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Groundwater Resources and Management– a Review

Ali R A Moursy*[1], Marwa Adly Abdel-Aziz[2], Rawan Ahmed Hessien Hassanein[1], Osama Ahmed Mohamed Abdellatif[3] and Dalia Saied Moslem Ahmed[4]

[1]*Soil and Water Department, Faculty of Agriculture, Sohag University, Sohag, 82524, Egypt.*
[2]*Agricultural Research Institute, Sohag, 12619, Egypt.*
[3]*Geology Department, Faculty of Science, Al-Azhar University, Assiut, 71524, Egypt.*
[4]*Special Chemistry Department, Faculty of Science, Sohag University, Sohag, 82524, Egypt.*

Corresponding Author: Ali R A Moursy; E-mail: *ali.refaat@agri.sohag.edu.eg*

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ABSTRACT

Understanding the nature of groundwater as the most important source of water is very important. Therefore, international governments, as well as specialists and decision makers, focus on the optimal exploitation of groundwater. There is no doubt that this water is necessary not only for drinking but also for agricultural and socio-economic activities. With the problem of water shortage and the increase in the number of population and their needs, it was necessary to develop some mechanisms and strategies that regulate water consumption. The most important recommendations resulting from this study are to constantly evaluate the groundwater to know its quantity, quality and suitability for various activities. Also, preserving groundwater from deterioration, pollution and salinization is a matter of everyone's concern.

1. Introduction

Groundwater is considered as stored water in tiny pore and spaces between gravels, rocks, sand, and soil under the ground surface. It forms in two zones viz the upper unsaturated zone where the majority of pores are filled with air; and the deeper saturated zone whereas all pores are filled with water over the year. Moreover, the groundwater is fresh water stored from different sources such as melting, snow ice or rain. Regarding the water quantities, groundwater is about 95 percent of the global fresh water resources which can be underground for thousands of years. Also, can come to the surface as a spring or be pumped from a well and helps in filling ponds, lakes, streams and rivers as well as wetlands. Groundwater used for drinking as well as about 50 percent of municipal, domestic, and agricultural activities (USGS, 2019). As mentioned, groundwater is formed inside the earth as a result of surface water intrusion mainly from rain through the pores. Therefore, the amount of water in the aquifer varies from one place to another depending on several factors. These factors are the amount of precipitation, leakage, geography and geology of the place (Lachassagne, 2021). Till the moment, the physical laws that govern groundwater are unknown and outside the scope of scientists and workers in related fields. However, groundwater is widely used around the world mainly because of its sustainability. Also, it is used mainly during the dry seasons and in arid regions. Groundwater is stored to be protected from surface pollution whereas well managed as high quality and quantity water source (Li et al., 2021).

Based on this basic information about groundwater, this work targeted identification of groundwater as an important water source; and to overview its utilities and applications.

Groundwater formation

Groundwater is formed as a result of water leaking from the earth surface into the ground (the process of feeding) depending on soil type and porosity (the source of nutrition). As previously mentioned, that groundwater is located in two regions (saturated and unsaturated). The upper surface of the saturated layer is filled with water and called as ground water table, while an area below the groundwater table is called as the aquifer (Lachassagne, 2021). The rocks located in the saturated region have different porosity and permeability characteristics. This may indicates that water does not move in the same way in all rocks, so the rate of recharge varies for all aquifers (Karlen et al., 2014).

Amount of groundwater

Groundwater is the most abundant source of fresh water on Earth which about 30% of the world's fresh water, and of the other 70%, approximately 69% are captured in ice caps and mountain snows/glaciers and only 1% is found in rivers and lakes.

Groundwater provides nearly 50% of all drinking water worldwide and 43% of all consumptive uses of water for irrigation in agriculture (Aggarwal et al., 2009).

Groundwater importance

Groundwater is considered as one of the most important water resources in the arid and semi-arid regions over the world. Moreover, groundwater is tapped by digging artesian wells in order to settle and settle pastoralist's tribes, encouraging them to grow different crops for agricultural purposes (Abdulrazzaq et al., 2020). Groundwater is an important component of the water cycle by the constant flow of water between the earth and the sea. Through evaporation and rain, water enters the atmosphere. As soon as the water cascades down, the upper layer of the soil becomes saturated at the earth's surface, and then it reaches the groundwater level, which is at the top of the saturated layer (Al-Taai, 2021). Actually, groundwater plays an essential function in many locations where rainfall and the genuine value sought from it. Regarding the importance of the groundwater resource, it is possible to rely on groundwater in areas remote from rivers, making the development of groundwater resources in dry regions where permanent rivers do not flow a critical issue. For example, Tunisia gets about 95 percent of water requirements from the sea while, groundwater in Marrakech represents around 75 percent of the total water quantity. It is also the main water source in Saudi Arabia. Many other arid areas over the world, such as western parts of the United States, Western Australia, North Africa, Afghanistan, Pakistan, as well as Central Asia depends only on groundwater (Abdulrazzaq et al., 2020). Moreover, as groundwater is the primary source of water for drinking and irrigation, farmers use groundwater to irrigate crops and their animals as well as many companies and industries depend on this water source. The production of electric power, food and beverage and the production of materials also depend on groundwater in several places. Groundwater is also providing security against droughts closely linked to surface water resources and the hydrological cycle. There are features that make groundwater more attractive when compared to other sources such as reliable supply, uniform quality and temperature, relative turbidity and pollution free, minimal evaporation losses, and low cost of development (García et al., 2018).

Sources of groundwater

Groundwater sources change throughout time. The main sources of groundwater are briefly described as following. The first source of groundwater is the air water, also known as falling water or a precipitation whereas water move on earth surface to the underground. Snowmelt is the second source of the groundwater whereas water stored in the stony layers and seeped into the ground. The third source is called as geological water which emerged from the ground and mainly contaminated by fungi. In this source, water is produced from rocks whereas fresh water or saltwater are presented. Water droplets are stored in the coherence of the edges of rocks and generating a groundwater aquifer sources. The other source of ground water is crystalline water which also known as rising water (Al-Taai, 2021). This type of water is connected with volcanic and galactic eruptions events occur during the formation of igneous rocks. This water is contaminated with a high concentration of minerals and dissolved salts. Sediment-contaminated water is another source of groundwater, whereas occasionally septic water stored during the sedimentation process (Jasim and Jalut 2020).

Concept of hydrologic cycle

Water is in a continuous cycle of transformation whereas it gets transformed from a phase to another based on several water properties. As known, the basic input to the world's water comes from precipitation and snow falls. Some amount of water flows towards the sea as runoff and the surface water collected in lakes, ponds, swamps, seas and oceans get evaporated into the atmosphere. Also, the vegetation transpires the water collected from the soil moisture then evaporated and transported water enters into the atmosphere as vapor which gets condensed form the clouds and starts precipitating again. This endless circulation of water is known as the hydrologic cycle (Tuan, 2019). Depending on the spatial and temporal scales, water hydrological cycle could be classified into two main kinds (terrestrial and global hydrologic cycles). The first cycle occurs as the mechanism of formation of water resources on a given area of the land, such as in a river basin or a watershed. The second cycle is the global hydrological cycle which controlled by the global climate, geological and physical processes (Li et al., 2021).

Classification of aquifers

Aquifers are classified into two main types, namely confined and unconfined aquifers. Confined aquifers is called also as Artesian aquifers which can be defined as water bodies accumulated in a permeable rock where enclosed by two impermeable rock layers. This type of aquifers is found to be overlain by a confining rock bodies and often made up of clay which might offer some forms of protection from surface contamination. The pressure on the geological barriers which are non-permeable and found exist between the aquifer causes the water within it to be under more pressure compared to the atmospheric pressure. Depending on gravity and geological formations in a specific area, groundwater vertically or horizontally flows through

aquifers. Unconfined aquifers are generally located near the earth surface without clay layers or other impermeable geologic material. These aquifers are located above the water table and lying relatively above impermeable clay rock layers. Moreover, the unconfined aquifers are more vulnerable to contamination from surface pollution as compared to confined aquifers. This may due to easy groundwater infiltration by land pollutants. Fluctuation in the level of groundwater varies and depends on the stored up groundwater in the space of the aquifer which in turn affects the rise or fall of water levels in wells that derive their source from aquifers (Salako and Adepelumi 2018).

Sources of groundwater pollution

There is several sources cause ground water pollution. Among them, oil and mining fields is a main source of pollution which include petroleum exploration and development, abandoned oil wells and test wells, buried pipelines and storage tanks, disposal of oil field brines, and mining activities (Chatterjee et al., 1995). The second source of ground pollution is described as from water wells, whereas disposal, drainage and abandoned wells, over pumping, well construction, river infiltration, and Sea water encroachment. The cultivated lands may cause groundwater pollution where many factors are affecting this process. These factors as animal wastes, dry land farming, fertilizers and pesticides, irrigation return-flow, and sewage treatment plant discharge. Other source of pollution is affected by the urban areas, whereas activities of urban and industrial landfills, surface impoundments, solid wastes, natural pollution, and septic tanks and cesspools (Lall et al., 2020).

Groundwater management

With the increase of human population as well as a huge demand of food and energy, managing groundwater is very critical and serious challenge. Groundwater management means balancing the consumption of groundwater resource regarding to quantity and quality. Management should take many factors in account such as efficiency, equity, and long term sustainability. In several regions, groundwater is consumed very faster than water nature restores which affects quality and quantity of this source (Romani, 2005; García et al, 2018). Groundwater pollution which hardly to be cleaned-up is caused by pollutants from earth surface such as pesticides and fertilizers, toxic substances, and oil. Decision makers and stake-holders focused on the management of quantity and quality of groundwater. Unsuccessful scenarios of groundwater management, lead to puts at massive risk for human well-being, sustainable development and biodiversity conservation (Jha and Sinha 2009).

Management of groundwater for sustainable agriculture

Protecting groundwater resources is the main challenge of sustainable management. Many factors such as climatic and socio-economic change are controlling the management. Several studies were conducted globally and suggested the importance of applying the integrated approach for managing groundwater (Shah, 2012; Lall et al., 2020). The consideration of factors such as food and energy is very necessary in managing groundwater resources. Balance management is needed for sustainable utilization of groundwater. Therefore, more efforts should be given to several factors such as water quantity and quality assessment, water supply and distribution, water reuse and recycling, protecting and water pollution. For better management of groundwater, two approaches are applied. The first approach is optimal yield in which the management is done in a short-term whereas controlled use of storage between recharge events. The second approach is called controlled management over exploitation whereas recognition of permanent depletion in storage is necessary to enhance socioeconomic development where water resource is limited (Shah, 2012). There are other several minor approaches for managing underground water resources such as methods of energy and technology pricing, regulating water consumption, controlling the acceleration of water degradation (pollution, salinity), as well as resolving the problem of competition for groundwater (Sikka et al., 2021).

Strategies of Groundwater Management

There are several issues related to groundwater management such as management of water resources to enhance water availability in order to time and geographic scale, management of water demands by socio-economic activities, and managing the competition of groundwater (Aggarwal et al., 2009). Therefore, groundwater management needs a proper evaluation of water resources to understand the mechanism of charging and detrition. The role of policy makers is important in the stage of controlling urban sprawl that affects negatively on groundwater. For sustainable utilization of groundwater, some strategies are needed which included a scientific development, artificial recharge, regulation, ensuring water for agriculture, as well as checking contamination of groundwater (Megdal, 2018).

2. Conclusion

People suffer from water and food shortage. Day after day, the situation will be worse if rapid steps are not taken towards sustainable development. Underground water is a buried treasure that is very important in providing food security as well as ensuring human livelihood. Therefore, there must be a clear-cut strategy that controls the development of groundwater resources. Moreover, groundwater must be constantly evaluated in terms of its quantity, quality and suitability for use in agricultural and socio-economic activities. Decision makers and planners should pay more attention to groundwater because it is simply the secret of life.

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