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Review Article

Load of Industrial & Domestic Waste in the Ground Water

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Abstract

Groundwater contamination is a global problem that has a significant impact on human health and ecological services. Studies reported in this special issue focus on contaminants in groundwater of geogenic and anthropogenic origin distributed over a wide geographic range, with contributions from researchers studying groundwater contamination in India, China, Pakistan, Turkey, Ethiopia, and Nigeria. Thus, this special issue reports on the latest research conducted in the eastern hemisphere on the sources and scale of groundwater contamination and the consequences for human health and the environment, as well as technologies for removing selected contaminants from groundwater. In order to evaluate the effects of seeping septic effluents on the quality of groundwater in a watershed, a number of contaminants such as nitrate, phosphorus, chloride, lead, copper, iron, chromium and manganese, were studied. To determine the extent of contamination, a network of observation wells was established in the drainage area of the septic systems. Groundwater samples from the observation wells were collected in the spring, summer and fall. The samples were extracted for the determination of various contaminants by standard methods.

Landfills are the most widely used method for **municipal solid waste** (MSW) disposal method in Kanpur. However, these facilities have caused serious **groundwater contamination** due to the **leakage** of leachate. Dumpsite is a widespread land meant or designed for deposition of waste and unwanted materials from household, institutions, industries or the environment and is generally open or covered with soil layer with or without liner at the bottom. Dump/landfill is a major source of contamination of groundwater. This study is therefore designed to review studies on the impact of groundwater contamination due to dumpsites using geophysical and physiochemical methods.

Keywords: groundwater contamination, landfills, sewer lines, septic tanks, waste storage works

INTRODUCTION

The elevation of underground water threatens the stability and the correct exploitation of many buildings due to the influence of the pollutants into the foundation soil. Groundwater usually contains high concentrations of natural dissolved materials that affect the ground composition. Most groundwater originates from rainfall that has entered the ground. About one-fourth of the quantity of precipitation infiltrates the soil and recharges local aquifers and the sediments that store and transport groundwater. Shallow, permeable water table aquifers are the most susceptible to contamination, due to specific site characteristics as: distance from the contamination source to the aquifer, residence time of the water in the unsaturated area, presence of clay and organic matter in the unsaturated area, potential of a particular contaminant to decompose, amount of precipitation that affects recharge, evaporation that decreases the amount of water that moves downward to the aquifer. The main factors influencing the transport of the pollutants in the ground are: the underground water level, the quantity of pollutants, their type, and soil bedding (Bedient et al., 1999). The groundwater measurement consists in: measurements of the water level depending on the level fluctuation amplitude, temperature measurements in specific drillings, experimental pumping to determine the properties of the hydrogeological layer, and periodical sampling to determine the water physico -chemical characteristics (Rotaru et al., 2001).

Groundwater is a major source of fresh water for the global population and is used for domestic, agricultural, and industrial uses. Approximately one third of the global population depends on groundwater for drinking water (International Association of Hydrogeologists 2020). Groundwater is a particularly important resource in arid and semi-arid regions where surface water and precipitation are limited (Li et al. 2017a). Securing a safe and renewable supply of groundwater for drinking is one of the crucial drivers of sustainable development for a nation. However, urbanization, agricultural practices, industrial activities, and climate change all pose significant threats to groundwater quality. Contaminants, such as toxic metals, hydrocarbons, trace organic contaminants, pesticides, nanoparticles, microplastics, and other emerging contaminants, are a threat to human health, ecological services, and sustainable socioeconomic development (Li 2020; Li and Wu 2019).

Dumpsite is a widespread land meant or designed for deposition of waste and unwanted materials from household, institutions, industry or environment and is generally open or covered with soil layer with or without liner at the bottom. These, most times lead to pollution and contamination of the environment. The presence of dumpsite in an area most times adversely affects the general condition of environment and residents of the area. It is worthy of note that when dumpsites are not covered (open) they attract flies, insects and other animals that would cause diseases or other public health problems to people living around such waste management facilities most especially scavengers (Dong et al. 2008).

In Nigeria and most other developing countries, solid wastes are disposed or dumped in barren lands and many are not properly managed if managed at all. Dumpsite could be classified as landfills and open dumpsites. Landfills are properly designed to offer a great advantage over the open dumpsites like minimization of environmental issues and reduction of health risks. However, they have been considered to be major contributors to groundwater pollution due to the leakage of solutions from leachate to the ground. This is a combination of contaminants having different chemical components that are toxic, (Yang et al. 2013; Regadío et al. 2012; Li et al. 2014). Leachates move through the dump to the bottom and sides beneath the soil until it gets to the groundwater zone or aquifer by pull of gravity. The contaminants from the leachate will first get to the unsaturated zone and later move to the groundwater table in the saturated zone. Hence, groundwater contamination from leachate migration due to dumpsite can be a major source of environmental problem and concern (Singh et al. 2008) but lined dumps on the other hand are better in terms of prevention of contamination, however, lined dumps could also be a source of problem to the quality of groundwater if the liners fail (Banu and Berrin 2015).

Groundwater generally is an important and renewable source of water for human life and any form of economic development. It constitutes part of the earth's water system and the hydrologic cycle is incomplete without it. It occurs in permeable geologic formations called aquifers. These form structures that can store and transmit enough quantity of water to the wells as fast as possible. Groundwater plays an important role in agricultural irrigation particularly in the rural areas where it is mainly the key to provide additional resources for food security and in cities; it is an important source of quality water at relatively low cost where pipe borne water is not guaranteed. Groundwater is threatened by degradation due to contamination and also by misuse. The threat due to pollution as a result of disposal of chemicals to the land surface by agricultural, industrial and domestic dumps is of great concern to humanity.

Groundwater plays an important role in agricultural irrigation particularly in the rural areas where it is mainly the key to provide additional resources for food security and in cities; it is an important source of quality water at relatively low cost where pipe borne water is not guaranteed. Groundwater is threatened by degradation due to contamination and also by misuse. The threat due to pollution as a result of disposal of chemicals to the land surface by agricultural, industrial and domestic dumps is of great concern to humanity.

The numbers of classes of contaminants detected in groundwater are increasing rapidly, but they can be broadly classified into three major types: chemical contaminants, biological contaminants, and radioactive contaminants. These contaminants can come from natural and anthropogenic sources (Elumalai et al. 2020). The natural sources of groundwater contamination include seawater, brackish water, surface waters with poor quality, and mineral deposits. These natural sources may become serious sources of contamination if human activities upset the natural environmental balance, such as depletion of aquifers leading to saltwater intrusion, acid mine drainage as a result of exploitation of mineral resources, and leaching of hazardous chemicals as a result of excessive irrigation (Su et al. 2020; Wu et al. 2015; Li et al. 2016, 2018).

Nitrogen contaminants, such as nitrate, nitrite, and ammonia nitrogen, are prevalent inorganic contaminants. Nitrate is predominantly from anthropogenic sources, including agriculture (i.e., fertilizers, manure) and domestic wastewater (Hansen et al. 2017; He and Wu 2019; He et al. 2019; Karunanidhi et al. 2019; Li et al. 2019a; Serio et al. 2018; Zhang et al. 2018). Groundwater nitrate contamination has been widely reported from regions all over the world. Other common inorganic contaminants found in groundwater include anions and oxyanions, such as F−, SO42−, and Cl−, and major cations, such as Ca2+ and Mg2+. Total dissolved solids (TDS), which refers to the total amount of inorganic and organic ligands in water, also may be elevated in groundwater. These contaminants are usually of natural origin, but human activities also can elevate levels in groundwater (Adimalla and Wu 2019).

Toxic metals and metalloids are a risk factor for the health of both human populations and for the natural environment. Chemical elements widely detected in groundwater include metals, such as zinc (Zn), lead (Pb), mercury (Hg), chromium (Cr), and cadmium (Cd), and metalloids, such as selenium (Se) and arsenic (As). Exposures at high concentrations can lead to severe poisoning, although some of these elements are essential micronutrients at lower doses (Hashim et al. 2011). For example, exposure to hexavalent chromium (Cr6+) can increase the risk of cancer (He and Li 2020). Arsenic is ranked as a Group 1 human carcinogen by the US Environmental Protection Agency (EPA) and the International Agency for Research on Cancer (IARC), and As3+ can react with sulfhydryl (–SH) groups of proteins and enzymes to upset cellular functions and eventually cause cell death (Abbas et al. 2018; Rebelo and Caldas 2016). Toxic metals in the environment are persistent and subject to moderate bioaccumulation when they enter the food chain (He and Li 2020; Hashim et al. 2011).

Organic contaminants have been widely detected in drinking water, and many of these compounds are regarded as human carcinogens or endocrine disrupting chemicals. In groundwater, more than 200 organic contaminants have been detected, and this number is still increasing (Lesser et al. 2018; Jurado et al. 2012; Lapworth et al. 2012; Sorensen et al. 2015). Some organic contaminants are biodegradable, while some are persistent. The biodegradable organic contaminants originate mainly from domestic sewage and industrial wastewater. Many of these organic substances are naturally produced from carbohydrates, proteins, fats, and oils and can be transformed into stable inorganic substances by microorganisms. They have no direct toxic effects on living beings but can reduce the dissolved oxygen levels in groundwater. Common organic contaminants include hydrocarbons, halogenated compounds, plasticizers, pesticides, pharmaceuticals, and personal care products and natural estrogens, among others (Lapworth et al. 2015; Meffe and Bustamante 2014). Many of the halogenated compounds (e.g., chlorinated, brominated, fluorinated) are stable in the environment and can be accumulated and enriched in organisms, causing harmful effects in organisms from higher trophic levels, including humans (Gwenzi and Chaukura 2018; Schulze et al. 2019). The persistent organic contaminants are mainly compounds used for agriculture, industrial processes, and protection of human health (Lapworth et al. 2015). Because these compounds degrade very slowly or even not at all, they may permanently threaten the quality of groundwater for drinking purposes (Schulze et al. 2019).

Radioactive contaminants in groundwater can originate from geological deposits of radionuclides but also can originate from anthropogenic sources, such as wastes from nuclear power plants, nuclear weapons testing, and improper disposal of medical radioisotopes (Dahlgaard et al. 2004; Lytle et al. 2014; Huang et al. 2012). Radioactive substances can enter the human body through a variety of routes, including drinking water. However, radioactive contaminants have been rarely detected in groundwater at levels that are a threat to human health.

Biological contaminants include algae and microbial organisms, such as bacteria, viruses, and protozoa. For microbial contaminants, more than 400 kinds of bacteria have been identified in human and animal feces, and more than 100 kinds of viruses have been recognized (Shen and Gao 1995). Some of these microbial organisms originate from natural sources, but some include microscopic organisms that co-exist with natural algal species and compete for available resources (Flemming and Wuertz 2019; Lam et al. 2018). Drinking water contaminated by microbial contaminants can result in many human diseases, including serious diarrheal diseases, such as typhoid and cholera. Currently, the COVID-19 virus has resulted in pandemic affecting every corner of the world. This coronavirus is primarily transmitted from person-to-person through respiratory droplets (Centers for Disease Control and Prevention 2020). However, water contaminated by this virus also can threaten human health (Bhowmick et al. 2020; Lokhandwala and Gautam 2020). Algal contamination is very common in surface waters, such as lakes and reservoirs due to eutrophication, but algae are rarely found at a high biomass in groundwater.

The solid waste from the industrial zones dumped in a dumpsite reacts with percolating rain water and other environmental conditions thereby resulting in leachate which is therefore the product of the reaction of the percolating rainwater, ions, trace elements and other degradable constituents of dump transferred to the water level. The leachate moves in accordance with the direction of groundwater and spreads across a large portion of the groundwater system thereby polluting the water. The rate of percolation of leachate and other properties are dependent on the following factors: composition of solid waste, level of compaction, size of particle, hydrology of site, age of dumpsite/landfill, moisture, temperature conditions and available oxygen.

$$DAD = \frac{C \times TC \times K_i \times CF \times EV \times ED \times EF \times SSA}{ABW \times AET}$$

$$HQ_{Dermal} = \frac{DAD}{RfD}$$

$$HI_{Total} = \sum_{i=1}^{n} (HQ_{Oral} + HQ_{Dermal})$$

Health risk assessment

In general, the intake of polluted groundwater can cause a severe threat to humans, primarily by two exposure routes, first one is the ingestion of drinking water or oral route, and the second one is the dermal interaction route 23,49. Te US Environmental Protection Agency originally proposed this rigorous model for the assessment of human health risk34,35. In this study, the risk assessment was carried out in three groups of the exposed population, comprising children, females, and males. Te non-carcinogenic health risk from oral intake was calculated as follows 3,15,16,50.

$$CDI = \frac{C \times EF \times ED \times IR}{ABW \times AET}$$

$$HQ_{Oral} = \frac{CDI}{RfD}$$

Where, in Eq. CDI is referred as chronic daily intake (in mg/kg/day); "C" is the concentration of groundwater nitrate (in mg/L); IR is denoted for daily ingestion rate of groundwater (in L/day) for both males and females ingestion rate is 2.5 L/day and for children, ingestion rate is 1 L/day 34 EF is denoted for the exposure frequency (in days/year), and the exposure frequency is considered as 365 days/year for males, females, and children34, ED is denoted for exposure duration (in a year), for children 12 years, for females 67 years, and for males, 64 years have considered for this study23,25. ABW is the average body weight as 65 kg, 55 kg, and 15 kg for males, females, and children, respectively3 . Te average exposure times (AET) are 23,360 days, 24,455 days, and 4380 days for males, females, and children, respectively. In Eq. 2the hazard quotient is presented as HQ. RfD indicates reference dose of nitrate contaminant (in mg/kg/day) which is 1.6 mg/kg/day34,35. Te non-carcinogenic health risk from dermal contact is calculated by the following formulae14,15,16,17 18.

Where in Eq.DAD indicates the dermal absorbed dose (in mg/kg×day); TC is the contact time (in h/day) taken as 0.4 in h/day; Ki represents the dermal adsorption parameters (in cm/h) taken as 0.001 cm/h; and CF is denoted for conversion factor taken as 0.00134,51. EV represents bathing frequency (in times/day) and considered as one time in a day, and SSA indicates the skin surface area (in cm2) and values for SSA are taken as 16,600 sq. centimetres for both males and females, and 12,000 sq. centimetres for children35,51. In Eq. (5), HI is the hazard index, and non-carcinogenic human health risk is denoted by the value of HI. Te HI value greater than one shows the potential human health risk from nitrate contamination, and HI value less than one expresses an acceptable level of health risk on human35.

Causes Effects and Solution

1. Kanpur is densely populated industrial city in Uttar Pradesh , is located the banks of Ganga.The city with an estimated population near about 40 lakh, generates near about 500 million - liter of sewage and other solid waste daily.It has 450 tanneries which produce toxic effluents.The untreated sewage from the city's 16 major drains has been directoly flowing into the river Ganga.

   Sisamau nala is a big problem till now.Which produces nearly 145MLD of domestic waste per day.Although government has done efforts and tapping of all nala were done but recently Rawatpur ,Barra 8 and so many areas are facing water contamination problem.

   Apart from urban sewage ,leather industry in Kanpur is considered to be a primary source of industrial pollution in the Ganga.Untreated waste from septic tanks or sewerage systems may leak into the surrounding soils and enter aquifers where they mix with the groundwater that serve local wells. This untreated waste carries bacteria along with nitrates and organic chemicals into the groundwater which could be very harmful if consumed.

Across the world, septic systems are the main cause of pollution of underground water. The pollutants are outflow from privies, septic tanks, and cesspools. Agriculture can also adversely affect groundwater quality. The spreading of slurry, fertilisers and animal waste on the land can result in pollutants such as nitrates and bacteria seeping into underground water sources. These pollutants can have serious adverse effects on the plants, animals and people who rely on these water sources.

2. Landfills contain many sources of pollution, after heavy rain these pollutants seep into the soil below them. These leached pollutants then enter aquifers contaminating the groundwater with harmful chemicals and heavy metals such as lead and cadmium. These pose serious health risks to humans and animals.

   Kanpur has been one of the highly industrial urban centres of India. Along with unbridled unbanisation coupled with intense industrial activities, the city plays host to innumerable environment related problems. These include urban solid waste, industrial effluents and emissions besides hazardous solid waste dumbing from the industrial sectors which ultimately lead to ground water contamination.

Chemicals and Road Salts

- The widespread use of chemicals and road salts is another source of potential groundwater contamination. Chemicals include products used on lawns and farm fields to kill weeds and insects and to fertilize plants, and other products used in homes and businesses. When it rains, these chemicals can seep into the ground and eventually into the water. Road salts are used in the wintertime to put melt ice on roads to keep cars from sliding around. When the ice melts, the salt gets washed off the roads and eventually ends up in the water.

- Effect of Ground Water Contamination

1. Health Issues

Contaminated groundwater has detrimental effects on human health. In areas where septic tank installation is not set up correctly, human waste may contaminate the water source. The waste may contain hepatitis-causing bacteria that may lead to irreversible damage to the liver. Also, it may cause dysentery, which leads to severe diarrhea, dehydration, and, in some cases, death. Additional health problems include poisoning that may be a result of the use of excessive pesticides and fertilizers or natural chemicals. The chemicals leach into water sources and poison them. Drinking water from such a source may lead to serious health effects.

2. Affects economic growth

Contamination of groundwater sources renders the area incapable of sustaining plant, human, and animal life. The population in the area reduces and the land value depreciates. Another effect is that it leads to less stability in industries relying on groundwater to produce their goods. Therefore, the industries in the affected areas will have to outsource water from other regions, which may turn out to be expensive. In addition they may be forced to close down due to the poor quality of water.

3. Can lead to damaging impacts on the environment such as aquatic systems and the overall ecosystem

Groundwater pollution can lead to devastating environmental changes. One such alteration is the loss of certain nutrients that are essential for the self-sustenance of the ecosystem. Also, when the pollutants mix with water bodies, alteration of the aquatic ecosystem may also occur. Aquatic animals such as fish may die off quickly as a result of too many contaminants in the bodies of water.

Animals and plants using contaminated water may also be affected. Toxic substances accumulate with time in the aquifers and once the prime spreads, it may render the groundwater unsuitable for human and animal consumption. The effects are serious, especially for people who rely on groundwater during drought periods.

Solutions of Groundwater Pollution

Safe Drinking and Clean Water regulations should ensure the protection of drinking water by establishing measures for it to meet health standards.

Don't dump hazardous waste on the ground. It can contaminate the soil, which could also contaminate the groundwater or nearby surface water. A number of products used at home contain hazardous or toxic substances that can contaminate ground or surface waters, such as:

- Motor oil
- Pesticides
- Leftover paints or paint cans
- Mothballs
- Flea collars
- Household cleaners
- A number of medicines

Don't overuse pesticides or fertilizers. Many fertilizers and pesticides contain hazardous chemicals. These can travel through the soil and contaminate groundwater. If you feel you must use these chemicals, please remember to use them in moderation.

Find a watershed or wellhead protection organization or source water collaborative in your community and volunteer to help.

Awareness programs and strict punishment should be made by the Government.

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