organisms including human beings are dominantly made up of water and rely on water to regulate temperature, carry dissolved materials inside and between cells, remove waste products, etc. Human beings need to consume large quantities of fresh and clean water. Of the earth’s total amount of fresh water, around 75% exists in the frozen state in polar ice caps and glaciers, while less than 2% is in surface waters and a relatively small amount is contained in unsaturated soil. That leaves nearly 22% of our planet’s fresh water that permeates porous rocks and sediments, at some depth below the ground surface, called groundwater. The importance of this water as part of the biosphere is now widely recognized.
In many regions, groundwater constitutes an important source of fresh water for domestic, agricultural or industrial use. It provides also the most reliable perennial source of freshwater on earth. Groundwater resources have been threatened not only by excessive withdrawal but also by contamination resulting from past and present industrial, agricultural and commercial activities. Most natural groundwaters contain at least some amount of dissolved substances that we think of as contaminants. These contaminants result from the deliberate use of chemicals in industry and agriculture, waste disposal, unintended transport accidents, leaking storage facilities and other human activities.

Because it lacks visibility, groundwater is difficult to understand and easy to overlook. Ignorance has led to its abuse and abuse to endangering critical supplies, both in terms of quantity and quality. The reduction of groundwater supply from overuse and degradation of groundwater quality by contamination in many countries have become major issues bearing on public health and socioeconomic development. There is a growing concern about the impacts of groundwater contamination on hydrological, biological and ecological systems.

Furthermore, because of the relatively slow rates of recharge and fluid migration through the subsurface environment, and because of the vast potential for exposure of subsurface materials to sources of pollution, groundwater contamination represents a critical resource problem to the generation to become.

The term contamination is used for addition of any solute into the hydrological system as a result of man’s activity while the term pollution is restricted to a situation when the contamination attains levels that are considered to be objectionable (Singhal and Gupta, 2010).

Examples of typical groundwater contaminants include industrial chemicals (solvents, fuels, heavy metals, etc), agricultural chemicals (fertilizers, pesticides, etc) and municipal wastes (fecal coliform, nutrients, NO₃⁻, disinfectants, detergents, etc). Today, more than 1,000 organic chemicals have been identified in groundwater. Some contaminants adsorb onto the surface of aquifer solids, moving very little from their source, while others migrate freely with the flowing pore water, sometimes ending up many kilometers from their source. Chemical reactions along the way can cause a contaminant to disappear or worse, appear from apparently nowhere.

It is now established that these compounds enter the environment from a number of sources and pathways. These sources are both natural and human-induced. Based on the contamination properties, groundwater contamination sources can also be classified as point sources and nonpoint sources. Point sources are those that release contaminants from a discrete geographic location, including leaking underground storage tanks, ruptured transfer pipes, septic systems, injection wells, landfills and spillage due to traffic accidents. Such sources threaten groundwater resources directly at the point of entry, where transport processes may subsequently facilitate migration.

Nonpoint sources of contamination are more extensive in area and diffuse in nature. For example, agricultural activities, large industrial areas and urban runoff are potential nonpoint sources. These nonpoint sources threaten regional water resources on a larger scale. The main anthropogenic sources of groundwater contaminants are various industries that emit hazardous chemicals. In fact, in the last century, the rise of industrial manufacturing complexes and synthetic chemicals have led to the release of complex mixtures of contaminants. Another major source of groundwater contaminants is associated with agricultural activities. In agricultural practice, pesticides, fertilizers and sometimes animal wastes, human wastes or sewage sludge are applied to the cropland. Excessive use of fertilizers makes NO₃⁻ the most ubiquitous contaminant in groundwater. Animal and human wastes contribute to the elevation of pharmaceutical agents, NO₃⁻, phosphorous, pathogens and viruses in groundwater. Other sources of groundwater aquifer contamination includes, mining activities, oil and gas exploration, septic and un-
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