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GROUND WATER RESOURCE MANAGEMENT

Prof. Kailas V. Nikhade, Associate Professor & Head, Dept. of Geography, R.V. Art & Comm. College Bhamragad Dist. Gadchiroli

Abstract

With the ever increasing use of groundwater throughout the world along with the mismanagement or lack of management of groundwater basins, there is a continuing need to manage this vital resource effectively so as to ensure sustainable groundwater development. The modern concept of water management states that surface water and groundwater are integrated resources, and hence they should be managed together. This concept must be followed in practice for efficient water resources management at a local, regional or national scale.

Introduction

Ground water resource management is the process of ensuring that groundwater is available in sufficient quantities and quality to meet the needs of people, the environment, and the economy. It also involves protecting groundwater from pollution and depletion. The assessment and development of groundwater resources are essential for ensuring sustainable water supplies to domestic, agricultural and industrial sectors along with the ecosystems. There are overriding advantages of storing surplus water in subsurface reservoirs compared to surface reservoirs, which are as follows: Large storage volume which can be developed in stages according to the water demand, Little land-area requirement, Resilience to droughts, Relatively low environmental impact of well-field developments, More or less uniform water temperature, Relatively high purity and less vulnerability to contamination, Slight to no evaporation loss, No requirement of conveyance systems; and Slight to no danger of catastrophic structural failure. Groundwater management involves planning, implementation, and operation necessary to provide safe and reliable groundwater supplies. This necessitates groundwater management at a basin scale. Ground water management objectives typically focus on aquifer yield, recharge, and water quality (i.e., groundwater quantity and quality) as well as on socio-economic, legal, and political factors. After the proper evaluation of available water resources in a basin and the preparation of alternative management plans, action decisions can be made by suitable government or public agencies. The formal groundwater management approach, though generally more important for large-scale development, can also be applied to smaller-scale projects or even individual well projects (Roscoe Moss Company, 1990).

Keywords : Preparation, typically focus, hydrogeological, implemented periodically,

Study Objectives

The present study has the following objectives,

i) To study the Discussion in Ground water resource management.
ii) To understand the Ground water resource management.

Data Base & Methodology

The data has been furnished from the related articles, research papers. Some data has furnished the websites & as well as time magazine. For the present research paper the primary and secondary sources have been used. Materials from various libraries have been collected. The articles regarding to it have been read thoroughly. The descriptive and analytical research methods has been used for this research paper.

Basic Concepts of Groundwater Management

To manage a groundwater basin, a proper knowledge of the quantity of water that can be developed is a prerequisite. Determination of available water within a basin requires the evaluation of the elements constituting the water cycle. Therefore, the most fundamental approach to groundwater management is based on water balances within a groundwater basin. The water balance equation (or hydrologic budget) for a groundwater basin can be written as:

$$R + \frac{Q_i}{A} - ET - \frac{Q_o}{A} - \frac{Q_p}{A} = \pm \Delta S$$

Where, R = recharge to groundwater [L/T], Q_i = surface-water inflow into groundwater storage in the basin [L^3/T], A = area of the basin [L^2], ET = loss of groundwater due to evapotranspiration [L/T], Q_o = groundwater outflow from the basin (groundwater outflow into surface water) [L^3/T], Q_p = total groundwater pumping from the basin [L^3/T], and ΔS = change of groundwater storage in the basin [L/T]. The values of these parameters are considered over a specific period of time for which the groundwater balance is sought. indicates that for a given amount of recharge ($R+Q_i$) in a groundwater basin, the increase of pumping rate (Q_p) will eventually decrease the groundwater outflow into surface water (Q_o), evapotranspiration (ET), and groundwater storage (S). The decrease in the groundwater outflow into surface water may reduce flow in streams, creeks, lakes and springs, whereas the decrease in groundwater storage will lower the groundwater level in aquifers. Exactly how, when, and where these changes will be manifested depends on several factors such as the basin size, hydrogeological setting, and the times involved. Complexity often arises in real-world basins because an increase in pumping also increases recharge to some extent; it is known as induced recharge. Proper management of groundwater basin is concerned with renewability of the groundwater resource and its practical exploitation. Historically, one of the earliest approaches to analyzing groundwater yields was built on the concept of safe yield, which is associated with the amount of groundwater supply that a water user can depend upon (Todd, 1980; Fetter, 1994; Schwartz and Zhang, 2003). Safe yield is defined as the ratio of groundwater extraction from a basin for consumptive use over an indefinite period of time that can be maintained without producing negative effects on groundwater quantity, quality or environment. The goal of the safe yield is to achieve a 'long-term balance' (e.g., annual) between groundwater use and groundwater recharge in a basin so as to avoid groundwater depletion. Note that the purpose of the safe-yield goal is not to prevent pumping and use of groundwater, rather to limit pumping to the amount of groundwater that can be safely withdrawn each year. A few rules of thumb concerning safe yield are (Schwartz and Zhang, 2003): (i) the annual withdrawal of groundwater should not exceed the average annual recharge, (ii) the withdrawal of groundwater should not lower the groundwater level so that the permissible cost of pumping is exceeded (i.e., pumping becomes uneconomical), (iii) groundwater pumping should not lead to an undesirable deterioration in the quality of groundwater due to influx of contaminants, and (iv) groundwater pumping should not lead to land subsidence. Although the concept of 'safe yield' is widely used as a groundwater management tool, it has been criticized by some groundwater experts for not taking surface water into consideration. As indicated by Eqn. (21.1), excessive pumping not only lowers the groundwater level but also decreases the groundwater outflow into surface water bodies. Many perennial streams across the world dried up as groundwater levels significantly declined due to excessive pumping. Also, plants and animals thrive in fragile ecosystems developed along the perennial streams. These ecosystems are particularly at risk when the overdevelopment of groundwater resources lowers water tables in the riparian zones or results in significant water-table fluctuations. Thus, groundwater plays an important role in sustaining life as well as in sustaining some aquatic and terrestrial ecosystems (Humphreys, 2009; Steube et al., 2009). Further discussion on the concepts of 'safe yield' and 'sustainable yield' can be found in Alley et al. (1999), Alley and Leak (2004), and Jha (2013). A thorough discussion on the constraints and challenges of sustainable development and management of groundwater resources in developing nations can be found in Jha (2013).

Salient Techniques for Groundwater Management

A well-organized plan is essential to any groundwater management program, because it relates all necessary tasks, resources and time. During the preparation of a groundwater management plan, the knowledge of possible management techniques plays an important role, among other information. In this section, some useful groundwater management techniques such as 'conjunctive use of surface water and groundwater', 'artificial recharge of groundwater and seawater barriers', 'interbasin transfer of water', 'intrabasin transfer of water', 'indirect recharge through avoidance of pumping', and 'control well fields' are briefly discussed, while Fig. 21.1 illustrates these management techniques. Further details of groundwater management, with salient case studies can be found in Todd (1980), Fetter (2000), Schwartz and Zhang (2003) and Sarma (2009).

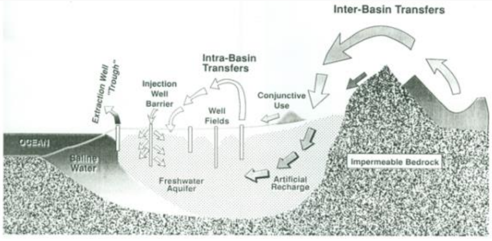

Illustration of salient groundwater management techniques.
(Source: Roscoe Moss Company, 1990)

Conjunctive Use of Surface Water and Groundwater

Conjunctive use of surface water and groundwater is a management technique designed to maximize the use of available water resources. The major objectives of conjunctive use technique are: (i) to maximize net benefits, (ii) to increase reliability of supply, (iii) to enhance overall efficiency of a water system, and (iv) to minimize the degradation of ecosystems/environment. It requires a coordinated operation plan for both surface water and groundwater designed to meet demands while ensuring maximum water conservation (Roscoe Moss Company, 1990). Conjunctive use plans vary from percolation of natural streamflows to complex programs involving inter and intrabasin water transfers, with facilities for recharge, extraction, and distribution. Some important benefits of conjunctive use are (Roscoe Moss Company, 1990): (i) reduced surface-water storage facilities, (ii) water conservation, (iii) smaller surface-water networks, and (iv) less evaporation loss.

Artificial Recharge of Groundwater and Seawater Barriers

Storing surface water into underground formations as groundwater for future use is an established practice in a conjunctive-use program. Groundwater recharge is accomplished by inducing percolation of surface water, thereby replenishing underlying aquifers. Further details of artificial groundwater recharge are given in Section 21.4. When pumping near coastal areas creates depressions in groundwater levels, seawater migrates into the inland and contaminates underlying freshwater aquifers. Protection of coastal aquifers against seawater intrusion requires some kind of seawater barriers such as a ridge of ‘protective groundwater elevations’ constructed through the use of a line of injection wells (recharge wells) along the seashore or a ‘pumping trough’ to intercept intruding seawater. These methods, together with other methods of controlling seawater intrusion into freshwater aquifers are discussed in ASCE (1987).

Intrabasin Transfer of Water

Complex geologic conditions exist in most groundwater development areas. For example, it may be possible to overdraft one area while excessively recharging another, and still not exceed the safe-yield values predicted by regional groundwater budget calculations (Roscoe Moss Company, 1990). Therefore, a detailed basin investigation and analysis is necessary to delineate the areas of excess or deficiency and effectively design optimum pumping, distribution, and recharge programs. This management technique is usually less expensive and more environment friendly (i.e., reduced environmental impact) than the ‘interbasin transfer of water’.

Indirect Recharge through Avoidance of Pumping

This is one of the innovative groundwater management techniques, which makes use of an indirect method of recharge. This technique encourages or requires groundwater users to purchase imported water instead of pumping groundwater (Roscoe Moss Company, 1990). In fact, this is equivalent to recharging the basin by the quantity of water not pumped. Such water management programs are made effective by keeping the costs of imported water supplies equal to or less than the pumping costs. They are implemented periodically by groundwater basin managers to regulate groundwater levels (Roscoe Moss Company, 1990).

Control Well Fields

Another technique used to conserve groundwater is through the use of 'control well fields'. Control well fields are strategically placed to produce interference effects for the control of hydraulic gradients and induce desirable groundwater-flow directions (Roscoe Moss Company, 1990). Control well fields typically control outflow from basins or restrain contaminant plumes. Well head protection (WHP) strategy used in many developed countries is one example of groundwater management by using the technique of control well fields.

Concept and Significance

In order to augment the natural supply of groundwater, people artificially recharge groundwater basins. Artificial recharge can be defined as "augmenting the natural movement of surface water into underground formations by some method of construction, by spreading of water, or by artificially changing natural conditions" (Todd, 1980). Various methods have been developed for artificial recharge, including water spreading, recharging through pits and wells, and pumping to induce recharge from surface water bodies such as rivers and lakes (Asano, 1985; Huisman and Olsthoorn, 1983; Johnson and Finlayson, 1988). The choice of a particular recharge method depends on several factors such as local topography, geologic and soil conditions, amount of water to be recharged, and the ultimate use of water. Under special circumstances, the value of land, water quality, or climate can be important factors in the selection of recharge methods (Todd, 1980).

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