Chapter 1

Introductory Chapter: Aquifers Today and Tomorrow

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1. Introduction

As defined in many scientific texts "An aquifer is an underground layer of water bearing permeable rock, rock fractures or unconsolidated material from which groundwater can be extracted using water well" [1]. Related terms used are aquitard, which is a bed of low permeability along an aquifer, and aquiclude, which is a solid, impermeable area underlying or overlying an aquifer, making an aquifer confined or unconfined. Aquifer system is a series of two or more aquifers hydraulically connected with each other. If an aquifer or an aquifer system spans more than one state, it is called transboundary aquifer [2]. An aquifer is therefore the combination of both; an underground rock structure, and water mass existing in the pores and voids. Aquifers contain by far the largest volume of unfrozen fresh water on earth thus making it an enormously important natural resource, entrusted to us by the Mother Nature for equitable use and safe custody for the next generations to come. Because of the fact that aquifer is hidden to the eye, therefore till today they are poorly known and understood by the common masses and decision makers alike.

2. Aquifers today

Aquifer, the solid rock structure and fluid occupying the interstices, being a transitional resource has been prone to exploitations, silent revolutions and progressive pollutant attacks inherent to modern lifestyles. A considerable amount of risk and uncertainty is therefore attached to the aquifers because of stresses on groundwater systems produced inherent to modern domestic and industrial life patterns. At present, the key issues related to the aquifers may be summed up as:

Falling groundwater levels and storage depletion.

Groundwater quality and resource pollution.

Effect of climate change and sea level rise.

Effect of natural hazards and emergencies on aquifers.

Management of transboundary aquifers.

In the absence of well installation and pump operation laws in many countries of the world and lack of enforcement of these laws wherever these do exist, excessive pumping leading to mining of the aquifers is a constant source of depletion of aquifers. It is feared that in many arid, semi-arid, and increasingly water-scarce areas around the world, dependency on aquifer water will increase because of storage buffers rendering the groundwater a better option than dwindling surface waters. There is, thus, a dire need that laws be made and regulations be implemented to effectively monitor the excessive pumping from aquifers. According to a recent news in the city of Cape Town, the water taps will cease to supply water to the entire city in April 2018 because water supplies are likely to deplete to unmanageable lower limits.

Aquifer quality degradation is another major issue that has been and is bothering the stakeholders the world over. At conventional drilling depths, the water found is usually of potable quality, fit for municipal, agriculture and industrial consumption. However, exhaustive use of micropollutants in particular pharmaceuticals and personal care products and endocrine disruptive compounds is drastically affecting the quality of aquifer waters for all purposes. It remains a major global, regional and local concern to protect the groundwater against quality degradation in all respects.

Inherently aquifers are very resilient to the effects of atmospheric variations above ground, surface hazards and climate change effects and therefore are preferred over the surface waters, making them as more dominant sources of water. However, climate change adversely alters the aquifer's groundwater recharge thus introducing uncertainties in the recharge estimates and spatial pattern definitions. Climate change alters the mean annual groundwater recharge and mean annual surface water flows and their distribution in time. The water demand and water use have also been found to have been affected by the climate change phenomena.

Artificial recharge is the planned human activity of augmenting the amount of groundwater available through works designed to increase the natural replenishment or percolation of surface waters into the groundwater aquifers. Artificial recharge is also used for the purpose of disposal of floodwaters, control of salt water intrusion, water storage to reduce pumping and piping costs, temporary regulation of groundwater abstraction, and water quality improvement by removal of suspended solids. Managed aquifer recharge is increasingly being used to facilitate water recycling in areas where it is possible to improve scarcity by harvesting urban storm water and wastewater. Pretreating injection water should be made obligatory.

Natural treatment can be achieved in the aquifer during managed aquifer recharge, resulting removal of pathogens, nutrients and micropollutants.

Aquifer storage transfer and recovery (ASTR) in contrast to aquifer storage and recovery (ASR) uses separate wells for injection and for recovery, allowing an attenuation zone to exist around the recharge zone [3].

Aquifer management and groundwater governance are very complex phenomena and need to be tailored to local conditions and socio-politico-economic environments. For transboundary aquifer systems, due to international dimension coming into play, this complexity is even greatly enhanced. International cooperation and wide range international initiatives could add significant value to aquifer management. International cooperation could be in the form of enhancing and disseminating technical data about aquifers and groundwater, developing and promoting approaches and tools for aquifer management, and raising global commitment for priority action when required.

Administrative and political borders dividing transboundary aquifer systems provide great barriers and obstacles to the coordinated development and management of aquifers, making this even more complex in nature. Lack of information or information gaps, conflicting interests of states and a lack of coordination across the boundaries, easily lead to the problems that may otherwise be preventable. A study on international law revealed that very few institutional arrangements and legal instruments exist to resolve such conflicts of interests [4]. In its 66th session, the United Nations General Assembly passed a resolution on "Law of Transboundary Aquifers" [5]. Salient of the resolution being:

States concerned to make appropriate bilateral or regional arrangements for proper management of their transboundary aquifers, taking into account the provisions of the resolution.

Encourages International Hydrological Program (IHP) of United Nations Economic Scientific and Cultural Organization (UNESCO) to offer further scientific and technical assistance to the states concerned.

To formally legislate on "the law of transboundary aquifers."

3. Aquifers tomorrow

Due to excessive demand of water by the ever increasing population, the necessity of artificial recharge of aquifers is increasing day by day. Extensive research is being conducted to explore new and novel techniques for artificially recharging the aquifers to enhance their capacity, water quantity, and improve the water quality. Kavuri et al. have reviewed the existing methods of artificial recharge such as infiltration basins and canals, water traps, cut waters, surface run off, drainage wells, etc. [6]. Modern techniques like direct surface and subsurface recharge including seepage from surface reservoirs like Khanpur reservoir, and indirect recharge have been thoroughly explored and improved for achieving better efficiency in meeting the artificial recharge goals like storage of fresh waters within saline aquifers, secondary oil recovery, and wastewater disposal, etc. [7]. Indirect methods include installation of groundwater pumping facilities, hydraulically inducing infiltration in the drainage basins, modification of aquifers or construction of new aquifers.

The latest trend in aquifers is the modification of existing aquifers or creation of new artificial aquifers or underground reservoirs for water. Aquifers can be modified by structures that impede outflow of groundwater. Groundwater barriers or dams have been built underground to obstruct or detain flow in/out of the aquifers. Recent example is the creation of artificial aquifer under Liwa desert in south of Abu Dhabi, United Arab Emirates which can provide water at the rate of 600 l per day per person. Reportedly Liwa Strategic Water Reserve (Liwa ASR) can store 26 billion liters of water, and it will take approximately 26 months to fill it up [8].

4. Conclusion

Since groundwater as a natural resource is very vital for survival of human race on this planet earth, the present generation is answerable to the future generations for its safe custody, upkeep and maintenance of quality and quantity. Therefore, all endeavors must be made in understanding the nature and behavior of aquifers, their protection, their maintenance and sustainable development for use by all stakeholders concerned.

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