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Assessment of Groundwater Pollution and Remediation-A Review

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ABSTRACT

In this study, an overview of hydro geological processes and concepts regarding groundwater flow and contaminant in most parts of many countries .Groundwater pollution is imminent in most developing countries as a result of increased anthropogenic activities apart from possible natural pollutants. The world's population is facing a water crisis, which is expected to worsen dramatically during the 21st century. Problems due to over exploitation of groundwater, as well as from natural and anthropogenic contamination are major challenges facing humanity. This study reviewed groundwater pollution and discussed possible remediation measures. It is recommended to carry out a continuous water quality monitoring program and development of effective management practices for utilization of water resources.

Keywords: Groundwater, Pollutants, Anthropogenic, Remediation, Water resources.

1. INTRODUCTION

Water available in arid and semi-arid regions of the world, which is almost one third of the earth's surface, quench the thirst of nearly one billion people. The infiltration of surface water into the ground depends on various factors such as soil pores, fracture,fold, fault and joint contributes to groundwater. This water resource forms the major source for domestic, irrigation and industrial purposes in India. The nation uses around 80% of its water for irrigation, in which the groundwater-based irrigation accounts for 65%. However, there are limitations to the availability of groundwater as most of the water is confined to weathered and fractured zones and the water availability in hard rock terrains are limited. The hard rock terrains in India cover nearly 65% of the total geographical area where the porosity is less than 5% with a permeability of 10^{-1} to 10^{-5} m/day. (Kanagaraj et al. 2018).

The groundwater in the semi-arid crystalline aquifers of Central and Southern India is highly dynamic and the groundwater fluctuation is high, where it is controlled by rainfall recharge during monsoons (October to January) and over pumping in summer (February–May). Over pumping of groundwater in semi arid and hard rock dominant areas are often noticed with well dry out, which results in poor productivity. Therefore, there is a need to explore the groundwater potential zones for better abstraction of groundwater. In general, the occurrence and efficiency of groundwater in an aquifer system is controlled by several factors such as topography, geological

structure, lithology, fracture density, aperture and connectivity of fractures, secondary porosity, groundwater table distribution, slope, landform, drainage pattern, and land use land cover (Kanagaraj et al. 2018).

The natural chemical composition of ground water is influenced predominantly by type and depth of soils and subsurface geological formations through which ground water passes. Ground water quality is also influenced by contribution from the atmosphere and surface water bodies. (Sivakumar et al. 2015)

Sustainable water resources management is a crucial concern in most countries across the globe. Only 3% of total water on the Earth is considered as fresh water resources and approximately 30% of that is accessible as groundwater, which is vital for human health, ecosystem, energy industry and other water-dependent topics. The increasing demand by residential, industrial and agricultural uses have caused groundwater depletion and decreased quality in many regions. From sustainable development perspective, environmental, economic and social impacts are consequences of water pollution in any region of the world. Hence, careful attention should be paid to preserve water resources. (KooshaKalhor et al. 2019).

Groundwater is very important source of drinking water for both human being and animal in the world. It is also very essential source of water for the drinking, agricultural and the industrial sector. Being a significant part of the hydrological cycle, water resources depends on the rainfall and recharge methods. Groundwater quality is based on the physical, chemical and biological characteristics of groundwater. The suitability of groundwater for various uses majorly depends on quality of groundwater. Water quality assessment is the major important tool for share the information on the qualities of water to the public. It acts as the indicator of the quality of water. The purpose of assessment water quality is to turn multifaceted water quality data into simple information that is essential for the public. Many other researchers have conducted a study on groundwater quality by estimating the water quality index to substantiate the variation of groundwater quality.(Poonkundran.T2019)

The availability of a water supply depends upon the both quality and quantity is vital to human existence. The supply for water has increased over the year by year and this has led to water scarcity in many other part of the world. The situation is aggravated by the problem of contamination or water pollution. India is facing towards a freshwater crisis mainly due to improper miss management of water resources and environmental degradation. This leads to deficiency of access to safe drinking water supply to millions of people. This drinking water crisis is already evident in many parts of India, varying in scale and intensity depending mainly on the time of the yearPoonkundran.T (2019)

The groundwater storage and the recharge is the fundamental component of hydrological system. It is the result of water percolating through various layers of soil and rocks due to the atmospheric precipitation and snow. (Sivakumar and Neelakantan 2016)

With particular reference to this study provides a comprehensive review of hydrological concepts and novel investigation and modeling techniques followed by a discussion of groundwater contamination and remediation techniques. This paper aims to present and review the work of other researchers in the recent years (especially after 2018) and to discuss the latest improvements that have been made regarding groundwater quality and quantity assessment. In each section, the associated research work that has been done for Puerto Rico is presented to better understand what research works have been conducted and what are the research gaps on karst aquifers of this island. (KooshaKalhor et al. 2019).

Every year, 2, 70,100 million tons of water is required because of 90 million increasing population and approximately 25 million persons die as a result of water pollution. Tamil Nadu accounts for 4% of the land area and 6% of the population, but only 3% of the water resources of

the country. Most of Tamil Nadu is located in the rain shadow region of the Western Ghats and hence receives limited rainfall from the southwest monsoon. Salman A. Salman et al. 2019 reported that about 47% of the groundwater is unfit for drinking and agricultural purposes due to high salinity. The quality of water for irrigation is determined by the concentration and composition of dissolved ions which are generally governed by lithology of subsurface, velocity and quantity of groundwater flow, nature of geochemical reactions, solubility of salts and various anthropogenic activities. Groundwater quality variation is a function of physical and chemical patterns in an area influenced by geological and anthropogenic activities. (Umamageswari et al. 2019).

A. Contaminant types and sources of contamination

Agricultural, industrial, residential, commercial and municipal development is considered as the main sources of groundwater pollution in recent decades. In particular, leakage of storage tanks, chemical spills, landfills, fertilizers and pesticides, sanitation systems, untreated waste discharge and sewage are some of the main sources of contamination due to anthropogenic activities. Generally, regardless of the source of contamination, pathogens, organic compounds, metals, and other inorganic compounds (e.g., nitrates, chlorides) are often found in groundwater. The most commonly found contaminants in karst GW are presented below. (KooshaKalhor et al. 2019).

Drinking water is contaminated through the pipe distribution system or directly through groundwater due to addition of waste water discharged from domestic, industrial and agricultural sources. The bore wells from which the samples are extensively used for drinking purpose. (Sivakumar et al. 2015)

If the groundwater is contaminated, its quality cannot be return to its original quality, till stopping the pollutants from the sources. Water Quality Index (WQI) is the important tool to give the information on the water quality to the concerned citizens and policy makers. It is an important parameter for the analysis and management of groundwater. WQI is defined as a rating reflecting the composite influence of different quality of water parameters. (Poonkundran.T 2019).Environmental factors, such as land-use pattern, type of aquifer, and soil-drainage capacity, affect the level of groundwater contamination (Salman A. Salman et al. 2019).

After the severe crisis facing in water supply, local bodies, Irrigation Departments, State and Central governments and other NGO’s are showing keen interest on cleaning lakes and restoring the existing remaining water bodies(Mohan et al. 2015)

Groundwater plays an important role in supplying water to much of the global population for use in agriculture, drinking water, and industrial purposes. Physical and/or economic water scarcity occurs on all of the populated continents, with some parts of the world facing a genuine water crisis. Water quality problems are both natural and anthropogenic in nature, with emerging contaminants playing an increasing role. Groundwater quantity and quality problems constitute a major set of challenges facing the world during this century (John Luczaj 2016)

B. Groundwater Pollution

This study also takes an anthropocentric viewpoint in that it is concerned with the causes/ sources of potential pollution that are human induced, the effects/consequences of pollution on humans and management options will relate to human activity. Groundwater contamination is nearly always the result of human activity. In areas where population density is high and human use of the land is intensive, groundwater is especially vulnerable. Virtually any activity whereby chemicals or wastes may be released to the environment, either intentionally or accidentally, has

the potential to pollute groundwater. When ground water becomes contaminated, it is difficult and expensive to clean up. (Abel O. Talabi and Tosin 2019)

Rapid industrial development, urbanization and increase in agricultural production have led to freshwater shortages in many parts of the world. The water resources of the basin remain almost constant while the demand for water continues to increase. The utilizable water resources of India are stimulated to be 1123 BCM is surface water resources and 433 BCM is ground water resources. (Sivakumar et al. 2015)

To begin to address pollution prevention or remediation, we must understand how surface water and groundwater interrelate. Groundwater and surface water are interconnected and can be fully understood and intelligently managed only when that fact is acknowledged. If there is a water supply well near a source of contamination, that well runs the risk of becoming contaminated (Figure 1). If there is a nearby river or stream, that water body may also become polluted by the groundwater. Depending on its physical, chemical, and biological properties, a contaminant that has

C. Pollution Classification

Water resources pollution and the respective groundwater quality degradation are been released into the environment may move within an aquifer in the same manner that groundwater moves. Some contaminants do not always follow groundwater flow. It is possible to predict, to some degree, the transport within an aquifer of those substances that move along with groundwater flow.(Abel O. Talabi and Tosin 2019)

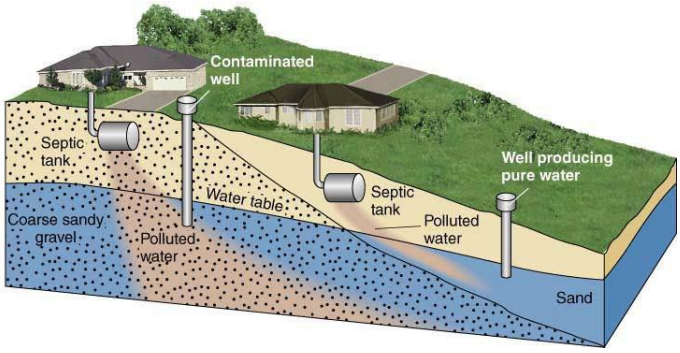

Fig1. Groundwater contamination

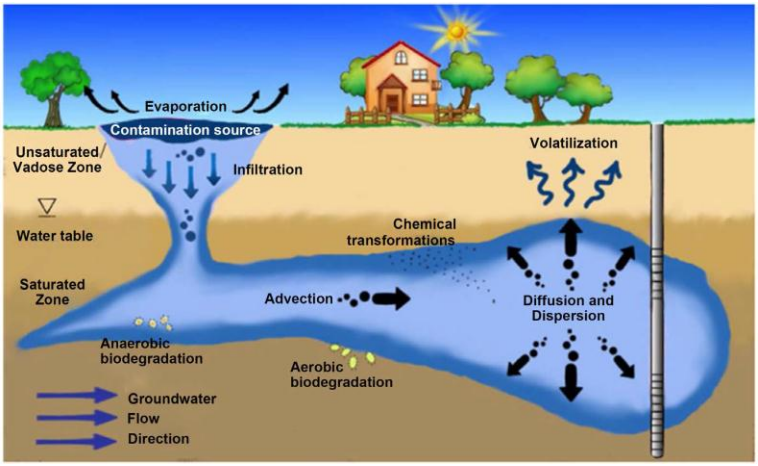

Fig2. Main processes involved in contaminant transport in the aquifer

C. Point and Non-Point Pollution Sources

Possible water pollutant sources are numerous and can also be classified into point sources and diffuse pollution sources. Pollution of surface waters is directly related with groundwater pollution. Thus, pollution of surface water usually results in respective groundwater pollution. Groundwater pollution sources are summarized in Figure 3. Major point sources include municipal and industrial wastewater treatment plant effluents, which can be located in urban, industrial or agricultural regions. It is not unusual that wastewater treatment plants, combined sewage-storm water overflows treatment plants or improper treatment of hospital effluents does not provide a final effluent of appropriate quality. Specific organic micro pollutants might end up in this way in surface and groundwater. Other point sources of groundwater pollution are industrial activities such as food processing, mining activities, manufacturing plants, livestock farms and landfill sites. (Abel O. Talabi and Tosin 2019)

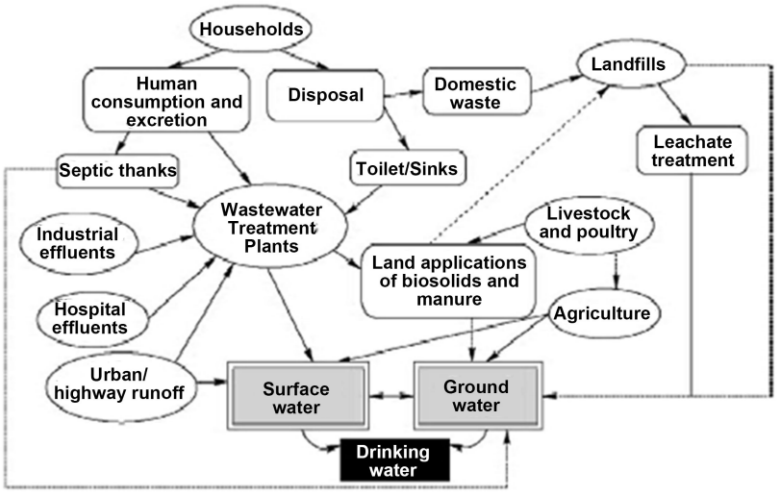

Fig 3. Possible water pollutant sources

D. Prevention of Groundwater Pollution

Investing in safe drinking water is not only good for personal health and hygiene as well as the environment. It also promotes economic growth. It is therefore necessary to have effective means of preventing groundwater pollution. Prevention of groundwater pollution is the cheapest and most effective solution vis-à-vis remediation. Groundwater pollution can last for years without being detected and by the time it is detected, it must have caused a lot of havoc. Prevention therefore saves tremendous cost. An effective prevention plan should take the following points into consideration: waste disposal, hazardous materials, storm water, management practices, storage tanks and pipelines, small and medium scale business, monitoring wells and water policy formulation.(Abel O. Talabi and Tosin 2019)

Groundwater is the primary and most trusted source of drinking water in many arid and semi-arid regions of the world. The chemical composition of groundwater is an indicator of its suitability as a source of water for human and animal consumption, irrigation, and for industrial and other purposes. The definition of water quality is therefore not objective, but socially defined depending on the desired use of the water.Groundwater pollution is common in both the developing and developed world. Contamination of groundwater can result in poor drinking water quality, loss of water supply, high clean-up costs, high costs for alternative water supplies, and/or potential health problems (Sajil Kumar 2019)

E. Remediation of Groundwater Pollution

Groundwater remediation is the process that can be used to remove pollution from

Groundwater. Because each groundwater aquifer is unique, mineralization of organi contaminants by either biotic or abiotic mechanisms (e.g., complete conversion of the chemical to CO2 and water) is a function of the spatial heterogeneity of subsurface properties such as pore structure, hydraulic conductivity and microorganism populations as well as carbon and energy sources. This information, along with laboratory studies of degradation, sorption and transport (as described by hydraulic conductivity and chemical dispersion), must be incorporated into plans to design and engineer the proper conditions for restoration in the field. The two approaches described below have some steps in common but differ because bioremediation methods are much more amenable to in-situ operations. If in-situ bioremediation methods can be successfully transferred from the laboratory to the field, they have a clear economic and environmental advantage over physical-chemical methods. (Abel O. Talabi and Tosin 2019)

In spite of the many steps taken to maintain and improve the quality of surface and groundwater, the quantities of wastewater generated by these industries continue to increase and municipalities and industries continue to increase and municipalities and industries are confronted with an urgent need to develop safe and feasible alternative practices for wastewater management. (Mohan et al. 2017)

The safe development of groundwater resource mainly depends upon the groundwater recharge. Artificial groundwater recharge is essential in terrains with low natural groundwater recharge. (Sivakumar and Neelakantan 2016)

CONCLUSIONS

A brief review discussion on groundwater contamination and risk assessment was presented. Groundwater is essential need for growth of all country. If water resources are to remain available as good quality water for upcoming generations, it is very essential to control from the possible contamination. This freshwater and pure water crisis is already evident in many other part of India, particularly in Tamilnadu, varying in scale and intensity, depending mainly on the climate condition of the year. In Tamil Nadu, water supply scarcity plays an important role. However, water quality monitoring is an important tool to find contamination of groundwater and to provide an advanced warning of the approaching contaminated groundwater to important sources of water supply. This is of great importance, because the problem concerns securing a safe portable water supply for the present and future generation people.

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