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Groundwater Contamination-an overview

Akshay Kumar Chaudhry[1], Kamal Kumar[2], M.A. Alam[3]
[1, 2, 3] *Department of Civil Engineering, Punjab Engineering College, Chandigarh*

Abstract

Water is limited in quality rather than quantity in many semi-arid regions of the world, India being one of them. The rapid growth of industrialization and urbanization has started to take toil on the freshwater resources all around the world during the past few decades. Thus, proper monitoring, assessment and knowledge of contamination at local/regional levels is required as a cost-effective measure to prevent this vital resource from further getting contaminated. Groundwater contamination is an artificially induced degradation of the quality of groundwater. It comes from two types of sources (point and non-point sources). A point source theoretically means those pollution sources that comes from a single, recognizable source or point. The effects of such sources usually remain relatively local to the point from which the pollution is originating. Non-point sources include naturally occurring contaminants and are less obvious. It is not focused around a specific point or source. Henceforth, a large number of sources and causes can alter the groundwater quality, making its use inapt and can cause various health hazards if consumed in contaminated states. With the rising recognition of the significance of groundwater resources, efforts are growing to prevent, decrease and eradicate groundwater contamination.

Keywords – Contamination, Groundwater, Non-point source, Point source

I. INTRODUCTION

Groundwater is one of the most essential and main source of drinking water around the world, because they are often free from contamination, difficult to pollute, widely dispensed, and adjust throughout the year (Kumari *et al.*, 2012). Groundwater contamination occurs when contaminants makes their way down into groundwater and exploit the quality. The flow and dispersion of water within the aquifer, distributes the contaminants over a large area. Groundwater can be contaminated through various mechanisms by numerous contaminants from a point or non-point sources. The term "point source" means any visible, confined and distinct conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, fissure, container, concentrated animal feeding manoeuvre, or vessel or other floating craft, from which pollutants are or may be discharged. Non-point source (NPS) pollution generally results from surface runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic alteration. NPS pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. It is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters. Besides geogenic sources (like dissolution of minerals, rock-water interaction, ion-exchange etc.), groundwater is also contaminated due to pollution associated with the anthropogenic sources. Groundwater contamination due to anthropogenic sources include sewage disposal system, solid waste disposal on land, municipal wastewater, brine disposal from petroleum industries, mine wastes, deep well disposal of liquid waste, agricultural activities and road salts (Terry, 1974). Contamination of groundwater is irreversible and difficult to restore its original quality (Mishra *et al*., 2005).

More than three-quarters of India’s rural population depends on groundwater for drinking, but the country’s aquifers are not only under tremendous stress, the quality of water they provide is also deteriorating. “Government data says 94% of the population has access to improved water sources but this number does not tell the whole story. If you dig deeper and question the quality of available water, the crisis becomes darker and more dangerous. Surface water contamination receives a lot of attention because of the visible pollution of this water. In India, 19 states have reported fluoride contamination of water and groundwater in at least 10 states is contaminated with arsenic. India has over 30 million groundwater extraction points and excluding a handful, in all states a majority of wells have registered declining water levels in the pre-monsoon months over a decade from 2006 to 2015. In pockets of Andhra Pradesh, Chhattisgarh, Delhi, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Rajasthan, Telangana and West Bengal the problem is particularly severe. If current trends continue, within 20 years 60% of all aquifers in India will be in a critical condition, according to a 2012 World Bank report” (*Hindustan Times*, March 22, 2017).

Groundwater quality issues now assume major importance in semi-arid zones, since scarce reserves of groundwater (both renewable and non-renewable) are under threat due to increase in industrialization and urbanization. In Punjab, water for drinking, industrial uses, and irrigation comes mainly from groundwater, which thus plays an important role in development. Punjab is the biggest agrochemicals user in India. By the excessive use of pesticides, fertilizer and other chemicals, it now leads in the Green Revolution and is one of the leading state in food grain production and also for the groundwater contamination. Industrial units including food & food products, beverages, paper, textile, tanning, electroplating & machinery units which discharge their industrial wastes (directly or indirectly) into drains are responsible for the contamination of groundwater quality in the region. (CGWB, 2017). These wastes are potential sources of groundwater contaminants as they produce harmful effects on the environment when released in the form of solids, liquid effluents and slurries. In order to curb these effluent discharge, pollution control board of each state has set certain standards which has to be followed by every industry. Before discharging the treated effluent on to the land or any surface water body the industries should meet the effluent discharge standard norms. In order to have proper processes in the effluent treatment plant, characterization of waste water, remediation techniques and planning of proper units and processes for effluent treatment is very much necessary (Barnett *et al*., 2010). The true assessment of dangers developing from groundwater contamination problems and the plan of capable and powerful procedures to reduce these concerns require the capacity to predict the conduct of chemical contaminants in streaming water. To pick a suitable remediation procedure, information of the contaminant discharge source and time discharge history becomes pertinent.

The importance of groundwater for the existence of human society cannot be overemphasized. Being an important and integral part of the hydrological cycle, its availability depends on the rainfall and recharge conditions. Till recently it had been considered a dependable source of uncontaminated water. The demand for water has increased over the years and this has led to water scarcity in many parts of India. The situation is aggravated by the problem of water contamination. India is heading towards a freshwater crisis mainly due to improper management of water resources and environmental degradation, which has led to a lack of access to safe water supply to millions of people. This freshwater crisis is already evident in many parts of India, varying in scale and intensity depending mainly on the time of the year. Groundwater crisis is not the result of natural factors alone; it is also caused due to human actions. During the past two decades, the water level in several parts of the country has been falling rapidly due to an increase in extraction. The number of wells drilled for irrigation has rapidly increased. India's fast growing population and changing lifestyles has also increased the domestic need for water. The water requirement for the industry also shows an overall increase (Kumar, 2012). Intense competition amongst agricultural, industrial and domestic sector is driving the groundwater table lower. These problems are the results of the past mistakes, today's necessities, and tomorrow's protection. If groundwater is to be used safely and effectively, both increased scientific understanding and improved engineering techniques must be brought to bear on the problem of groundwater contamination. The development of appropriate methods for managing and disposing of wastes is necessary for rectification of past mistakes and for future protection as well.

II. WHAT CAUSES GROUNDWATER CONTAMINATION?

When learning about what causes groundwater contamination, you should first think of direct contaminants (Hazard waste and landfills). When hazardous waste is dumped mistakenly, it leads to spilling and draining into soil and water. Once spill happens, it can more or less never be removed from groundwater. Landfills are another direct cause of contamination in groundwater. The longer a landfill remains full of waste, the more are the chances of seeping of toxins from that waste into the soil and groundwater. When landfills are very large, the amount of groundwater contaminated by them is significant. But there are some sources of groundwater contamination that are less direct. Sometimes, when surface water in the area becomes contaminated, it leads to evaporation of these contaminants into atmospheric air and water. In turn, contaminated air can drift into areas where humans are present more, and rain can fall as acid rain. This damages the environment and can also cause serious health risks for people. Apart from direct causes, there are some indirect causes of groundwater pollution. Diesel and gasoline are well-known indirect causes of groundwater pollution. In some instances, these fuels, when kept in underground storage, can leak significantly and seep into the groundwater around them, leading to groundwater contamination. Most of the time, the use of these fuels contaminates the atmosphere and leads to indirect atmospheric contamination of groundwater through the rain.

It’s no secret that human beings are a huge contaminator of groundwater. In semi-arid regions, city-based water and sewage are unavailable, especially in very rural areas. When this is true, septic systems are usually the only solution to provide running water and sanitation to people in such regions. Septic systems are very common these days, and in most cases, they are not supposed to cause any groundwater contamination at all. Unfortunately, sometimes they are installed incorrectly or become damaged over time without regular maintenance. This causes human waste to leach into the surrounding soil, which in turn causes a lot of contamination.

Road salts, solvents, and chemicals used on roads, in lawns, and around the home are some of the leading manmade causes of groundwater pollution (Terry, 1974). When these products are used on land surfaces or homes, they are easily washed away by natural rainfall and starts seeping into the soil and reach the groundwater quickly. When humans and animals drink this water, they are ingesting these chemicals, which can cause major health problems. Also, when groundwater that has been affected by these chemicals is then used in agriculture or industry, it is unable to provide the proper nutrients and hydration required to get the job finished. Much like chemicals and other man-made solutions, pesticides used by farmers during farming also leads to groundwater contamination. The chemicals involved in pesticides are very dangerous for both human and animal consumption, and when they reach groundwater, they are difficult to be removed completely (Purandara *et al*., 2003).

III. EFFECTS OF GROUNDWATER CONTAMINATION

The initial step in accessing the effects of groundwater contamination is to understand the common sources from where the contamination is occurring. Only after obtaining this information, one can study the effects is has on health, economy and environment. Health effects are some of the utmost risks associated with groundwater contamination. Hepatitis is a one such very serious risk that causes irreversible damage to liver. Much like hepatitis, dysentery can be caused by drinking water where waste is present. Methemoglobinemia or “blue baby syndrome”, an illness affecting infants, can be caused by drinking water that is high in nitrates. Benzene, a component of gasoline, is a known human carcinogen. Like hepatitis, lead also cause irreversible damage to liver. It also causes disabilities to nerves and kidneys in children and also causes risks in pregnancy (Smith *et al.,* 2000). Concentrations in drinking water of these and other substances are regulated by federal and state laws. Hundreds of other chemicals, however, are not yet regulated, and many of their health effects are unknown or not well understood. Preventing contaminants from reaching the ground water is the best way to reduce the health risks associated with poor drinking water quality (WHO, 2011).

Economy also suffers, when groundwater becomes contaminated. At the point when groundwater turns out to be more contaminated in a certain region, that region becomes less equipped for sustaining human, animals, and vegetation. As a result, the depreciation of land value and odds of individual required to live there also dimishes.

Last but certainly not least, the environment is also affected when groundwater is contaminated. When groundwater that supplies ponds, lakes, rivers, streams, and marshes becomes contaminated, this leads to contamination of the surface water as well. As a result, fishes, birds, animals and plants that live in the area become sick and die off. It also leads to destruction of the wetlands, which rely hugely on groundwater to recharge their lakes and ponds after droughts. Thus, people using such land for hunting, fishing, and even for their own sources of clean water are affected by this type of contamination.

IV. TREATMENT OF CONTAMINATED WATER

From a historical viewpoint, groundwater management paradigms have changed over several decades as our understanding of groundwater quality and quantity issues and effects it has on our society have become clearer. At this time we cannot say that we fully understand all water quantity and quality management issues and the societal impact of water management problems, but research findings in this area are increasing exponentially with very positive and encouraging results that may guide us through this maze. On the other end of this spectrum, the number of organic compounds that have been synthesized since past few decades now exceeds half a million, and some new compounds are added to this list each year. As a result, many of these new compounds are now found in waste streams and also in groundwater. Thus, the increasing number of emerging contaminants and their illusive health effects, it may be safe to say that the ultimate goal of completely identifying all societal issues associated with water quality and quantity management may not be fully achievable (Aral and Taylor, 2010).

In a past few decades, large number of groundwater treatment technologies have been developed (EPA, 1995). These technologies can be classified as in-situ or ex-situ, as summarized in table 1 (Houlihan and Lucia, 1999). In-situ or ex-situ treatment techniques can be subdivided into biological remediation technique (also known as bioremediation), volatization processes, and chemical and physical processes. In-situ treatment techniques either render a contaminant nontoxic through treatment of enhance extraction of the contaminant from the aquifer. The in-situ technologies perform these functions: 1). Removal of Contaminant source zone, 2). Aquifer Restoration, and 3). Minimize the continuation of contaminant migration.

TABLE I: GROUNDWATER TREATMENT TECHNOLOGIES

In-Situ	**Technology Description**
Air Sparging	Volatization of contaminants in saturated zone
Bioremediation	Biological degradation of contaminants using naturally occurring microbes in soil
Density Driven Convection	Enhanced bioremediation using single-well driven convection system in aquifer
Vacuum Vapour Extraction	Volatization, within a well of contaminants from saturated zone
Soil Vapour Extraction	Volatization of contaminants that are present in the vadose zone
Ex-Situ	
Air Stripping	Volatization of contaminants
Alkaline Precipitation	Alteration of water quality (usually pH adjustment)
Carbon Adsorption	Adsorption of contaminants to ion-exchange resin
Electro Kinetic Decontamination	Desorption of contaminants by acidic front of groundwater caused by hydrolysis of the groundwater
Ion-Exchange	Exchange type attachment of contaminants to ion-exchange resin

Source: Houlihan and Lucia

Other than legislation and checks to conserve and improve the quality of groundwater, society also plays a very important role. There has been a rising awareness among the common people on the need for conservation and development of groundwater. Renovation of forest tanks in drought-prone regions will have a significant impact on wildlife and forest cover. Similarly, in some urban cities there is a need to regenerate groundwater aquifers because of the high degree of dependence on them for drinking water. Rainwater harvesting schemes have been taken up in many cities and even enforced in some countries. Temple tanks need to be renovated and urban wetlands protected. All these will contribute to a rise in the groundwater level and may reduce salt water ingress. Community awareness and management of freshwater resources should be enhanced. The government should implement effective groundwater legislation and regulations through self-regulation by communities and local institutions. External support agencies should support freshwater resource management. Environmental restoration should also be promoted alongside household water security (Rao, 1998).

V. CONCLUSIONS

Groundwater is a vital part of the earth, and hence cannot be viewed in segregation. There has been a lack of satisfactory consideration to water conservation, efficiency in water use and re-use, groundwater recharge, and biological system sustainability. It is vital to understand that groundwater is not an asset that could be used ignorantly essentially in light of the fact it is available in abundant quantity. Problems and issues due to increase in industrialization and urbanization should be appropriately investigated and dealt with. Society itself plays a very important role, other than legislation and efforts to conserve and improve the quality of groundwater. No single action whether community based, legislation, water harvesting systems, or dependence on market forces will in itself improve the crisis in India. The effective answer to the freshwater crisis is to integrate conservation and development activities if the groundwater is to be used safely and effectively. This will at last prepare for consolidating protection of the earth with the indispensable needs of individuals.

REFERENCES

1. Aral, M.M. and Taylor, S.W. (2010). *Groundwater Quantity and Quality management.* ASCE, Virginia.
2. Barnett, J.W., Robertson, S.L. and Russell, J.M. (2010). Environmental issues in dairy processing. Environment Portfolio, New Zealand Dairy Research Institute, Private Bag 11029, Palmerston North
3. Central Groundwater Board (CGWB), (2017). *Aquifer mapping and management plan, Punjab*. Ministry of Water Resources: India
4. Houlihan, M.F. and Lucia, P.C. (1999). *The handbook of groundwater engineering.* CRC press, Boca Raton, FL.
5. Kumar, C.P. (2012). Climate change and its impact on groundwater resources. *International Journal of engineering and science*, 1(5), 43-60.

6. Kumari, R., Singh, C.K., Datta, P.S., Singh, N. and Mukherjee, S. (2012). Geochemical modelling, ionic ratio and GIS based mapping of groundwater salinity and assessment of governing processes in Northern Gujarat, India. *Environ Earth Sci.* doi: 10.1007/s12665-012-2067-3

7. Mishra, P.C., Behra, P.A. and Patel, R.K. (2005). Contamination of water due to major industries and open refuse dumping in the steel city of Orissa. *Journal of Environmental Science and Engineering,* 47, 141-151.

8. Purandara, B.K. and Varadarajan, N. (2003). Impacts on Groundwater quality by Urbanization." *Journal of Indian Water Resources Society,* 23, 107-115.

9. Rao, C.C.V. (1998). *Environmental status of India.* Atlantic Publishers & Distributors Pvt. Limited.

10. Smith, A.H., Lingas, E.O. and Rahman, M. (2000). Contamination of drinking water by arsenic in Bangladesh: a public health emergency. *Bull World Health Org,* 78, 1093-1103.

11. Terry, R.C. (1974). *Road Salt, Drinking water, and Safety*. Ballinger, Cambridge, MA, 161 pp.

12. U.S Environmental protection agency (U.S. EPA), (1995). *Groundwater and Leachate Treatment Systems*. EPA/625/R-94/005, Washington, DC.

13. Vyawahare, M. (2017). "Not Just scarcity, groundwater contamination is India's hidden crisis". *Hindustan Times*, March 22. https://www.hindustantimes.com/india-news/not-just-scarcity-groundwater-contamination-is-india-s-hidden-crisis/story-bBiwL1eyJJeMgFQcX4Cn7K.html

14. WHO (2011). *Guidelines for drinking water quality*. WHO Press: Geneva.