

Pollution of Groundwater

Paper- Advanced Hydrogeology

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Pollution of groundwater

- ❑ Pollution is a modification of the physical, chemical and biological properties of water, preventing its normal use in various applications.
- ❑ The degradation of natural quality of groundwater.
- ❑ **Pollution** shall signify any degradation of natural quality, while **contamination** shall be reserved for pollution that constitutes a hazard to human health.

Point & Nonpoint Sources

It is easier to control pollution that comes from a distinct source than pollution that does not come from a distinct source.

- **point sources** discharge pollutants at specific locations through pipes, ditches, or sewers which can be traced and identified (e.g., factories, sewage treatment plants, mines, oil wells, oil tankers);
- **nonpoint sources** can not be traced to a single site of discharge (e.g., acid deposition, substances picked up in runoff, seepage into groundwater);
- nonpoint source water pollution from agriculture is largest source of water pollution (64% of pollutants into streams & 57% of pollutants entering lakes).

☐ Sources:

The major sources of groundwater pollution can be classified as municipal, industrial, and agricultural and miscellaneous.

➤ Municipal Sources and Causes:

Municipal water pollution consists of waste water from homes and commercial establishments.

- **Sewer leakage:**

- ✓ Leakage may be results from defective sewer pipe, breakage by tree roots, rupture from heavy loads, fracture from heavy loads and seismic activity etc.
- ✓ Sewer leakage can introduce high concentration of BOD, COD, nitrate, possibly bacteria into groundwater.
- ✓ In industrial areas heavy metals such as As, Cd, Cr, Co, Cu, Fe, Pb may be within the waste water.

- **Liquid waste:**

- ✓ Wastewater in an urban area may originate from domestic uses.
- ✓ These waste waters can be reused after some treatments which accomplished by three methods
 - i. **Irrigation** – waste water is applying by spraying, ridge and furrow and flooding.
 - ii. **Infiltration- Percolation** – effluent is applied by spraying or by spreading in basins.
 - iii. **Overland flow** – wastewater is sprayed over the upper reaches of sloped terraces and allowed to flow across a vegetated surface runoff.
- ✓ Wastewater can introduce bacteria, virus, and inorganic and organic chemicals into the groundwater.
- ✓ Chlorination of wastewater can produce additional potential pollutants.

- **Solid waste:**

- ✓ Landfills are simply refused dumps.
- ✓ A landfill may of any land area serving as a deposing of urban or municipal solid waste.
- ✓ Leachate from a landfill can pollute groundwater if water moves through the fill material.
- ✓ Another possible sources include precipitation, surface water infiltration, percolation water from adjacent areas and groundwater in contact with the fill.
- ✓ Important pollutants frequently found in leachate include BOD, COD, Fe, Mn, Cl, NO₃, hardness and trace elements.

- **Septic tanks and cesspools:**

- ✓ A septic tank is a watertight basin intended to separate floating and settleable solids from the liquid fraction of domestic sewage and to discharged this liquid with its dissolved and suspended solids into the biologically active zone of soil mantle through a subsurface percolation systems.
- ✓ A cesspool is a large buried chamber with porous walls designated to receive and percolate raw sewage.
- ✓ Domestic sewage adds minerals to groundwater, bacteria, virus, and phosphorous is generally retained by soil system, but significant quantities of nitrogen can be added to groundwater.

- **Roadway Deicing:**

- ✓ Application of deicing salts (sodium chloride) to streets and highways in winter may results pollution of groundwater.
- ✓ Urban areas with winter temperatures below freezing are affected the most. But it has increasing demand for maintaining streets, highways in safe driving conditions throughout the winter.
- ✓ The salts have produced widespread degradation of groundwater quality.

➤ Industrial Sources and causes:

• Liquid waste:

- ✓ Major use of water in industrial plants are for cooling, sanitation and manufacturing and processing.
- ✓ The wastewater quality varies with the type of industry and type of use.
- ✓ Groundwater pollution can occur where industrial wastewater are discharged into pits, ponds and lagoons, thereby enabling the wastes to migrate down to the water table.
- ✓ The disposal of hazardous and toxic material wastes is sometimes accomplished by means of deep injection wells that place the fluids into the formation far below developed freshwater aquifers.

• Tank and pipeline leakage:

- ✓ These are used in industry for underground storage and transmission of a wide variety of fuels and chemicals.
- ✓ If these are subjected to structural failures so that subsequent leakage becomes a source of groundwater pollution.
- ✓ Petroleum and petroleum products moves downward through permeable strata until it reaches the water table and migrates laterally with the groundwater flow.
- ✓ Liquid radioactive wastes sometimes stored in underground tanks; leakage from such installations which has occurred, can cause serious pollution problems in local groundwater.

- **Mining activities:**

- ✓ Both surface and underground mines invariably extends below the water table so that dewatering to expand the mining is common.
- ✓ Water so pumped may be highly mineralized and is referred to as “Acid mine drainage”. Normal characteristics include low pH and high iron, aluminium, and sulphate.
- ✓ Coal deposits are often associated with pyrite (FeS_2). This is stable condition below the water table, but if the water table is lowered, oxidation occurs. Oxidation of pyrites followed by contact with groundwater produces ferrous sulfate (FeSO_4) and sulfuric acid in solution.
- ✓ Pollution may also results from the leaching of old mine tailings and settling ponds.

- **Oil- field brine:**

- ✓ The production of oil and gas is usually accompanied by substantial discharges of wastewater in the form of brine.
- ✓ Constituents of brine include sodium, calcium, ammonia, boron, chloride, sulfate, trace metals and high total dissolved solids.
- ✓ In the past oil fields brine disposal was discharged to streams or evaporation ponds. Presently deep injection wells are used for discharging the disposals.

- **Stock Piles:**

- ✓ Solid materials are frequently stockpiled near industrial plants, construction sites and large agricultural operations. Precipitation falling on unsheltered stockpiles causes leaching into the soil.
- ✓ This may transport heavy metals, salts, and other inorganic and organic constituents as pollutants to groundwater.

➤ Agricultural sources and causes:

• Irrigation return flow:

- ✓ Approximately one-half and two-thirds of the water applied for the irrigation of the crops is consumed by evapotranspiration.
- ✓ The remaining termed irrigation return flow, drains to surface channels or joins the underlying groundwater.
- ✓ Irrigation increases salinity of irrigation returned flow three to ten times that of the applied water.

• Animal wastes:

- ✓ Where animals are confined within a limited area, as for beef or milk production, large amount of waste are deposited on the ground. These are the highly concentrated pollutant to surface and subsurface waters.
- ✓ Animal wastes may transport salts, organic loads and bacteria, nitrogen-nitrate (most important persistent pollutant) into the soil.

• Fertilizers and Soil amendments:

- ✓ The primary fertilizers are compounds of NPK. Phosphate and potassium are readily adsorbed on soil particles and seldom constitutes a pollution. But nitrogen I solution is only partially used by plants and adsorbed by the soil and it is the primary fertilizer pollutant.
- ✓ Soil amendments are applied to irrigation lands to alter the physical and chemical properties of the soil. Lime, gypsum, and sulfur are widely used for this purpose. Substantial amount of these soil amendments may eventually leach to the groundwater, thereby increasing its salinity.

- **Pesticides:**

- ✓ Pesticides can be significant in agricultural areas as a diffused source of groundwater pollution.
- ✓ The minute concentration can have serious consequences to the potability of the water.
- ✓ The impact of pesticides on groundwater quality depends on the properties of the pesticides residue, rainfall and soil characteristics.
- ✓ Most pesticides are relatively insoluble in water, while others are readily adsorbed by soil particles or are subject to microbial degradation.

- **Miscellaneous Sources and Causes:**

- **Spills and Surface Discharges:**

- ✓ Liquids discharge onto the ground surface in an uncontrolled manner can migrate downward to degrade groundwater quality.
- ✓ Washing aircraft with solvents and spills of fuel at airports can form a layer of hydrocarbons floating on the water table.
- ✓ Hazardous and flammable liquids are often flushed by water from highways; this action may actually aid in transporting the pollutant to the water table.

- **Saline water intrusion:**

- ✓ Salt water may invade freshwater aquifers to create point or diffuse pollution sources.
- ✓ In coastal aquifers seawater is the pollutant, while in inland aquifers underlying saline water may be responsible.

- **Surface water:**

- ✓ Polluted surface water bodies that contribute to groundwater recharge become sources of groundwater pollution.
- ✓ Recharge may occur naturally from a losing streams or it may be induced by a nearby pumping well.

- **Attenuation of pollution:**

- ❖ Mechanisms involves include filtration- removes suspended materials. Groundwater filtration can remove particulate forms of iron and manganese as well as precipitates formed by chemical reactions.
 - ✓ **Sorption**- clays, metallic oxides, hydroxides and organic matter function as sorptive matters. Most of the pollutants can be absorbed under favorable conditions.
 - ✓ **Chemical processes**- Purification may be done by the precipitation reactions. Major constituents and trace metals can be removed through this method.
 - ✓ **Microbiological decomposition**- this method are used for removing the pathogenic organisms.
 - ✓ **Dilution**- this is the most important method for pollutants after they reach the water table. in this process pollutants in groundwater flowing through porous media tend to become dilute in concentration due to hydrodynamic dispersion occurring on the both microscopic and macroscopic scales.

1. Types & Sources of Water Pollution

disease-causing agents: bacteria, viruses, protozoa, & parasites;

oxygen demanding wastes: organic wastes that can be decomposed by aerobic bacteria;

water-soluble inorganic chemicals: acids, salts, & compounds with heavy metals;

organic chemicals: oil, gasoline, plastics, pesticides, cleaning solvents, detergents, etc.

sediment: suspended matter, insoluble particles of soil & other solids; biggest class of pollution by weight;

water-soluble radioactive isotopes: ionizing radiation sources;

genetic pollution: introduction of non-native species;

thermal pollution: heat added to water.