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"A STRATEGY FOR CONTROLLING GROUNDWATER DEPLETION IN THE MAHARASHTRA"

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Abstract:

The prime objective of this research is to study and examine depletion of the groundwater and its effect on agriculture in Maharashtra for a period of last five year. Recent studies suggest the increasing contribution of groundwater depletion in Maharashtra. Groundwater depletion has more than doubled during the last decades, primarily due to increase in water demand, while the increase in water impoundments behind dams has been tapering off since the 1990s. It has gained substantial importance because of agricultural prosperity. Almost all water consumption needs are met from groundwater resources. In the last decades, rapid population growth coupled with agricultural expansion has significantly increased demand on groundwater resources. Large increases in water demand with little recharge have strained groundwater resources resulting in declines in water levels and deterioration of groundwater quality in the major parts of this region. It's worth mentioning the paramount cause of sharp drop in the groundwater table in recent years is conclusively attributed to pumping out of well water which confirmedly exceeds the level of the natural recharge.

The peninsular shield is mostly constituted of granites, gneisses, basaltic rocks of volcanic origin and metamorphic complexes. In basaltic rocks are devoid of primary porosity. The groundwater occurs largely in the secondary porosity of weathered mantle and developed at a shallow depth. These aquifers is mostly phreatic, occurring up to the depth 10 to 12 meter. These weathered mantle is underline by massive rocks which from the bottom of the phreatic aquifer, limiting its downward extent. The groundwater in the shallow aquifers gets replenished annually and therefore, the status of water levels and its fluctuation play a key role in assessment of groundwater. In recent decades there have been frequent conflicts between ground water Over-exploitation of the groundwater resources is the major problem leading to groundwater resources and environmentally hazardous activity. In the Deccan plateau of Maharashtra some districts are in the rain shadow zone. Groundwater-irrigated agriculture is the chief economic activity in this region. The lack of institutional arrangements and management instruments, government intervention is not likely to alleviate the crisis.

Keywords: Aquifer, Depletion, groundwater level, fluctuation, hard rock terrain, infiltration.

Introduction:

India is a country with a total geographical area of about with a total area of 3,287,263 square kilometres (1,222,559 sq mi). A vast terrain nearly about 65% of the total area of the country is occupied by "hard rock" more predominantly in the peninsular shield of southern India. The peninsular shield is mostly constituted of granites, basaltic rocks, gneisses and metamorphic complexes. A major part of the hard rock terrain in the peninsular states is drought prone and hence groundwater use is intensively. Maharashtra too is occupied by hard rock whose receptiveness of precipitation is restricted to the degree of weathering and secondary porosity, so also its capacity to store and transmit the water. As a result, even in high rainfall areas of the state, water scarcity is experienced in summer months (GSDA, 2004). Main source of groundwater is from the the fractured, weathered and vesicular horizons. Hard rock aquifers are by nature limited in their potentials and heterogeneous in occurrence. It is confined mostly to the weathered residuum, fracture and fissure section generally up to the depth of 60 m.

Maharashtra is one of the most developed, progressive and industrialized states in India. It is also one of the leading states in the country with reference to groundwater based irrigation development and water supply. The overall stage of groundwater development in Maharashtra is above 30 percent despite being predominantly hard rock area with difficult hydrometereological conditions. Out of a total area of 307713 km^2, 65 percent is under cultivation, 23 per cent of the cultivated area is under irrigation of which more than 50 percent is based on groundwater, utilizing dugwells and borewells.

Groundwater is a vital natural resource. It is estimated that approximately one third of the world's population use groundwater for drinking. In some parts of the worlds such as large areas of the Middle East, groundwater is the unique source of water. Water is therefore the most important constraint for future development in this region. However, it is anticipated that the process of development will continue, resulting in greater demands for fresh water and declining groundwater level. Understanding the groundwater quality is important as it is the main factor determining its suitability purposes. In the study area, the extensive agricultural activities and urbanization resulted in the contamination of the aquifer in recent years.

Objectives:

To formulate a management strategy, a model was set of following objectives-

1. To analyses the ground water depletion of study region.
2. To suggest the strategy for controlling groundwater depletion level.
3. To find out the causes of ground water depletion level

Study Region:

Maharashtra is a state in the western region of India. The Maharashtra is situated north of the equator between 15°44' north to 22°6' north latitude and 72°36' East to 80°54' East longitude. It is the second most populous state after Uttar Pradesh and third largest state by area in India. Maharashtra is the wealthiest state in India, contributing 15% of the country's industrial output and 13.3% of its GDP. Maharashtra is bordered by the Arabian Sea to the west, Gujarat and the Union territory of Dadra and Nagar Haveli to the northwest, Madhya Pradesh to the north and northeast, Chhattisgarh to the east, Karnataka to the south, Andhra Pradesh to the southeast and Goa to the southwest. The state covers an area of 307,713 km^2 (118,809 sq mi) or 9.84% of the total geographical area of India. Mumbai, the capital city of the state, is India's largest city and the financial capital of the nation. Maharashtra is the world's second most populous first-level administrative country sub-division.

Map No.1

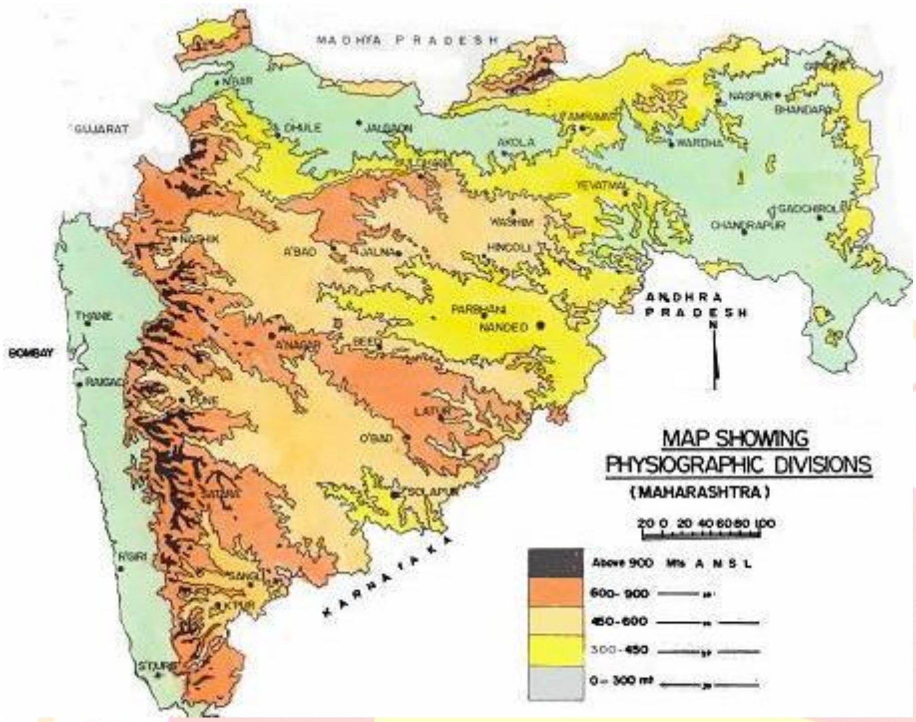
Geology and Hydrology of Maharashtra:

The State is divided into 5 groundwater provinces based on the prevailing hydrogeological conditions. It will be seen that major part of the State (82 percent) is occupied by Deccan Trap Basalts. Hence, the hydrogeology of the Deccan Traps is practically the hydrogeology of the State.

Physiographical division of state has been divided into tree units.1) The Sahyadri Range (Western Ghat) extends north to south and form the main drainage division and have elevations ranging between 600 to 1600 m above msl. 2) The western Coastal track (Kokan) runs almost 500km north to south and the elevation ranging up to 350 m above msl. 3) The Eastern Plateau (Deccan Plateau).

This correlation highlights topographic control over the dimensions of an aquifer. The physiography, rainfall pattern, geological details, aquifer details, availability of groundwater and degree of fracturing and jointing are contributing factors in hard rock area to make it a potential aquifer. This brings up the prima-facie groundwater scenario of Deccan Trap. This dynamic groundwater system gets annually replenished and thus pre and Post monsoon water levels assure the availability of groundwater for its usage in domestic,agriculture and industrial purpose. It is apparent that under such peculiar set-up, there are multiple factors controlling the water levels in hard rock terrain. The groundwater occurs in the secondary porosity developed by weathering and disintegration of hard rocks. The extent of secondary porosity depends on the

degree of weathering, jointing and fracturing due to various natural processes acting on these hard rocks. These conditions are reflected in the built up of topography. The highly dissected plateau (HDP)/mountainous areas have less weathered zone which develops poor secondary porosity in the rock. The similar situation is reflected in the moderately dissected plateau (MDP)



Map No.2

areas with moderately weathered mantle. This process is observed to its maximum in the undissected plateau (UDP)/valley terrain or peneplains where the weathered mantle is considerably high. As a result of this varying secondary porosity, the groundwater storage and occurrence also gets limited in these three situations as poor, moderate and good respectively. Rainfall is the main source of recharge and the aquifers get saturated by infiltration process. The recharging conditions also vary according to the topography. The HDP areas are predominantly runoff due to steep gradients. The saturation of the aquifer starts depleting after monsoon and reaches to its minimum during summer months which could be termed as residual recharge in the aquifer zone. This residual level observed in the summer months is the combine effect of total withdrawal/abstraction and discharge to the streams. Whether it is utilized or not, the groundwater does not remain static and the storage get emptied in the streams/lower reaches due to the movement of groundwater.

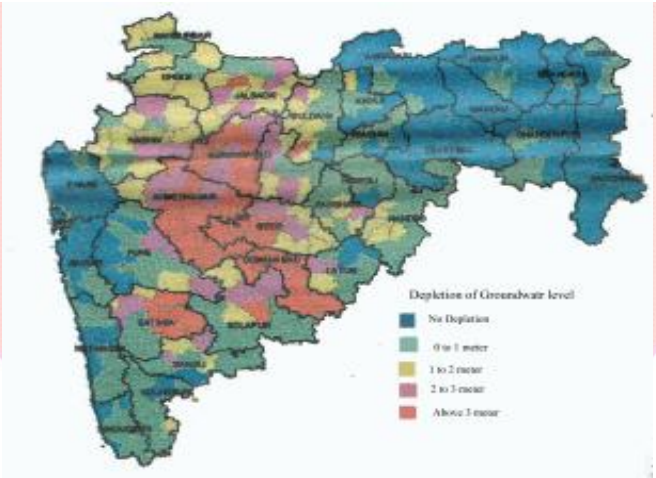
Current Status of Groundwater Depletion in Maharashra:

In Maharashtra there are only 130 tahsils where the depletion of groundwater level is no changed. Out of 353 tahsils in Maharashtra there are 72 tahsils in Aurangabd division where maximum numbers of tahsils groundwater level decreased. Other hand in Nagpur division was recorded only 11 tahsils which range is between 0 to 1 m in 2013.

Table No.1 No. of tahsils in various division of Maharashtra
2013

Sr. No	Division	Depletion of groundwater level in meter And Numbers of Tahsils			
		0 to 1	1 to 2	2 to 3	Above 3
1	Kokan	16	0	0	0
2	Nashik	10	23	10	11
3	Pune	27	8	8	5
4	Aurangabad	27	17	11	17
5	Amarvati	14	6	1	1
6	Nagpur	11	0	0	0
	Total	**105**	**54**	**30**	**34**

Maharashtra State
Depletion of Groundwater level
2013



Map No.3

Washi, Lohra, Kalamb, Paranda, Osmanabad, Bhum, Tuljapur, Umaraag, Dharngaon, Jamakhed, Shrigonda, Shegaon, Pathardi, Nagar, Karjat, Shrirampur, Kopargaon, Rahuri, Mohol, Man, Khatav, Phaltan, Koregaon, Aurangabad, Fulambri, Paithan, Kannad, Vaijapur, Shirur, Aasti, Padoda, Beed and Devulgaonraja tahsils recorded groundwater depletion level above 3 meter.

Causes of Groundwater level Depletion in Maharashtra:

Most of the aquifers get replenished annually and get depleted largely to full saturation thickness before the onset of monsoon leaving no groundwater available for extraction. This phenomenon is more predominantly and effectively observed in “basaltic rocks” . Further, aquifer is mostly unconfined and limits to the depth up to 20 m restricted to moderate to high weathered zone. The degree of weathering and topography are the influential factors in governing yield of wells. These are the main natural hydro-geological parameters along with groundwater dynamics for the crisis period in the state. Multiple reasons can be cited for the falling groundwater levels in unconfined aquifers as:

1) Rainfall variation.
2) Groundwater withdrawal during rainy season for irrigating khariff (rain-fed) crops.
3) Increase in the withdrawals due to development.
4) Extraction from the deeper confined aquifers through bore wells.
5) The groundwater in hard rock in shallow aquifers is dynamic and hence joins the surface water as base flow.

1. *Rainfall variation*

The rainfall is the main recharge of groundwater reservoirs. This huge variation in rainfall in the entire state is a leading factor in controlling the water levels in annually replenishing groundwater system. In the event of decrease in rainfall, the recharge also reduces which is seen in the depletion of post monsoon levels in the observation wells. In case of normal rainfall or excess rainfall, there can be a situation where post monsoon levels are depleted; this could be attributed to the variation in the rainfall pattern. Heavy intensity rainfall causes more runoff and less infiltration reducing the recharge quantity and depletion in post monsoon levels. Deficit rainfall and inadequate recharge from time to time causes drying up of existing sources. Patterns of rise and fall of water levels is directly related to the intensity, amount and duration of rainfall, seasonal fluctuation and water abstraction for different causes as there exists a variable time lag between two rainfall sessions or due to vagaries of monsoon.

2. *Withdrawal of Groundwater during irrigating khariff crops:*

Conditions of uncertain rainfall and land gradient creates problem of water availability both for irrigation and drinking purpose. Therefore, groundwater assumes a great importance in meeting the irrigation and drinking water demands of the rural population and especially during the long dry spell condition. It is particularly observed in the drought prone area of the state where the area constantly faces drought due to deficit rainfall. The cropping in this area is predominantly irrigated from groundwater. Therefore, the hydrographs of this area shows subsequent decline in the water levels during two rainfall episodes. This phenomenon of lowering of water level due to extraction for protective irrigation cannot be categorized as overexploitation as fluctuation is within the limit of annual recharge saturation and stage of development is underdeveloped and holds enough recharge for future development.

3. *Increase in the withdrawals due to development causing increase in extraction:*

Overexploitation occurs when groundwater draft exceeds its annual recharge and dents into the static reserve occurring below the zone of dynamic fluctuation. In view of the growing demand for domestic, irrigation and industrial purpose, the groundwater abstraction structures are found to be increasing every year. The extraction of groundwater for various purposes from these abstraction structures contributes to lowering of water level. Groundwater resources estimation committee (1997) has prescribed areas as critical, if the stage of groundwater development is 90 to 100% with significant long term decline of pre or post monsoon. In short it is the long term declining trend indicative of unbalanced groundwater regime which defines overexploitation. Therefore, the decline in water levels is attributed to increase in the withdrawals due to development causing increase in extraction. In such event, there is no availability of recharge excess than annual recharge.

4. Extraction from the deeper confined aquifers through bore wells

The extraction from the deeper confined aquifers leads to assess the cause for fluctuation in shallow aquifers. Once groundwater has been extracted from a deeper aquifer, its replenishment depends upon the inflow from the shallow system. Moreover, the rate and depth of extraction from these deeper aquifers renders the fluctuation intensity in the shallow aquifers. The deeper aquifer in hard rock below weathered mantle are infested with joints and fractures and receive recharge from shallow aquifer by vertical infiltration due to hydraulic connectivity between them. Because of the high density of bore wells the pre-monsoon groundwater levels in dug wells shows falling trend compared with post-monsoon rising level. The rising post-monsoon water levels depict the recharge from rainfall during monsoon.

5. The base flow in hard rock

The outflow of groundwater affects the water levels. Periodically monitoring of observation wells reveals that a large no. of dug wells gets completely dried during summer months. As such, the shallow aquifer does not hold any saturation worth exploitable or minable storages. The water level studies and its analysis have indicated that the storativity of groundwater is largely confined to weathered mantle. The extraction is only limited and controlled for seasonal irrigation for “khariff” (rain fed crops) and “rabbi” (winter) crops and the saturation gets depleted and the residual saturation during summer months is minimum rendering the wells not exploitable.

Strategy for Controlling Groundwater Depletion:

1. Sustainable use of Water resources.
2. Socio economic development and opportunities for future generation.
3. Limited possibility for developing additional supplies.
4. Change the cropping pattern.
5. Water demand management.
6. Institutional arrangements
7. Improving the irrigation efficiency.
8. Improving allocation of groundwater resources for agricultural and domestic.
9. Postponing new boreholes construction by efficient use of available water.
10. Moving toward sustainable groundwater development.
11. Promoting water demand measures.

Conclusion:

The analytical studies of water level fluctuation in the hard rock particularly basaltic terrain of Maharashtra has brought out conclusive evidence that the water level in the shallow aquifers have effects of various influencing factors. The depletion of water levels within the saturated horizon of the aquifer recharge is not an indication of overexploitation. The depletion of water levels in the underdeveloped watersheds shows the ground truth and evidence that these falling water levels are not due to over extraction but they are the effect of increase in development and the quantity of abstraction. Any situation of over extraction in the hard rock areas in the shallow unconfined aquifer therefore need to be carefully assessed and supported by micro level field data.

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