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Ground Water Management

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***Abstract*—The rapid growth in population with widespread extension of irrigated agriculture and industrial development are putting stress on the natural ecosystems. Groundwater is one of the most critical and vulnerable natural resources prone to quality and quantity deteriorations. Sustainability of groundwater resources for utilization by future generations must therefore be a high priority, not only for the purpose of fulfilling needs for water usage, but also for bringing people into harmony with their natural environment.**

But, over the last three decades, Groundwater Scenario in the country has completely changed, mainly because of indiscriminate exploitation and improper and unscientific management practices both in rural and urban segments, leading to the stage of 'Hydro geological Stress'. The fact is that groundwater has attained the position of a 'Democratic Resource' in the country; because it is a dependable and assured resource and can be exploited with greater ease and flexibility. It is noteworthy that more than 40% of private minor irrigation tube wells in the country are extracting very huge quantity of groundwater. Besides 80-90% of drinking water and almost all industrial needs in the country are also met by groundwater resulting into its continuous escalated abstraction and declining water levels, thereby affecting its sustainability in many areas. The reported occurrence of Arsenic in groundwater of some areas has also emerged as a new threat on drinking water front. So, due to such alarming situations, groundwater domain of various rural and urban sprawls has reached a critical country, both quantitatively and qualitatively.

The reason for these groundwater problems is poor management. Therefore, effective interventions and suitable groundwater management plans are urgently needed in the country to overcome these critical situations. The imperative need is to initiate, formulate and prepare a long term strategy plan with a sustainable framework for the effective management of groundwater resources in the country.

Key words: Groundwater, resources, sustainability, management

I. INTRODUCTION

Water is the basic necessity of the life. The demand for water has increased over the years due to increase in population, industrialization, urbanization and standard of living of people and this has led to water scarcity in many parts of the world. Beneath the growing economy and development facade of our towns and cities, is the gripping water crisis. According to a report of the World Bank, by 2025, fifty two countries having two thirds of the total world population would face shortage of water. India is heading towards a freshwater crisis which has lead to a lack of access to safe water supply to millions of people. Freshwater crisis is already evident in many parts of India varying in scale and intensity. If something is not done soon, more than 125 million Indians will soon face desperate domestic, agricultural and industrial shortages.

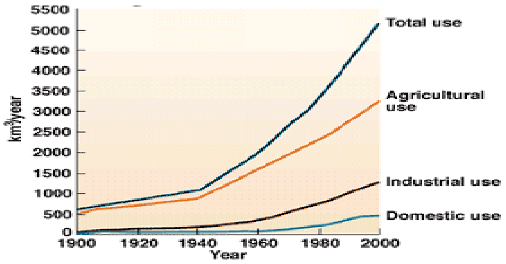


Figure: Global water consumption

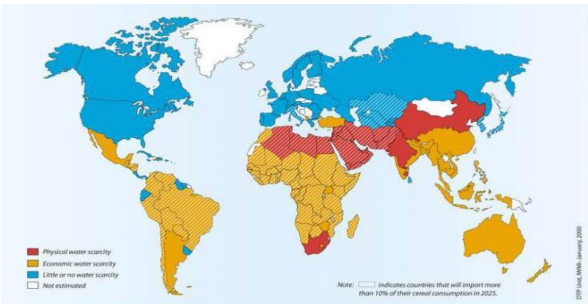


Figure: Projected water scarcity 2025

The planet earth has immense quantity of water. About 71% of the earth is covered with water but usable water is very limited. Out of the total quantity of water, 97.4% is salt water in the sea and other sources. Only 2.6% is fresh water, out of which 1.8% is surface water (frozen ice + liquid) and remaining 0.8% is ground water. Ground water is rechargeable to a certain extent; still it should be conserved as much as possible for future.

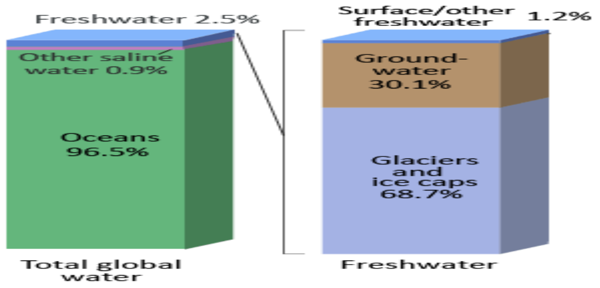


Figure: World's fresh water resources

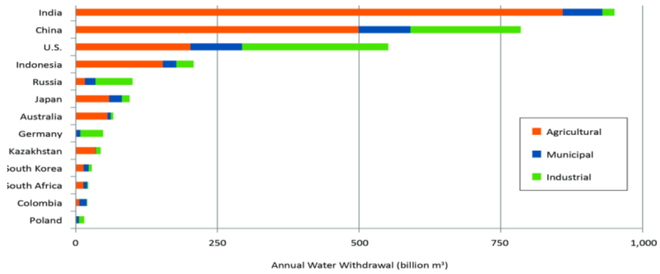
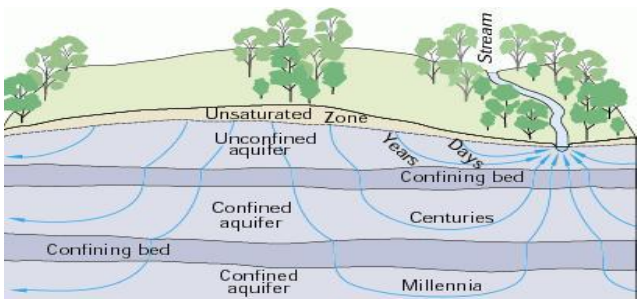


Figure: Top countries by groundwater withdrawal

Ground water refers to all water below the surface of the ground. Groundwater originates from precipitation that percolates into the ground. Percolation is the flow of water through soil and porous or fractured rock. Groundwater flow is of two types: shallow groundwater flow and deep groundwater flow. Shallow groundwater flow (groundwater runoff) intercepts the land surface, feeding springs and seeping back to the surface waters as the perennial flow of streams and rivers and other freshwater bodies, such as swamps and lakes. Conversely, deep groundwater flow (groundwater runout) does not intercept the land surface, flowing instead directly into the ocean. Age is a major difference between shallow and deep groundwater. Shallow waters are typically fresh, distinctly new and recycle with an average of 10 days. Deep groundwater does not recycle readily. Rates of groundwater turnover vary from days to years and from centuries to millennia, depending on aquifer location, type, depth, properties, and connectivity. The amount of deep groundwater is of considerable practical interest from the standpoint of sustainability.

Figure: Age of shallow and deep groundwater

Ground water is a major source of fresh water, critical for sustaining life and is nature's buried treasure. Underground water is the only source of water in many dry areas. Water is brought to the surface using pumps and used in various sectors. Groundwater is used to irrigate India's farmland and is an important source of water for the industrial sector. Groundwater is the major source of drinking water in both urban and rural India. Till recently it



had been considered a dependable source of uncontaminated water. According to The World Bank, India is the largest user of ground water in the world.

Excessive pumping can lead to groundwater depletion, wherein groundwater is extracted from an aquifer at a rate faster than it can be replenished. The Central Ground Water Board has reported that in the last decade, there has been a more than 4m decline in aquifers that supply six major cities, including Delhi, and Mumbai. Groundwater serves as a vital buffer against the volatility of monsoon rains, and India's falling water table therefore threatens catastrophe. The World Bank predicts that India only has 20 years before its aquifers will reach "critical condition", when demand for water will outstrip supply, an eventuality that will devastate the region's food security, economic growth and livelihoods.

The growing competition for rapidly dwindling natural resources may trigger interstate or intrastate conflict. China and India continue to draw on water sources that supply the wider region, and a particularly concerning flashpoint is the Indus River Valley basin that spans India and Pakistan. The river's waters are vital to the economies of areas on both sides of the border and a long-standing treaty, agreed by Pakistan and India in 1960, governs rights of access. But during the dry season i.e., between October and March, water levels fall to less than half of those seen during the remainder of the year. The fear is that cooperation over access to the Indus River will fray as shortages become more desperate.

II. REASONS OF DEPLETING GROUND WATER

Groundwater depletion is a logical consequence of a commons (a natural resource used jointly by many stakeholders) exploited in the absence of regulation or sustainable practices. As with any other natural resource held in common, an aquifer tends to be viewed by individuals pursuing their own self-interests as a resource to be exploited before others are able to get to it. The theoretical framework of the "Tragedy of the Commons" states that freedom in the commons eventually brings ruin to all, since every person is compelled to increase his individual benefit without limit in a world that is limited. Given the inherent logic of the commons, aquifer regulation appears to be the only way to avoid a re-enactment of the tragedy.

Human activities, primarily wasteful water use, over exploitation, a lack of sustainable water management policies and insufficient public investment are the main

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reasons of depleting ground water resources. These failings have each been exacerbated by rapid population growth, increasing population density and climate change. Apart from gross misuse, the government by virtue of its poor distribution system adds to the woes. In cities like Delhi and Pune, nearly 40% of the water supply is lost due to leakages.

Figure: Reasons of water crisis

Groundwater is an integral part of the environment, and hence cannot be looked upon in isolation. There has been a lack of adequate attention to water conservation, efficiency in water use, water reuse, groundwater recharge, and ecosystem sustainability. An uncontrolled use of the bore well technology has led to the extraction of groundwater at such a high rate that often recharge is not sufficient. The causes of low water availability in many regions are also directly linked to the reducing forest cover and soil degradation.

South Asia is a desperately water insecure region, and India's shortages are part of a wider continental crisis. According to a recent report authored by UN climate scientists, coastal areas in Asia will be among the worst affected by climate change. Millions of people across East, Southeast and South Asia will be affected by flooding, droughts, famine, increases in the costs of food and energy, and rising sea levels.

III. Groundwater Pollution

Quality of groundwater is also major concern where ground water resources are used for human consumption. Urban development, sewage contamination, runoff from landfills, and widespread application of fertilizers and pesticides are the major contributors polluting our ground water. The solid, liquid, and the gaseous waste that is generated, if not treated properly, results in pollution of the environment; this affects groundwater too due to the hydraulic connectivity in the hydrological cycle. For example, when the air is polluted, rainfall will settle many pollutants on the ground, which can then seep into and contaminate the groundwater resources. Some studies from the Central Pollution Control Board paint a dire picture. Water extraction without proper recharge and leaching of pollutants from pesticides and fertilizers into the aquifers has polluted groundwater supplies. The Central Pollution Control Board found DDT in groundwater, in the eastern Indian states of West Bengal and Bihar, at levels as high as 4500 micrograms per litre which is several thousand times higher than what is considered a safe dose. In addition, leachates from agriculture, industrial waste, and the municipal solid waste have also polluted surface and groundwater.

Fluoride is another natural contaminant that threatens millions in India. Aquifers in the drier regions of India are rich in fluoride deposits. Fluoride is an essential nutrient for bone and dental health, but when consumed in high concentrations, can lead to crippling damage to the neck and back, and to a range of dental problems. The WHO estimates 30 million in north western India are drinking water with high fluoride levels. The reason for this is that water has been pumped from deeper aquifers that contain high concentrations of arsenic. Groundwater depletion and contamination have forced cities to seek out alternate supplies of water, either because the groundwater has become unusable as is the case with Jaipur or groundwater will cease to exist by 2015 in the case of Hyderabad.

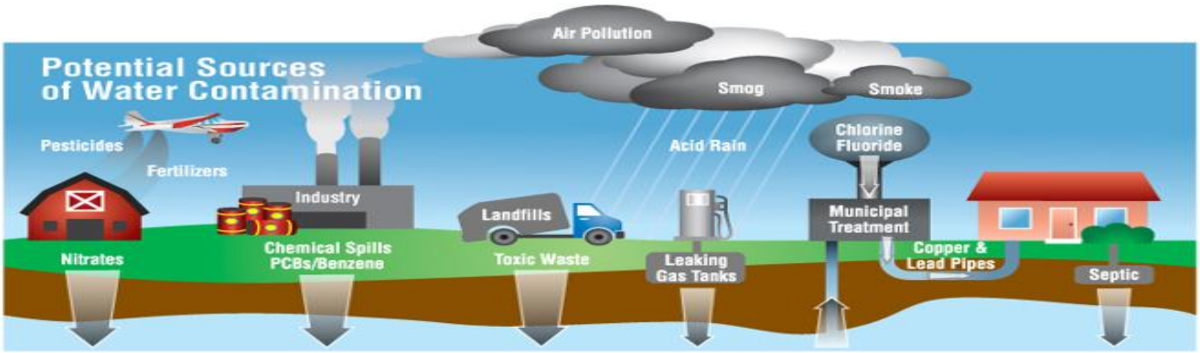

Figure: Water contamination

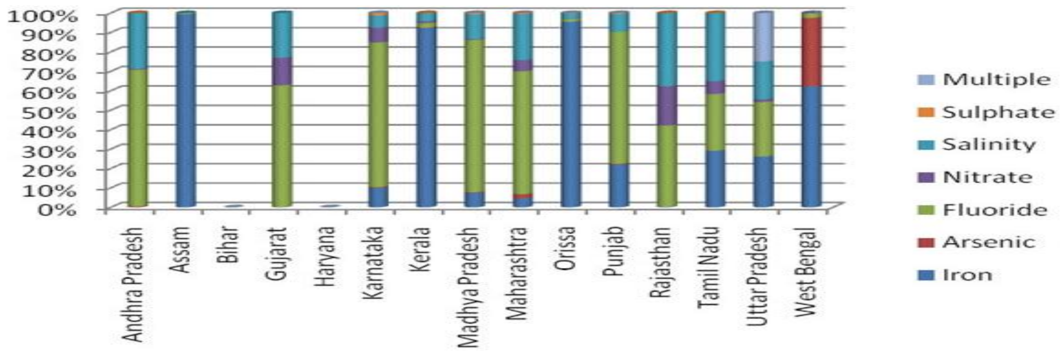

Figure: Percentage of affected habitations chemical contamination wise

Public health is also seriously at risk. The demand for safe drinking water in India is already high, and the situation will only grow more acute as levels drop further. The World Health Organization reports that 97 million Indians lack access to safe drinking water, while 21 percent of the country's communicable diseases are transferred by the use of unclean water. Some 45 million people the world over are affected by water pollution marked by excess fluoride, arsenic, iron, or the ingress of salt water.

IV. GROUNDWATER MANAGEMENT

Shallow groundwater is intrinsically connected to the surface water; therefore this should not be exploited in an unsustainable manner. Aquifers may have accumulated their volumes through centuries or millennia. Therefore, a groundwater use policy based on a substantial reduction of aquifer volume would be unsustainable, particularly if the rate of replenishment is slow. A sustainable policy for the exploitation of shallow aquifers should be based on the existing volume and the basin's recharge capacity. A mass balance can be used to evaluate the components of the water cycle, on an annual basis.

P - E - T - Q - G - D = 0

In which P= precipitation, E= evaporation (from surface water bodies), T= evapotranspiration (from vegetative ecosystems), Q= surface runoff (direct, or flood runoff), G= groundwater runoff, and D= deep percolation (runout to ocean).

It is important to realize that groundwater is not a resource that could be utilized unmindfully simply because it is available in abundant quantities. Problems and issues such as water logging, salinity, agricultural toxins, and industrial effluents, all need to be properly looked into.

In India, the Water Prevention and Control Act was passed by the Parliament in 1974, and by 1990 all the states adopted the act. In 1986, the Environment Protection Act was passed by the Parliament. Under both these acts, the states and the central government developed environmental norms for air emissions and waste water discharge for different types of sources. Since June 2001, the Ministry of Urban affairs and Poverty Alleviation has made rainwater harvesting mandatory in all new buildings with a roof area of more than 100 sq m and in all plots with an area of more than 1000 sq m, which are being developed. The Central Ground Water Authority (CGWA) has made rainwater harvesting mandatory in all institutions and residential colonies in notified areas; this is also applicable to all the buildings in notified areas that have tube wells. The World Bank report has suggested that pricing measures for groundwater use, including volumetric charges, taxes and user fees, may be used to act as incentives to conservation and more efficient allocation of water resources, assuming that these measures also address the concerns of equity and affordability for the poor.

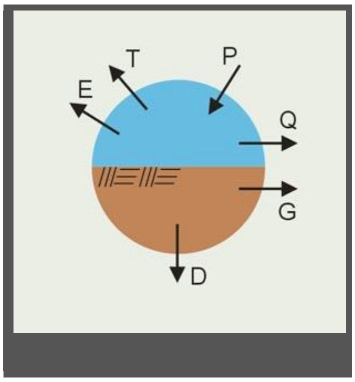

Figure: Groundwater basin mass balance

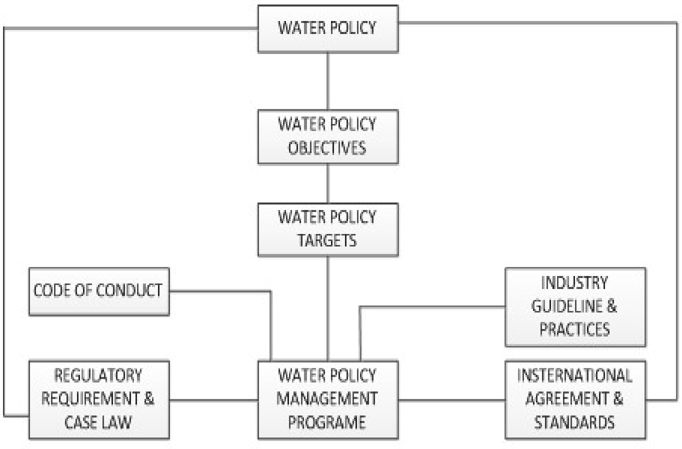

Figure: Water management

Ground water can be augmented through aquifer recharge (AR) and Aquifer storage and recovery (ASR). Artificial aquifer recharge is the enhancement of natural ground water supplies using man-made conveyances such as infiltration basins or injection wells. Aquifer storage and recovery is a specific type of aquifer recharge practiced with the purpose of both augmenting ground water resources and recovering the water in the future for various uses.

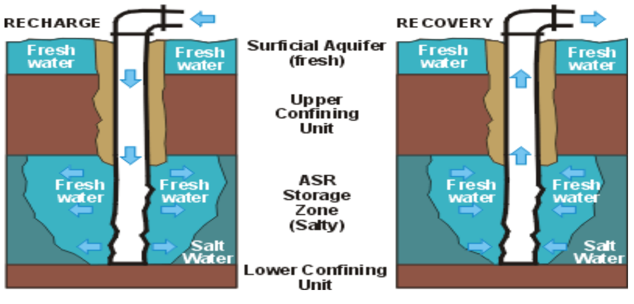

Figure: Aquifer recharge and recovery

Other than legislation and checks to conserve and improve the quality of groundwater, society itself plays a very important role. During the last decade there has been a rising awareness among the common people on the need for conservation and development of groundwater. Water use has to be integrated effectively with water regeneration, as was done in many traditional technologies. Renovation of forest tanks in drought prone regions will have a significant impact on wildlife and forest cover. Similarly, in some urban cities there is a need to regenerate groundwater aquifers because of the high degree of dependence on them for drinking water. Rainwater harvesting schemes have to been taken up in all cities and make legislations for protection of urban wetlands. New technology for rain water harvesting is rain saucer in which instead of using the roof for catchment, the rain saucer, which looks like an upside down umbrella, collects rain straight from the sky. This decreases the potential for contamination and makes potable water for developing countries a potential application. Other applications of free standing rainwater collection approach are sustainable gardening and small plot farming. All these will contribute to a rise in the groundwater level and a reduction of salt water ingress. Community awareness about water conservation and management of freshwater resources should be enhanced. The government should implement effective groundwater legislation and regulations through self regulation by communities and local institutions. Environmental restoration should be promoted along with household water security.

No single action whether community based, legislation, traditional water harvesting systems, or reliance on market forces will in itself alleviate the crisis in India. The effective answer to the water crisis is to integrate conservation and development activities from water extraction to water management at the local level; making communities aware and involving them fully, is therefore critical for success. All this will ultimately pave the way for combining conservation of the environment with the basic needs of people.

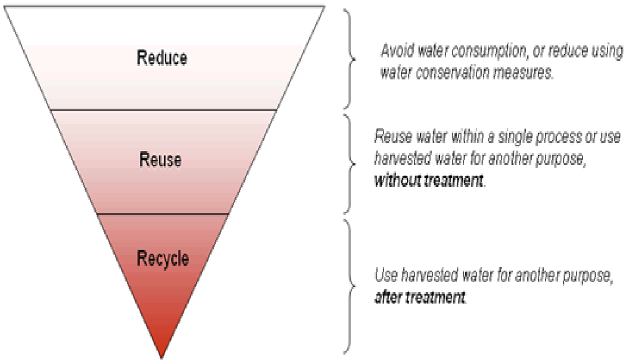

Figure: Water conservation

V. CONCLUSION

The unsustainable use of groundwater stands to significantly impact a host of hydrological, ecological and other natural resources and services, including freshwater bodies, and aquatic, riparian, transitional, and terrestrial ecosystems. The sustainable use of groundwater should begin by tapping primarily deep percolation, and secondarily shallow percolation. Detailed hydrological and hydro-geological studies are required to determine the percolation amounts. A contaminated aquifer cannot be used as a resource. Therefore, every effort should be taken to ensure that both groundwater quantity and quality are preserved for the benefit of present and future generations.

In 2013 Outlook Report, the Asian Development Bank calculated India's water security based on household, economic, urban and environmental needs, and concluded that India's water prospects are hazardous. The World Bank report has attempted to quantify the problem of over exploitation of groundwater resources and to provide a wide range of possible remedial actions. Access to clean groundwater is linked to our health, and food security. India's water crisis is predominately a man-made problem. According to the report, a comprehensive and immediate program of investment, regulation, and law enforcement is necessary. We not only need to acknowledge the severity of the ground water crisis, but also look at a more holistic approach towards resolving it. Conserving water, reducing water footprint, using rain-water to recharge aquifers are some of the solutions prescribed by scientists and experts.

Some parts of India have pioneered successful solutions. The south western state of Andhra Pradesh has introduced a highly effective program of self regulatory water use. In the World Bank report the region of Andhra Pradesh is cited as an excellent example, where farmers have been educated in the ways to make groundwater use sustainable through the Andhra Pradesh Farmer–Managed Groundwater Systems (APFAMGS) Project. In some of the villages in this region farmers have reduced their groundwater use voluntarily and in doing so have still been able to irrigate crops and obtain drinking water. Community water management schemes and awareness campaigns among farmers have seen levels of water consumption fall significantly. This model provides a set of easily replicated and implemented programs for the consideration of other state governments in India. Self regulation is a vital short term solution. For India to be water secure, it would need to ensure long-term access that is affordable, equitable, efficient and sustainable. Major industrial, agricultural and domestic water reform is therefore necessary.

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