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A Study of Groundwater Resources

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Abstract:

Groundwater is an increasingly water supply source globally. It is understanding the amount of groundwater used versus the volume available is crucial to evaluate future water availability. It present the groundwater stress valuation to quantify the relationships between groundwater use and availability in the world's 37 largest aquifer system. The concept of "safe yield" system has been used in case of determining the how much water can safely be withdrawn from an aquifer system. A new approach is suggested that adds a safety margin to the assessment of the production capacity of an aquifer. This approach is defined as "managed yield" and it is suggested as a replacement for safe yield when developing management strategies for groundwater system. In this paper, discuss about the safe yield and sustainable yield for groundwater supplies.

Keyword: *Sustainable yield, Groundwater, Aquifer, Safe yield*

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Introduction

So many natural resources exist, in which ground water is one of the Nation's most important resources. It provides about approximately 40% of Nation's public water supply. More than 40 million people, including most of the rural population that supply their own drinking water from domestic wells. In every state, ground water is an important source of drinking water and irrigation. Nation's principal reserve of freshwater and represents much of the potential future water supply. In many streams and rivers, ground water is a major contributor to flow and it has a strong influence on river and wetland habitats for plants and animals.

According to Meyland in National Geographic Magazine's special issue on water described the world's present water situation as follows:

"Nearly 70 percent of the World's freshwater is locked in ice. Most of the rest is in aquifers that we're draining much more quickly than the natural recharge rate. Two-thirds of our water is used to grow food. With 83 million more people on the earth each year, water demand will keep going up unless we change how we use it"

The basic statistics of water distribution are well-known, until it is unsettling to see the documentation of groundwater depletion continue to accumulate. **According to Meyland** found that groundwater around the world is being pumped faster than it can be refilled and it have doubled since 1960s at rates. It have to be increase is due to increased agricultural use of groundwater that accounts for 70-80% of increase globally. It is also estimate the fate of this water via infiltration, evaporation, and runoff for land parcels around the globe. Then, calculated how much water was leaving and entering world aquifers. Majority of this pumped groundwater is increased as much as 95%, ends up in the oceans where it is a contributor to the world's sea level rise. Researcher team has found that groundwater use has contributed 25% of sea level rise that is observed since 2000.

A groundwater management program is needed at the local and national level

In water management and allocation, essential tool is used that is tabulation of total water resources. This tabulation is also referred to as water budget which is an accounting of inflows, outflows and water in storage in an aquifer or in a surface water system. While pre-development water budget is an interesting exercise and this tabulation is more useful in current or post-development water budget that include the influence of human activities. Groundwater resources is characterized by pre-development of water budget that is in prior to human development. Its use has led to the creation of what has come to be known as the "safe yield myth." **According to Meyland**, safe yield "is myth because it is an oversimplification of the information that is needed to understand the effect of developing a groundwater system… As human activities change the system, the components of the water budget (inflows, outflows, and changes in storage) also will change and must be accounted for in any management decision." Before discuss the sustainable yield and managed yield, it is useful to briefly examine the role of water budget for an aquifer system and safe yield myth.

Water budgets and myth of safe yield

"Safe yield" is the traditional concept of water supply that is driven from surface water reservoir studies. "Maximum quantity of water that could be supplied from the reservoir during a critical period" is define as safe yield of a reservoir such as a drought. The term safe yield was first used in 1915 that have the means "without dangerous depletion of the storage reserve, quantity of water that can be pumped regularly and permanently". Safe yield to groundwater mainly is define to as the "amount of water which can be withdrawn from it annually without producing an undesired result". From many different scales, aquifer yield can be viewed such as for a well, for a specific aquifer or for an entire aquifer basin or system. But basic yield can be define as the "maximum rate of withdrawal that can be sustained by the complete hydrogeologic system in a basin without causing unacceptable declines in hydraulic head anywhere in the system or causing unacceptable changes to any other components of the hydrologic cycle in the basin". In shorthand version, safe yield has been popularized that define the safe yield of a groundwater basin as the long-term balance between "the amount of ground water withdrawn annually and the annual amount of recharge".

Safe yield of groundwater supplies is related to the traditional water budget that have the formula which expressed the relationship between inflow, outflow and water in storage for an aquifer.

$$\text{Inflow} = \text{Outflow} \pm \Delta \text{ Storage}$$

This relationship describes a natural aquifer system which is not influenced by human activities such as an aquifer in a steady state of dynamic equilibrium. In system, it represents a finite amount of water. In an aquifer, natural, undeveloped system, the quantity and flow of water is in balance. According to the seasonal variability, natural variations are off-set by minimal changes in storage. The inflow component is mainly represented by precipitation/recharge in un-developed system but outflow component is composed of discharge into boundary waters such as the ocean, lakes, and other boundary features. Into water surface, it may also include discharge such as streams and rivers that run through an aquifer watershed.

Pumping upsets the natural balance of flow in an aquifer

Water held have significant changes in storage that come into play when equilibrium between inflow and outflow is upset. The greatest factor that draws water from storage is when human development of an aquifer tips the equilibrium balance in apart from normal variations. Then, outflow (total water lost from the system) may begin to exceed inflow (Outflow > Inflow). Due to pumping, meet to new extraction of water and water must come from storage and still continue the normal outflow discharge. In case of water development and withdrawals increase, total water leaving the system may become gradually greater than inflow and water removed from storage (extra outflow) that is represented by pumpage.

Normal outflow will decline as the imbalance between inflow and total water loss continues if pumping stabilizes and water loss continues until a new equilibrium is reached. In the form of induced recharge, recharge of aquifer may also increase from water surface bodies such as stream and ponds that is replace the water being loss from storage. Between the aquifer equilibrium and surface water features exists the important relationship within an aquifer watershed. **According to Meyland**, "the sustainable yield of an aquifer must be considerably less than recharge if adequate amounts of water are to be available to sustain both the quantity and quality of streams, springs, wetlands, and groundwater-dependent ecosystems".

Safe yield myth contain the several misunderstanding, first one is safe yield is used to evaluate water withdrawals for human needs and that needs are paramount to all other users or components represented in system. In the system, human need are met, then the assessment examines the water remaining. Second one is the safe yield approach associates the aquifer to a large storage container. The safe yield's myth implies that if human withdrawals do not exceed recharge, then the amount of water left behind is static, like water held in a massive, leak-proof tank.

Moving toward sustainable yield and beyond

According to the American Society of Civil Engineers' Sustainability yield is stated that, "sustainable water resource systems are those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity".

It contain the six-step process for determining the how much water an aquifer system can sustainably produce. This steps are follows as:

- Determine average annual replenishment.
- Identify the most stringent constraint, i.e., the first unacceptable effect that will occur when water levels are lowered.
- Quantitative relation is identified between water-level elevations and occurrence of this unacceptable effect.
- For whole aquifer, define minimal water levels.
- Compute the rate of natural outflow that will occur when a quasi-steady state of flow commensurate with minimal water level is established.
- Sustainable yield is the difference between identify the most stringent constraint and compute the rate of natural outflow.

These steps are helpful in developing a more advanced amount of water production from an aquifer system. If any change in conditions such as changes in land use, economics or importation of new water supplies that required calculation of new yield.

Review of Literature

Wada et.al 2010, concluded that increasing the global groundwater depletion since 1960 and likely to increase further in future while increase of impoundment by dams has been tapering off since 1999s. In future, contribution of groundwater depletion to sea-level rise may increasingly.

Nwankwoala 2011, stated that serious management of groundwater that is successful and need an interdisciplinary and holistic approach incorporating all stakeholders, technocrats, hydrogeological conditions, local specific environmental issues, indigenous methods of water conservation and usage etc. Effective policy are made for sustainable groundwater management and any groundwater scheme to succeed then, stakeholders must be involved, motivated and trained. For future, taking an appropriate actions on groundwater resources management, in line with developing international water policies (UN-Agenda 21, 1992), should involve combined and coordinated efforts of all stakeholders. There is need to build up a momentum with significant impact and credibility and to avoid repetition and duplication of efforts.

Fan 2015, in this paper, understanding the behavior and functions of groundwater in Earth's critical zone at scales of a column (atmosphere-plant-soil-bedrock), along a toposequence (ridge to valley), and across a small catchment (up to third-order streams) and understanding the large-scale patterns and process such as represented in global climate and earth system models. It also profoundly shape critical zone evolution at continental to global scales. This implication to understanding past and future global environmental change are discussed as well as critical discipline, scale and data gaps.

Richey et.al 2015, concluded that existing socio-economic tensions may collide with water stress to produce stress-driven conflicts. By using with trends, quantifying the groundwater in groundwater storage anomalies from Gravity Recovery and Climate Experiment (GRACE) holistically represents the distribution of renewable groundwater stress. GRACE includes the influence of withdrawals, the aquifer's response to withdrawals through capture, and natural variability. GRACE-based estimates of use can encompass natural and anthropogenic variations on groundwater systems across a range of biome types.

Graaf et.al 2017, concluded that contribution of global-scale groundwater study is the parameterization of world's aquifer systems that including information on their vertical structure. This parameterization is based on global data-sets of surface geology and hydraulic properties and topography-based estimated of vertical structure of the aquifer systems. The world's aquifers are classified into confined and un-confined systems that is understand aquifer sensitivity to groundwater abstractions and to properly project future groundwater level.

Qiguang et.al 2017, dictated that different with different water levels, time of groundwater recharge from irrigation, the deeper groundwater level is and the longer recharge time is. During the fast growing period of crops, irrigation water mostly expended by crops. The soil moisture had the similar trend with the groundwater level, whose recharge was ahead of the groundwater. By irrigation, water consumption of crops, precipitation and evaporation, coefficient of recharge from irrigation was affected. It is calculated by groundwater level and soil moisture that have similar results.

Conclusion

Groundwater play an important role in safe yield and sustainable yield. The solution of regional and local water problems that requires education, technical assistance and supporting research. Community at large participates in policy formulations and in judgments that is imperative. Strong public education and outreach programs are needed to improve the understanding of nature, complexity and diversity of groundwater resources and to emphasize how this understanding must form the basis for operating conditions and constraints. From community, pressure was come for better management of natural resources that will be main driving force for most changes.

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