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WATER RESOURCE MANAGEMENT IN RAJASTHAN, INDIA.

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Abstract:

Water is a natural resource, fundamental to life, livelihood, food security and sustainable development. The earth that once had enough pure and potable water is being transformed into a water-scarce planet owing to rapid growth in population, misuse, excessive exploitation and mismanagement of water. The management of water resources is absolutely necessary and the only way to save human life on earth. Rajasthan is the largest State of India and has a tropical desert climate. Surface water resources are insignificant and the entire state is principally dependent on groundwater. 91% of the Domestic Water requirements are being catered from Groundwater Sources and only 9% Water requirement is being met from surface water sources. Water related problem in the state is a consequence of low precipitation and hence low recharge to aquifers and high evapotranspiration. The rainfall is erratic and there is a large variation in the rainfall pattern in the state. The state has witnessed frequent drought and famine conditions in the past 60 years. Water demand is increasing at a faster rate due to increase in population, green revolution, rapid Industrial growth, urbanization and changing living standards. Apart from this, water resource of Rajasthan is facing problems of over exploitation, water logging, salinity, and fluoride and nitrate contamination. Present research article emphasized on various use and their possible impact on water resources of Rajasthan state. Some possible solutions of these problems are also described in this regard.

Key Words: Evapotranspiration, Management, Contamination, Hydrogeological.

Introduction:

Water is a natural resource, fundamental to life, livelihood, food security and sustainable development. Water is indeed most essential for human life and an absolute necessity for all multi activities like drinking/ domestic purposes, agriculture and industry, and allied sectors; it is also a vital element in the development of the economy of a country or region. It would not be an exaggeration to say that no life on the earth is possible without water.

Water scarcity is a major issue that is rising very rapidly in the modern world. The problem has become so severe that in many countries the groundwater has almost dried up and people have to depend on water supply from other sources. In addition, water is one of the most misused commodities that we still waste. It is the central point of our lives but not the central point of our focus. The earth that once had enough pure and potable water is being transformed into a water-scarce planet owing to rapid growth in population, misuse, excessive exploitation and mismanagement of water. In the past, people understand the value of water and plan their lives around it. Moreover, many civilizations bloom and lost on account of water. But, today we have knowledge about the value of water but we still fail to understand. Therefore, the management of water resources is absolutely necessary and the only way to save human life on earth.

Water resource management is the activity of planning, developing, distributing and managing the optimum use of water resources. It is a sub-set of water cycle management. This article emphasized on various use and their possible impact on water resources of Rajasthan state. Some possible solutions of these problems are also described in this regard.

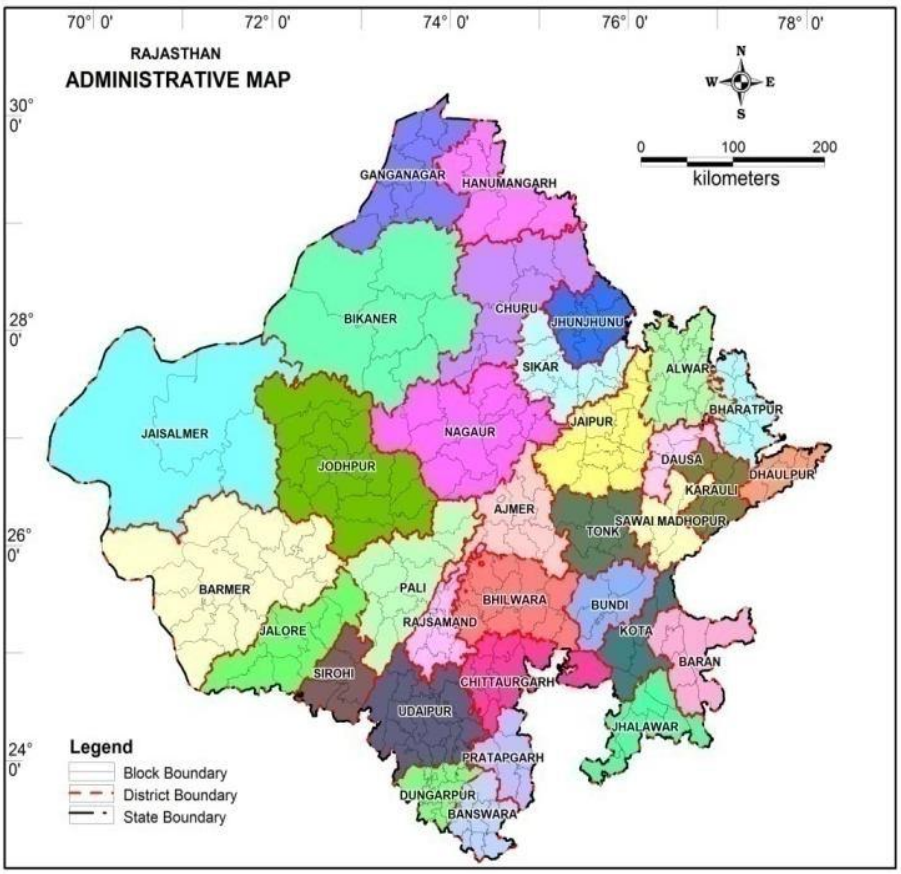
Objective:

The objective of present study is to highlight the various activities regarding water resource utilization and management in Rajasthan and to identify their possible impacts on water resources of the region along with some suggestions to manage or minimize the pollution related problems.

Study Area:

Rajasthan is the largest state by area, located in the north-western side of the country and extends between 23^0 03' to 30^0 12' North latitude and 69^0 30' to 78^0 17' East longitudes. It covers an area of 342,239 square kilometres or 10.4 percent of the total geographical area of India. It shares international border with Pakistan and state border with five states: Punjab to the north; Haryana and Uttar Pradesh to the northeast; Madhya Pradesh to the southeast; and Gujarat to the southwest. An administrative boundary of districts has been shown in fig. No.01.

Figure 01: Administrative Divisions of Rajasthan



Rajasthan has a tropical desert climate. It remains very cold in the months of October to February while it bears the blazing heat of the sun from March to September. Rainfall in Rajasthan is meager therefore, it suffers from drought. During summers, the temperature in Rajasthan is very high and it ranges between 32°C and 46°C (maximum 49°C). Like the climate, rainfall is also keeps varying throughout the state of Rajasthan. Most of the rainfall is received from the South-west monsoon during the period of three months from July to September. The average annual rainfall of the state ranges between 200-410 mm. In the south eastern part of Rajasthan, rainfall is as high as 1000mm. some parts of western Rajasthan receive very little rainfall; it is only 100 mm per year.

Rajasthan has an agricultural economy with nine agro-climatic zones and various types of soil that help during the cultivation of crops. According to Census, 2011 report 75 per cent population of the State lives in the rural areas and around 62 per cent depend on agriculture and allied sectors for their livelihood. It is among the largest mineral-producing states in India. As per 2011 Census of India, Rajasthan has a total population of 68,548,437. The state has a population density of 200 per km2.Its population growth rate over the decade of 2001- 2011 is 21.31 %. The state has a sex ratio of 928 females for every 1000 males, and a literacy rate of 66.11 %.

Methodology:

In order to meet the objective of the research paper secondary data sources has been extensively used. The data has been collected from different governmental agencies, NGOs, and Internet sources. Relevant data has been analyzed to evaluate and find out the current status of water resources of the region and predict some consequences of various anthropogenic activities.

Water Resources:

Surface water resource is any water that collects on the surface of the earth. This includes lakes, rivers, wetlands, oceans, seas etc. Surface water is maintained by precipitation, and it's lost through seepage through the ground or by evapotranspiration. Rajasthan is among the states with greatest climate sensitivity and lowest adaptive capability. Rajasthan has only 1.16 percent of India's total surface water resources or 21.71 billion cubic meters (BCM), however 16.05 BCM of this is economically usable. The state has created capacity to harness and store 11.29 BCM, or around 70 percent of available water. The state has 1.72 percent of the country's groundwater, translating into 11.36 BCM. Dependent on inflows into the rivers, 17.88 BCM is allocated through inter-state agreements, although not dependable due to political compulsions of the upper riparian states. On paper, water use can be expanded by a further 30 percent. However a more realistic assessment of additional availability is economically usable water or 21 percent. This is broken down in figure below, which accounts for the use of 79 percent of the 45.09 BCM of total available water.

Except Chambal all the rivers of Rajasthan is seasonal in nature that flows only during the rainy season. Topography and precipitation influence the formation of catchment areas of the river. The uplands which are the origin of streams, which form rivers, are highly dissected, rugged and rolling in nature. There are no deep channels to add stream density; therefore, catchments are of low stream density.

The Aravalli Range forms the main water divide in Rajasthan. Luni is the only river flowing west of Aravallis. In the rest of western Rajasthan encompasses about 60% of the geographical area of the state, the drainage is internal, and the streams are lost in the desert sands after flowing for a short distance from the point of origin. Luni itself is an ephemeral stream with flood cycle of 16 years. The drainage in western Rajasthan is towards the west and south-west. East of Aravalli ranges, the main drainage is towards the north-east. It flows approximately 226 km north-east direction in Rajasthan. The Chambal and its tributary Banas, rises in the Aravalli Range, drains south-eastern region of Rajasthan.

The other important catchments include Yamuna-Ganga in the north-east and Sabarmati and Mahi in the south-west. In the northern and north-eastern parts of eastern Rajasthan, Barah, Sota, Sahibi, Banganga and Kantli rivers are of inland nature. The drainage pattern of rivers in the Rajasthan is generally dendritic.

In the desert area, a few salt lakes exist, important among them being the Sambhar lake, Didwana lake, Bap, Pokran, Pachpadra and Rann of Jaisalmer. In addition, Rajasthan gets some water from inter-state river basins as a part of Inter-State agreements. Table 01 depicts the Status of available surface water and storage created in Rajasthan in the year 2010.

Table - 01: Status of available surface water and storage created in Rajasthan (2016).

Sl. No.	River Basin	Basin Area (Sq. Km.)	**Available Yield (in MCM)**	**Storage Created (in MCM)**
1.	Banas	46902	5,097.26	3639.76
2.	Banganga	9949	754.83	412.26
3.	Chambal	31229	8,702.14	2906.77
4.	Gambhiri	4934	700.89	231.56
5.	Luni	69580	2,269.92	1136.66
6.	Mahi	16598	3,720.25	2726.59
7.	Parvati	1891	427.18	157.28
8.	Ruparail	2550	641.38	101.64
9.	Sabi	4615	348.09	113.65
10.	Sabarmati	4118	732.52	212.09
11.	Shekhawati	9691	562.85	89.72
12.	Sukli	994	137.61	48.00
13.	West Banas	1835	222.14	80
14.	Other Nallah of Jalore	1775	51.42	6
15.	Outside Basin	135603	990.60	9

Source: Water Resource Department, Government of Rajasthan.

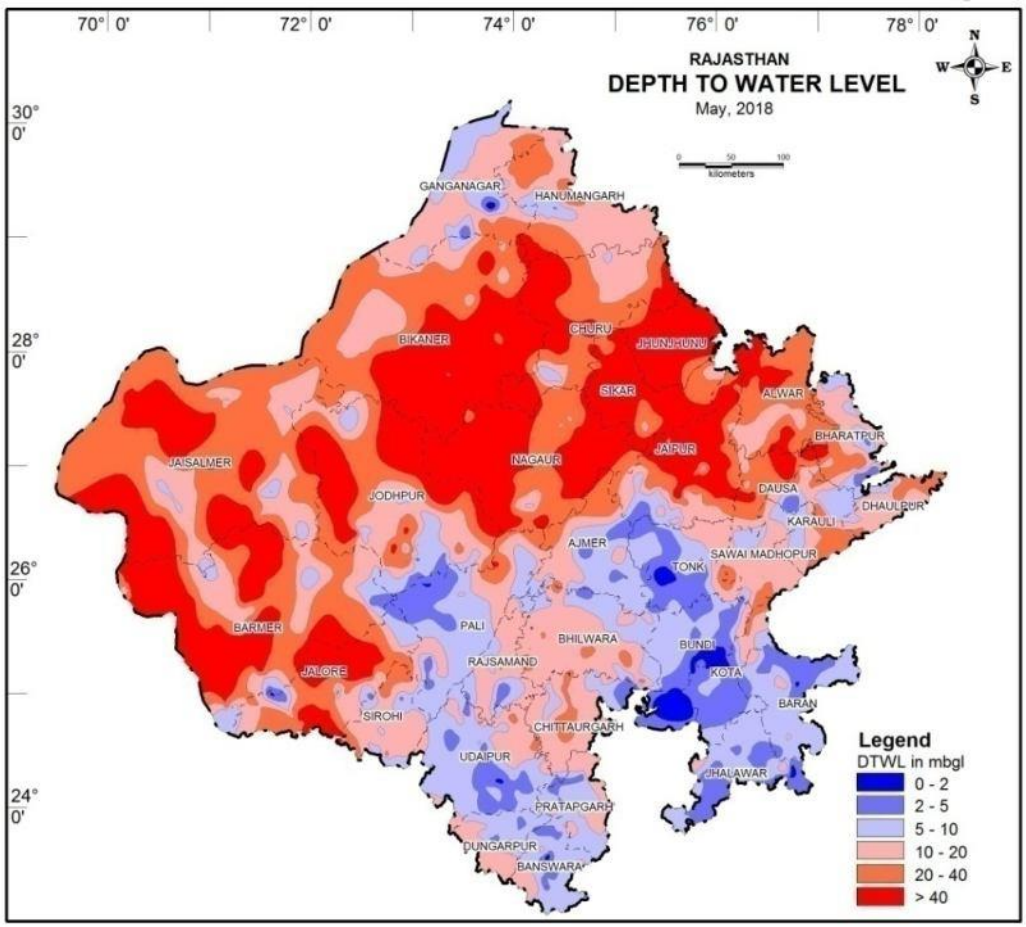
The State government has given high priority to the development of surface water resources during the last five decades. A large number of irrigation projects have been planned and implimented in different parts of the State.

Major irrigation projects in Rajasthan are Indira Gandhi Nahar Pariyojana (IGNP), Mahi Bajaj Sagar Project, Bisalpur Project, Jakham Irrigation Project and Gurgaon Canal Project.The Indira Gandhi Nahar Pariyojana (IGNP) spans over four districts of Rajasthan, namely Ganganagar, Bikaner, Hanumangarh and Jaisalmer. Its main aim is to assist in agricultural activities and provide drinking water.

To study about ground water occurrence and its movement Rajasthan can be divided into three hydrogeological units namely, unconsolidated sediments, semi-consolidated sediments and consolidated rocks. The Quaternary sediments including younger and older alluvium are the most important unconsolidated formations because of their wide-spread occurrence. The sediments are composed of silt, clay, sand, gravel and mixture of calculus etc. Sand, gravel and mixture of these creates potential aquifers in northern, eastern, north-eastern, western and south-western parts of the state. The maximum alluvium thickness is 543.51 mbgl at Anupgarh in Ganganagar district. The semi-consolidated formations are composed of shale, conglomerate limestone siltstone, claystone and sandstone. Sandstones and limestones form the main aquifers in Barmer, Bikaner, Jaisalmer and Jodhpur districts. Sandstones of Lathi formation are the most potential aquifers in Barmer, Jaisalmer and Jodhpur districts. The consolidated rocks includes granites, gneiss, schist, marble, phyllites and Vindhyan limestone, sandstones, quartzite and basaltic flows, mainly restricted to eastern part of Rajasthan. The yield prospect is limited until the well is located near major lineaments or any other weak planes. Generally, the ground water quality is poor (brackish to saline) at deeper levels.

The depth to water level varies widely across the State; shallow water levels have been observed in canal command area of Ganganagar, Bundi, Banswara and Kota districts whereas deeper water levels have been noticed in the western districts, particularly Barmer, Bikaner, Jaisalmer and Jodhpur. The depth to water level map of pre-monsoon (May 2018) has been demonstrated in fig no. 02. The depth of water level is comparatively shallower in the east of Aravallis than that in the west. Generally, the depth of water to the east of Aravallis, varies between less than 10 to 25 meters whereas in the west it ranges between 20 to 80 meters. The water level slopes towards the east and south-east on the eastern side of Aravallis, whereas to the west it slopes towards the west and in the north-west. Although, local variations are usual both in the direction and movement of ground water. Over-exploitation and excess use of ground water have led to considerable decline in water levels, which can eventually result in drying up of aquifers in many areas of the State.

Fig.02: Depth to Water Level in Rajasthan,

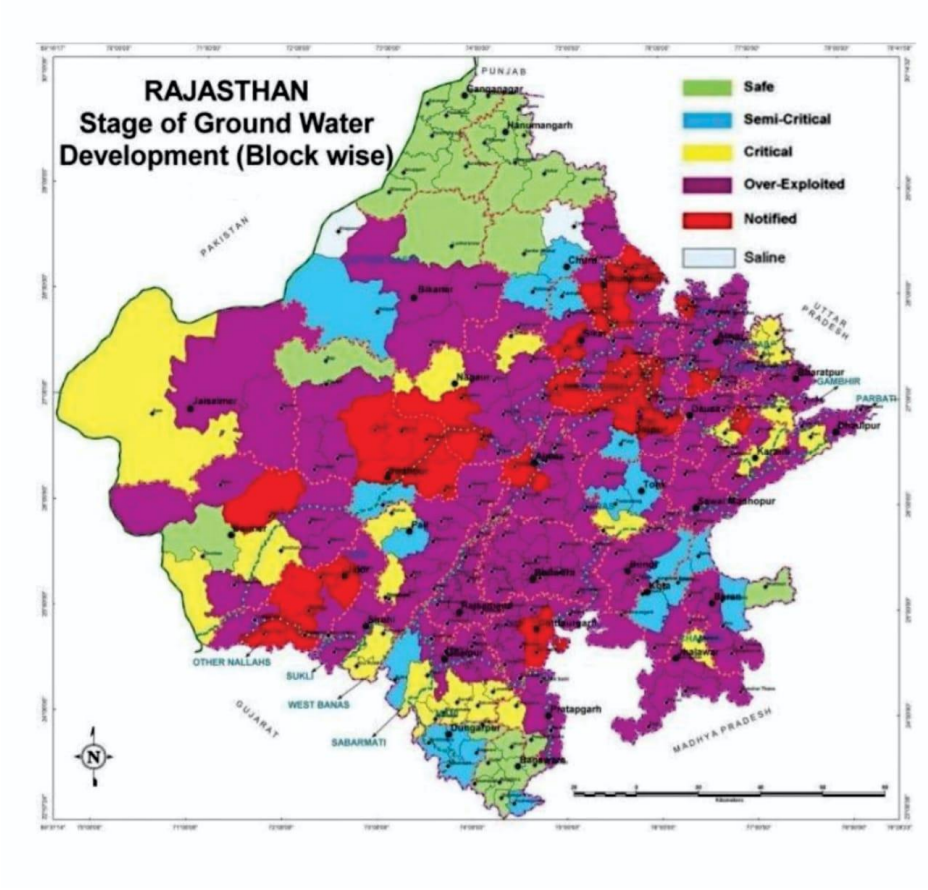


Source: CGWB, 2019

To study effect of monsoon on the groundwater regime and subsequent utilisation of groundwater for various needs like domestic, industrial agriculture etc., changes in depth of water levels with respect to pre-monsoon period were analyzed. Water level analysis reveals that there is a moderate rise in water level due to monsoon rainfall in eastern and western part while a slight increase or no change in the western part of the state.

The annual water table loss is 1 to 3 meters in Rajasthan. As per the estimates, the state has Net Ground Water availability of 11.2567695 BCM. The existing gross ground water draft for all purposes is 15.7059976 BCM. The allocation of water for domestic & industrial purposes is 2.3151773 BCM and that for irrigation requirement is 0.9031139 BCM. The overall stage of groundwater development in the State is 139.52%. The stage of groundwater development in different districts of Rajasthan shows that Jhunjhunu has the highest degree of over-exploitation of groundwater with the total draft equal to 200 per cent of the annual recharge. The stage of ground water development in Jaipur is 186.6 per cent. After a deep study of ground water development in the state it can be said that those areas which are underlain by alluvium and limestone and semi consolidated sandstone aquifers experience very high intensity of groundwater use, and have high degree of exploitation. Whereas those which are underlain by crystalline rocks, since there are not much static groundwater resources, the chances of over-exploitation beyond a certain level is impossible as wells would dry up under over-draft conditions. The most poorly developed groundwater resources are found in Ganganagar district, with a stage of development of only 45 per cent. One reason behind this phenomenon despite the very low potential of fresh groundwater could be the presence of canal water. Block wise ground water development status has been shown in the following fig. No 03.

Fig. 03: Ground water development map of Rajasthan



Source: Hydrogeological atlas of Rajasthan 2018.

In Rajasthan, surface water resources are inconsequential and the entire state is principally dependent on groundwater. 91% of the Domestic Water requirements are being catered from Groundwater Sources and only 9% Water requirement is being met from surface water sources. The state has witnessed frequent drought and famine conditions in the past 60 years. About 80% of the total irrigation water demand and most of the Industrial Water requirements are being catered from Groundwater resources only. Thus, meeting the various sectors' demands and safe water supply to human being are the challenging tasks for the planners in the State.

Problems:

Water resource of Rajasthan is facing problems of over-exploitation, water logging, salinity, and fluoride and nitrate contamination in most of the districts of the state:

Over exploitation:

There is a progressive increase in ground water draft in Rajasthan because of increasing population, urbanization and industrialisation. The limited availability and distribution of the surface water resources puts extra pressure on the groundwater resources and this has resulted in their over-exploitation. As per present groundwater resource estimates, out of total 295 blocks in the state, 184 blocks are categorized as Over-exploited, 34 blocks as Critical, 29 blocks as Semi Critical and 3 blocks as saline. Remaining 45 blocks, which have been categorized as Safe, have limitations for groundwater development due to its poor quality, deep water levels or falling in canal command area. Taranagar Block of Churu, Khajuwala Block of Bikaner and Rawatsar Block of Hanumangarh districts have not been assessed due to poor quality in the entire blocks.

Arsenic in ground water:

The arsenic concentration in groundwater of Rajasthan crossed the safety limit and is therefore unsafe for drinking purposes. As per the groundwater estimates, out of 33 district of Rajsthan, 4 districts (Churu, Sikar, Gangapur and Hanumangarh) are contaminated with arsenic above the WHO standard of 10 µg/L. Arsenic concentration is also reported in the mining areas of Rajasthan, especially around the mining areas of Khetri Copper Complex and Zawar mines in Jhunjhunu and Udaipur districts respectively.

Fluoride in ground water:

Rajasthan is the only state in India where almost all the districts are affected by high fluoride. As per the estimates of CGWB, out of total 33 districts in the state, 30 districts are categorized as fluoride contaminated district. Of the 13,334 habitations affected by fluoride in the country, Rajasthan has 6,589 where more than 45 lakh people live, report said. Fluorosis, a disabling disease, is caused by drinking fluoride-contaminated water. The Thar Desert covers most of the area affected by fluoride. Ajmer, Nagur, Pali, Jalore, Jaipur, Jodhpur and Sirohi districts are worst affected by fluoride with average concentration of 2mg/l. Due to the higher level of fluoride in drinking water, several dental and skeletal diseases have been reported in the state. The favourable factor which contributes to rise of fluoride in ground water is presence of fluoride rich rock system in the state. Fluoride enters into soil through weathering of rocks, precipitation and impure water, mainly from waste run-off and fertilizers.

Nitrate in groundwater:

Another contaminant which is commonly found in groundwater of Rajasthan is Nitrate. The contamination of groundwater from nitrate has become an environmental and health problem in the state. Nitrate pollution is caused by the intensive use of nitrogen fertilizers, irrigation with domestic wastewater and use of manure. The nitrate concentration in groundwater is influenced by rainfall. Where the amounts of rainfall are low, the concentration tends to be high because the diluting effect is reduced. Almost all of Rajasthan suffers from the problem of high nitrate concentrations. Ajmer, Sawai Madhopur, Jaisalmer, Jaipur, Bharatpur, Jalore, Nagaur, Sikar, Sirohi, Barmer, Jodhpur, Churu, Jhalawar, Tonk & Udaipur districts are worst affected with nitrate concentration where have nitrate values beyond permissible limit. High nitrate levels found in drinking water have been proven to be the cause for numerous health conditions across the world such as gastrointestinal cancers, methaemoglobinaemia, alzheimer's disease, vascular dementia, multiple sclerosis in human beings.

Water Logging

Water logging is a severe problem in outside basin and Chambal basin in the state. The causes are seepage from canals in the outside basin, and over irrigation in the Chambal basin. As a result of rise in water tables, 145,600 hectares has turned critical (water table within six meters of land surface). A far more serious problem is anticipated in stage-II of IGNP. Experts believe thousands of hectares of land will be submerged in 25 to 30 years.

Salinity:

Rajasthan is the largest State of India having significant volume of saline groundwater especially in its western parts covering about 97673.13 Sq.Km. areas falling in 16 districts of state. The total saline groundwater available in the State has been assessed as 3053.38 MCM while the gross draft is 592.75 MCM. District wise details of ground water resources in saline (Poor Quality) zones are given in Table 02.

Table 02: Ground water resources in saline areas in Rajasthan, 2016

Sl. No.	Districts	Saline Zone area (Sq.km.)
1.	Alwar	376.40
2.	Bharatpur	1339.00
3.	Barmer	15441.09
4.	Bikaner	16779.24
5.	Churu	8601.21
6.	Ganganagar	10058.00
7.	Hanumangarh	8301.10
8.	Jaipur	340.06
9.	Jaisalmer	26054.96
10.	Jalor	2023.43
11.	Jhunjhunun	119.78
12.	Jodhpur	3321.80
13.	Nagaur	1339.75
14.	Pali	3188.85
15.	Sikar	93.46
16.	Tonk	295.00
	Total	**97673.13**

Source: CGWB, 2016

Conclusion and suggestions:

Change in climate, rapid growth in population, change in life style of people, urban development, industrial development and environmental degradation are severely affecting the water resources of the country in general and arid & semi arid regions in particular. Together with water scarcity, the quality of water also degraded in the country which creates an unhygienic condition, therefore, by adopting best suited method of waste water treatment and best suitable use of treated waste water can reduce the unhygienic and mismanagement condition of the water resources.

Water is a scarce resource and most essential for the survival of plant and other organism. Human life can't be imagined without water. Demand for this limited resource continues to increase as population grow and move, so its proper management is required. Proper management depends on reliable information about the quantity and quality of water available and various uses, so that it can be protected and developed sustainably. From the present study following conclusions have been drawn:

- Water related problem in the state is the result of low precipitation and hence low recharge to aquifers and high evapotranspiration. The rainfall is erratic and there is a large variation in the rainfall pattern in the state.
- In spite of poor quality and little quantity, the groundwater resources in the state are the only most reliable and dependable source for sustenance of life.
- Water demand is increasing at a faster rate due to increase in population, green revolution, rapid Industrial growth, urbanization and changing living standards.
- There is a progressive increase in ground water draft in Rajasthan because of increasing population, urbanization and industrialisation. Any further increase in the draft will aggravate the situation of declining water levels and degrading water quality in some areas.
- Since larger part of Rajasthan fall under over exploited category, there is an urgent need for enforcement of groundwater regulation, control and management strategies in the state.
- Ground water level declines are being witnessed both in hard rock and alluvial areas. The ground water development in such areas therefore needs to be regulated through suitable measures to provide sustainability and protection to ground water reservoir.
- Planning for the management and development of ground water in any area must address the factors like limited ground water availability, low rainfall, and salinity, deserted conditions and deep water levels in most of western parts of the state.
- Reuse and recycling of urban wastewater should be necessary. Recycled water should be used for irrigation and industrial purposes.
- In the canal command areas of IGNP, Mahi, Chambal and other surface irrigation systems, water-logging problem has been increasing rapidly. Improved irrigation practices, change in cropping pattern and controlled discharge of water from canals are urgent in such areas.

- Instances of growing levels of nitrates in ground water are noticed due to disorganized disposal of wastes, particularly faecal disposals in urban areas. Educating people regarding the maintenance of hygiene and installation of organized sewerage system are the need of the hour to reduce these hazards.
- Restrictions must be laid on the construction and energization of individually owned structures for drinking and domestic use to avoid wastage of water.
- Education and involvement of people in water management practices including conservation, protection, development, and augmentation is the prime requirement to protect resource against further quality degradation and guarantee quality assurance.
- Community based fluoride removal plant can tackle the fluoride menace. There are numbers of fluoride removal techniques. Nalgounda technique is very effective.
- The feasible schemes on rainwater harvesting and artificial recharge structures in Overexploited areas should be implemented as early as possible.
- Water security planning and implementation should be strictly followed at village, district and State levels.
- Promotion of drip and sprinkler irrigation systems in water stressed areas.
- The construction of water reservoirs like dams, tanks and ponds becomes a necessity due to the distinct variability and seasonality of rainfall to store some part of rainfall water to meet irrigation and drinking water requirement throughout the year.

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