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STUDY OF UNDERGROUND WATER IN DIFFERENT REGIONS OF MAHARASHTRA

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ABSTRACT:-

Quality and accessibility of groundwater resources are required for sustainable development, especially in rural and highly populated states like Maharashtra. The current research attempts to analyze the status of underground water across various areas of Maharashtra with respect to parameters like the depth of the water table, seasonal variation, quality parameters (pH, hardness, salinity, nitrates content), and anthropogenic effects on groundwater stock. Maharashtra possesses geographically and climatically varied profile, including the dry zone of Marathwada, Konkan coastal zone, fertile plains of Vidarbha, and plateau regions of Western Maharashtra. All are quite different from each other and contribute immensely to the distribution and quality of groundwater.Data was compiled from government hydrological research, borewell statistics, field inspections, and laboratory testing of water samples collected at sampled points across the regions. The study reveals unprecedented patterns of groundwater depletion, particularly in dry regions like Marathwada and parts of Vidarbha, primarily due to over-extraction for irrigation, poor recharge, and variable monsoons. On the other hand, coastal regions have higher water levels but face salinity intrusion issues due to over-drawal and seawater percolation.It also points towards the impacts of urbanization, industrial effluent, and waste mismanagement in deterioration of groundwater quality in cities such as Pune, Nagpur, and Mumbai. Seasonal observation shows a significant reduction in groundwater levels during the pre-monsoon season, giving utmost priority to increasing better rainwater harvesting and recharge.

INTRODUCTION

Water is one of the most vital natural resources. It is essential for human survival and also holds significant value as a national asset. Beyond drinking, water plays a crucial role in various human activities such as agriculture, industry, bathing, cooking, washing, recreation, navigation, and fisheries.[1] Maharashtra is the third-largest state in India, covering an area of 30.8 million hectares, and it also ranks third in population, with approximately 97 million people. Around 58% of the population resides in rural areas, and nearly 80% of them rely on agriculture for their livelihood. As of 1999/2000, the rural poverty rate stood at about 32%, with particularly high poverty levels among cultivators (23%) and agricultural laborers (57%). Water availability across the state is highly uneven, both geographically and seasonally, with the majority of rainfall occurring within a short span of 40 to 100 days. Maharashtra's ultimate irrigation potential is estimated at 12.6 million hectares—8.5 million hectares from surface water and 4.1 million hectares from groundwater sources[2]. Water is an inorganic chemical compound that is odorless, tasteless, completely colorless, and fully transparent. It exists in various natural forms and plays a key role in atmospheric processes, contributing to the formation of fog (aerosols) and precipitation such as rain. Clouds are composed of tiny, suspended water droplets, while steam and water vapor represent water in its gaseous state. The quality of water varies from place to place due to differences in chemical composition and concentration across regions. When water becomes polluted, its quality deteriorates, reducing its suitability for use.[3]

GEOGRAPHICAL REVIEW OF VIDARBHA REGION

District	Villages	Total Population			Vanavasi Population			Percentage		
		Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
1	2	3	4	5	6	7	8	9	10	11
Nagpur	1874	4067637	1453886	2613751	444441	217752	226699			
Wardha	1382	1236736	911695	325041	154415	132766	21649			
Bhandara	778	1136143	960418	175728	175728	84740	12978	8.6	8.82	7.38
Gondia	893	1200707	1057276	143431	196455	189358	6097	16.36	18.0	4.25
Gadchiroli	1679	970294	851672	42468	364256	358775	5481			
Chandrapur	1791	2071101	1405034	655067	389587	333298	56289	18.1	22.7	7.4
Amravati	1996	2607157	1707578	898879	356493	222622	34011			
Akola	1009	1630239	1002742	627497	100088	85540	14548	6.1	8.5	2.3
Washim	789	1020216	841771	178445	70987	67797	3190	7.0	8.1	1.8
Buldhana	1433	2232480	1759097	473383	115156	105935	9221	5.2	6.0	1.9
Yavatmal	2117	2458271	2001060	457211	473370	31971	31971	19.3	22.1	7.0
Grand Total	15741	20630981	13952229	6590901	2840976	1830554	422134			

IMPORTANCE OF GROUND WATER

Groundwater is a key natural resource that's essential for life and everyday human activities.

It's a major source of drinking water, especially for people living in rural and semi-urban areas.

Farmers depend on it for irrigation, which helps grow food in areas where rainfall isn't reliable.

Many industries also use groundwater in their processes. It plays a big role in keeping the environment healthy by feeding rivers and wetlands during dry times. Since it's stored underground, groundwater is less likely to get polluted or evaporate compared to surface water, making it a dependable and long-lasting water source. That's why it's so important to manage groundwater wisely—for the sake of the environment, the economy, and our health[2]

Drinking water: Groundwater serves as a major source of drinking water for many communities around the world, particularly in areas where surface water is scarce.

Agriculture: Groundwater is used for irrigation to grow crops and sustain agriculture in many parts of the world.

Industry: Groundwater is used in various industrial processes such as cooling and manufacturing.

Ecosystem support: Groundwater plays a crucial role in supporting ecosystems such as wetlands, rivers, and lakes[4]

Groundwater is stored in underground aquifers—permeable rock formations that can both hold and transmit water. These aquifers are naturally replenished through the infiltration of precipitation and the seepage of surface water. Groundwater plays a critical role in sustaining life, particularly in arid and semi-arid regions, where it often serves as the primary source of drinking water. Its effective management is therefore essential for ensuring food security and safeguarding public health.Despite its importance, groundwater faces numerous challenges. Over-extraction, driven by population growth and agricultural expansion, is causing water tables to drop and aquifers to become depleted. Moreover, contamination from agricultural runoff, industrial waste, and poor waste management practices poses significant health risks and degrades water quality. Climate change adds further pressure by disrupting precipitation patterns and increasing evaporation, both of which negatively impact groundwater recharge. For example, while heavy rainfall events may seem beneficial, they often lead to rapid surface runoff, reducing the amount of water that actually infiltrates the ground to replenish aquifers.[5]

THE ROLE OF GROUNDWATER IRRIGATION IN INDIA

The growth in irrigated area and the rising contribution of groundwater can be seen.. The net irrigated area has increased from 21 million hectares in 1950-51 to 56 million hectares in 200102. The share of groundwater irrigation through wells has risen from 28 percent to 62 percent. The main contribution has come from rapid growth in tubewell irrigation. The share of this has risen from zero in 1950-51 to over 40 percent by 2001-02. Groundwater is found in underground aquifers—layers of permeable rock that store and transmit water. These aquifers are replenished through processes such as the infiltration of rainwater and the seepage of surface water. Groundwater is vital to life, especially in arid and semi-arid areas, where it serves as the main source of drinking water. As such, its sustainable management is crucial for maintaining public health and ensuring food security. However, groundwater resources are under increasing pressure. Excessive extraction, fueled by growing populations and expanding agricultural demands, is leading to falling water tables and the depletion of aquifers. In addition, pollutants from agricultural runoff, industrial discharges, and poor waste management practices threaten water quality and pose serious health hazards. Climate change further exacerbates these issues by altering rainfall patterns and raising evaporation rates, which disrupt natural recharge processes. For instance, more intense rainfall can result in higher surface runoff, leaving less water to percolate into the ground and restore aquifer levels.[6]

THE ROLE OF GROUND WATER IN DRINKING

Groundwater systems provide nearly half of the world's drinking water, which is delivered to populations via private and public water systems. In the United States, drinking water is available through both public and private water supply systems, with 86% of the population receiving water from public utilities. Groundwater constitutes 37% of water used in public systems, equating to nearly 16 billion gallons of groundwater withdrawn and consumed per day. About 13.1 million households in the U.S. use an estimated 3.5 billion gallons of groundwater per day pumped from individual household wells for their drinking water supply. Even areas that primarily rely on surface water for their water supply are still using discharged groundwater to an extent, as groundwater supplies about half of streamflow in the U.S.

METHODOLOGY

1)Ground water sample were collected in polythene bottle of 2 lit from different location of Vidarbha,maharastra, India. The samples were collected from open wells, bore wells as well as from hand pump. The polythene bottle have been previously washed with 10% HNO_3 and 1:1 HCl and rinsed with same sample water taken in that bottle and labeled. Immediately add few drops of HNO_3 were added in order to prevent bacterial and fungal growth.

The sample are collected from different location feburary2025 to April 2025.[7]

2)The sampling containers (plastic/glassware) leached with 2 M reagent grade nitric acid for 48 hrs at room temperature and rinsed with double distilled water. All the samples were preserved as per standard preservation technique prior to its transportation to the laboratory. Field parameters viz. temperature, pH, dissolved oxygen were analysed immediately after collection. The main aim of the study was to investigate the physicochemical characteristics of ground water samples. Physicochemical parameters were analysed as per standard procedures given in APHA. All these samples were analyzed for Temperature, pH, Electrical Conductivity (EC), Turbidity, Total Solids[1].

SELECTION OF REGION

1) NAGPUR
2) BHANDARA
3) AKOLA
4) BULDHANA
5) GADCHIROLI
6) AMRAVATI
7) GONDIA

HYDROGELOGICAL ASSESMENT

Hydrogeological assessment is the scientific evaluation of groundwater conditions, aquifer systems, and subsurface geology. It helps determine:
1.Groundwater availability and quality
2.Aquifer characteristics (depth, thickness, type)
3.Seasonal and long-term water level trends
4.Suitability for drinking, irrigation, and industrial use
5.To assess the geological formations controlling groundwater occurrence.
6.To analyze aquifer parameters (transmissivity, storativity, yield).
7.To determine water table trends (pre- and post-monsoon).
8.To evaluate groundwater quality.
9.To identify groundwater recharge and discharge zones.[8]

GROUND WATER RECHARGES

Groundwater recharge is the process where surface water or precipitations infiltrates the soil and percolates downwards to the water table.
Groundwater Recharge is the primary method through which water enters underground resources like the aquifer[1]

TYPES OF GROUNDWATER RECHARGE

Groundwater recharge occurs in two forms:
1.Natural Groundwater recharge
2.Artificial Groundwater recharge

1. Natural Groundwater Recharge
Groundwater is recharged naturally through:
Precipitation ie. rainfall and snowmelt and to a smaller extent by surface water like rivers and lakes.
The water is able to move underground through the rock and soil due to connected pore spaces.
This downward movement of water through different soil layers is called percolation.
Some types of soils allow more water to infiltrate than others depending on the soil's permeability.
During natural recharge, water is first pulled into the zone of aeration; where a mixture of water and air fills the pore space.
Then the water further travels downwards to the zone of saturation – where the pore spaces are completely filled by water.
The upper boundary of the zone of saturation is known as the water table.
Aquifers are the underground layers of rocks that hold the groundwater and they are found in the saturation zone.
Groundwater is recharged naturally through the infiltration of rain water on the soil surface.
Groundwater can move as slow as a meter per year.
This means it can take several thousands of years for underground aquifers to become replenished.
2. Artificial Groundwater Recharge In areas where groundwater is utilized faster than its natural replenishing rate, man-made recharge method becomes a necessary option for balancing the water levels.
Artificial recharge is the process of increasing the amount of water that enters an aquifer through planned, human-controlled means.
Groundwater can be artificially recharged by redirecting water across the land surface through canals, infiltration basins, or ponds; adding irrigation furrows or sprinkler systems; or simply injecting water directly into the subsurface through injection wells[1].

WATER QUALITY ANALYSIS

Water quality refers to the chemical, physical, and biological characteristics of water, typically evaluated based on its suitability for a specific intended use. Water may be utilized for various purposes such as drinking, recreation, fisheries, agriculture, or industrial processes. Each of these uses requires water to meet distinct standards relating to its chemical composition, physical properties, and biological integrity. For instance, water intended for drinking or recreational activities like swimming must meet stricter quality criteria compared to water used for agricultural irrigation or industrial applications.[8]
Water quality analysis is a critical process used to assess the physical, chemical, and biological characteristics of water to ensure its suitability for specific uses such as drinking, agriculture, or industrial processes. The analysis typically involves testing parameters such as pH, turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), nitrates, phosphates, and the presence of heavy metals or microbial contaminants. These tests help determine the presence of pollutants and the overall health of the water body. Advanced methods such as spectrophotometry, chromatography, and microbial culture techniques are often employed for precise measurement. Accurate water quality analysis supports effective water resource management, pollution control, and the protection of public health and ecosystems[8]

PARAMETERS OF WATER

1)PHYSICAL PARAMETERS

• Temperature
Importance: Influences chemical reactions, biological activity, and oxygen levels in water.
Ideal range: 20–30°C (varies with intended use).
Measurement tool: Thermometer or digital temperature sensor.
• Turbidity
Definition: The cloudiness or haziness caused by suspended solids (clay, silt, organic matter).
Unit: NTU (Nephelometric Turbidity Units)
Acceptable limit:
•Drinking water:
<5 NTU (BIS Standard)
High turbidity can protect microorganisms and interfere with disinfection.
• Color
Caused by: Organic materials, metals (iron, manganese), industrial discharge.
Unit: Hazen units (Pt-Co scale)
Acceptable limit for drinking: ≤5 Hazen units
• Odor and Taste
Normal: Water should be free from any unpleasant taste or odor.
Caused by: Organic decay, algae, industrial waste, or contamination.
Tested: Subjectively (by panel) or using electronic sensors.
•Total Dissolved Solids (TDS)
Definition: Measure of all organic and inorganic substances dissolved in water.
Unit: mg/L or ppm
Ideal range for drinking:
Excellent: <300 mg/L
Acceptable: <500 mg/L
Not suitable: >2000 mg/L
•Electrical Conductivity (EC)
Definition: Water's ability to conduct electricity due to dissolved salts.
Unit: µS/cm (microsiemens per centimeter)
Typical range:
Freshwater: <1500 µS/cm
Irrigation suitability: varies with crop tolerance [9]
•pH (Can be considered physical/chemical)
Definition: Indicates acidity or alkalinity.
Scale: 0–14 (7 = neutral)
Drinking water: 6.5–8.5 (BIS standard)
Outside this range may cause corrosion or health issues [10]

CHEMICAL PARAMETR

Chemical parameters of water refer to the various chemical constituents and properties that determine water quality. These parameters are critical for assessing water safety for drinking, agriculture, industry, and aquatic life. Here are the **key chemical parameters** of water:

1 . pH
- **Definition**: Measures the acidity or alkalinity of water.
- **Range**: 0–14 (neutral at 7)
- **Typical Standards**: 6.5–8.5 for drinking water

2.Dissolved Oxygen (DO)
- **Definition**: The amount of oxygen dissolved in water, essential for aquatic life.
- **Unit**: mg/L (milligrams per liter)
- **Desirable Range**: >5 mg/L for aquatic organisms

3.Biochemical Oxygen Demand (BOD)
- **Definition**: The amount of oxygen required by microorganisms to decompose organic matter.
- **Indicator**: Water pollution; higher BOD = more organic pollution
- **Unit**: mg/L

4.Chemical Oxygen Demand (COD)
- **Definition**: Total oxygen required to oxidize all organic and inorganic matter.
- **Indicator**: Pollution level, including non-biodegradable compounds
- **Unit**: mg/L

5.Total Dissolved Solids (TDS)

- **Definition**: Sum of all dissolved substances in water (salts, minerals, metals).
- **Unit**: mg/L
- **Acceptable Range**: <500 mg/L for drinking water

6.Nitrates (NO_3^-) and Nitrites (NO_2^-)

- **Sources**: Fertilizers, sewage
- **Health Concern**: Methemoglobinemia (blue baby syndrome)
- **Drinking Water Limit**: Nitrate <10 mg/L (as N), Nitrite <1 mg/L

7.Ammonia (NH_3/NH_4^+)

- **Source**: Decomposition of organic matter, sewage
- **Indicator**: Pollution from waste
- **Desirable Level**: <0.5 mg/L

8.Hardness (Calcium and Magnesium)

- **Definition**: Caused by Ca^{2+} and Mg^{2+} ions
- **Unit**: mg/L as $CaCO_3$
- **Soft Water**: <60 mg/L, Hard Water: >120 mg/L

9.Chloride (Cl^-)

- **Sources**: Salts, seawater intrusion, sewage
- **Drinking Water Standard**: <250 mg/L

10.Fluoride (F^-)

- **Importance**: Beneficial in small amounts; harmful in excess
- **Limit**: 0.7–1.5 mg/L (WHO guideline)

11.Sulfate (SO_4^{2-})

- **Source**: Natural minerals, industrial waste
- **Limit**: <250 mg/L

12.Heavy Metals

- **Includes**: Lead (Pb), Arsenic (As), Mercury (Hg), Cadmium (Cd), Chromium (Cr), etc.
- **Toxic at low concentrations**
- **Safe Limits** (WHO Guidelines): o Lead: <0.01 mg/L o Arsenic: <0.01 mg/L o Mercury: <0.006 mg/L

13. Alkalinity

- **Definition**: Water's ability to neutralize acids (mainly due to bicarbonates, carbonates)
- **Unit**: mg/L as $CaCO_3$
- **Desirable Range**: 20–200 mg/L

14. Turbidity

- Though more physical, it relates to chemical contamination from suspended solids.
- **Unit**: NTU (Nephelometric Turbidity Unit)
- **Limit**: <1 NTU for drinking water[11]

BIOLOGICAL PARAMETER

1. Total Coliform Bacteria

- **What it indicates**: Presence of bacteria that originate from soil, vegetation, and fecal contamination.
- **Use**: Indicator of water safety for human consumption.
- **Standard (Drinking Water)**: **0 CFU/100 mL** (Colony Forming Units)

2.Fecal Coliform (e.g., Escherichia coli*)*

- **What it indicates**: Direct fecal contamination from humans or warm-blooded animals.
- **Use**: Stronger indication of potential pathogens.
- **Standard**:
  o**0 CFU/100 mL** for drinking water oLimits vary for recreational and agricultural wate

3.Biological Oxygen Demand (BOD)

- **Also a chemical parameter**, but it measures **biological activity** (oxygen needed by microorganisms to decompose organic material).

- **High BOD** indicates high organic pollution.

4.Microbial Pathogens

- Includes:
  - o**Bacteria**: *Salmonella*, *Shigella*, *Vibrio cholerae*o **Viruses**: Rotavirus, Norovirus, Hepatitis A
  - o**Protozoa**: *Giardia lamblia*, *Cryptosporidium*o **Helminths**: Parasitic worms (in poorly treated water)
- **Detection methods**: PCR, culture techniques, immunoassays

5.Algal Biomass (Chlorophyll-a)

- **What it indicates**: Algal growth, especially **phytoplankton**
- **Chlorophyll-a** is used as a proxy for algae presence.
- **Use**: Indicator of **eutrophication** and nutrient pollution.

6. Biological Indexing (Bioindicators)

- Involves evaluating the presence or absence of certain organisms:
  - o**Macroinvertebrates** (e.g., mayflies, stoneflies) o **Plankton diversity**o**Fish population health**
- **Example index**: Biological Monitoring Working Party (BMWP) Score, used in rivers.

7. Biotic Index

- Combines data on different species (mostly macroinvertebrates) to assess pollution levels.
- A **higher biotic index** suggests **cleaner water(28)**

CONTAMNATION AND POLLUTION OF GROUND WATER

Depending on its physical, chemical, and biological properties, a contaminant that has been released into the environment may move within an aquifer in the same manner that ground water moves. (Some contaminants, because of their physics Ground water and contaminants can move rapidly through fractures in rocks. Fractured rock presents a unique problem in locating and controlling contaminants because the fractures are generally randomly spaced and do not follow the contours of the land surface or the hydraulic gradient. Contaminants can also move into the ground water system through macropores—root systems, animal burrows, abandoned wells, and other systems of holes and cracks that supply pathways for contaminants. In areas surrounding pumping wells, the potential for contamination increases because water from the zone of contribution, a land area larger than the original recharge area, is drawn into the well and the surrounding aquifer. Some drinking water wells actually draw water from nearby streams, lakes, or rivers. Contaminants present in these surface waters can contribute contamination to the ground water system. Some wells rely on artificial recharge to increase the amount of water infiltrating an aquifer, often using water from storm runoff, irrigation, industrial processes, or treated sewage. In several cases, this practice has resulted in increased concentrations of nitrates, metals, microbes, or synthetic chemicals in the water. Under certain conditions, pumping can also cause the ground water (and associated contaminants) from another aquifer to enter the one being pumped. This phenomenon is called interaquifer leakage. Thus, properly identifying and protecting the areas affected by well pumping is important to maintain ground water quality. Generally, the greater the distance between a source of contamination and a ground water source, the more likely that natural processes will reduce the impacts of contamination. Processes such as oxidation, biological degradation (which sometimes renders contaminants less toxic), and adsorption (binding of materials to soil particles) may take place in the soil layers of the unsaturated zone and reduce the concentration of a contaminant before it reaches ground water. (29)

GROUND WATER LEVEL AND TRENDS

Agriculture is the most important sector of Indian economy contributing about 18 percent to the Gross Domestic Product (GDP). India has about 61% net irrigated agricultural area playing a vital role in food security of the country. Groundwater is one of the most used water sources for irrigation. Introduction of contemporary drilling techniques, electrical controlled pumping systems, nominal cost of electricity and groundwater legislation rules are not fully promised in the agriculturally advanced regions of the country. The major cause of depletion of fresh groundwater resources and increase of grey and dark areas in Indian e related to large scale population, exploitation in agricultural sector and changes in land use patterns for urbanization[30] In recent decades due to climate change and anthropogenic factors global attention has been drawn to water resource security using integrated water resource management. Established in 2015, the 17 Sustainable Development Goals (SDGs) of the United Nations aim to inspire global action for the eradication of poverty, the promotion of peace and prosperity, and the preservation of the environment for future generations SDG 6, which emphasizes the availability and sustainable management of water and sanitation for everyone, is especially relevant to the water sector . Increasing the integration of water resources, increasing water-use efficiency, promoting sustainable groundwater development, lowering pollution, guaranteeing access to sanitation and hygiene, repairing water-related ecosystems, and strengthening local community involvement are just a few of the objectives that make up this goal . According to , the study highlights the decrease in groundwater levels and noticeable seasonal variations between wet and dry periods. These variations highlight the critical role that the wet season plays in replenishing groundwater. Groundwater sustainability is further threatened by the observed decrease in rainfall and rise in temperature, in addition to irrigation uses which become a leading factor in populated areas. Moreover, there is a noticeable declining groundwater level in the area due to the increasing production rate associated with population, agriculture and industry, in addition to variation in the rainfall pattern. These changes exacerbate the current problems of decreasing groundwater level and tend to make it increasingly difficult to reach SDGs. However, the western part of the area which is bounded by GZAB R tends to have lateral recharge. Wherever the declining rate is lower, combined with the geology of the KSB, it has a great influence on the lateral recharge of the aquifers. Further comprehensive research is necessary with long-term field measurements to strategically address groundwater decline. Insights of this study will help to work out the regional groundwater policy for the management of sustainable groundwater supply.[12]

IMPACT OF AGRICULTURE ON GROUND WATER

A study was conducted to assess the groundwater status in Meerut district, an area known for intensive cropping. Notably, sugarcane alone accounts for 35% of the total cultivated area. Due to reports of groundwater depletion at a rate of approximately one meter per year, a sustainable water management plan was developed to preserve groundwater for future agricultural use.

An analysis of 14 years of groundwater utilization data (1983–1997) revealed an 8.8% increase in net coverable recharge in 1997 compared to 1983. However, during the same period, net groundwater draft rose by 22.4%, indicating an annual growth of 1.6% in draft versus only 0.63% in recharge. This growing gap between recharge and draft has resulted in a continuous decline in the groundwater table.

The major causes of this depletion include changes in cropping patterns, the expansion of sugarcane cultivation, excessive irrigation, and low rainfall. To address this issue, an optimal land use plan was developed. It recommends reducing the cultivation area of water-intensive crops like wheat and sugarcane by 19.5% and 5.9% respectively, and promoting less waterdemanding crops such as pulses and millets in their place.

Using a linear programming model, the sustainable plans propose a 5% and 10% reduction in the area under rice, wheat, and sugarcane. As sugarcane is the most water-intensive crop, its area was reduced to 51.9% and 49.2% compared to the current plan. As a result, water use is projected to decrease significantly—from 547,208 hectare-meters in the current plan to 391,455 in the optimized plan, and further to 378,822 and 352,310 hectare-meters in Sustainable Plans I and II, respectively.[13]

CHALLENGES IN GROUND WATER MANAGEMENT

Groundwater management poses significant challenges due to limited understanding of subsurface systems, difficulty in monitoring, ill-defined flow boundaries, and weak regulatory structures—particularly in transboundary and coastal regions. For instance, groundwater discharge into Oneida Lake (New York, USA) caused phosphorus enrichment, highlighting surface water impacts.

Urbanization and land-use changes—such as deforestation, surface sealing, and the conversion of recharge zones to built-up areas—further reduce infiltration and natural recharge.

Groundwater quality, especially in developing countries, is deteriorating rapidly. Natural interactions with geological formations lead to geogenic contamination (arsenic, fluoride, radionuclides, salinity), exposing millions to serious health risks. In Chile, magmatic and hydrothermal processes have caused widespread arsenic contamination, while studies in Ivory Coast and Greece illustrate how fractured and karstic bedrock systems complicate flow and contaminant transport.

Simultaneously, human activities contribute to both localized and diffuse pollution through agriculture (nitrates, pesticides), untreated wastewater, industrial discharge, and emerging contaminants like microplastics. Some pollutants can be mitigated using nature-based or advanced treatment technologies, but many human-derived contaminants persist for decades in groundwater systems.

Groundwater movement is slow and largely invisible, with long residence times—ranging from years to millennia. Its behavior is governed by the hydraulic and chemical properties of aquifers and is further influenced by urban and irrigation demands. In fractured or karst aquifers, flow is unpredictable, often dictated by bedrock discontinuities.

The widespread use of non-renewable groundwater for irrigation threatens long-term global food security. Key stressors include population growth, increasing consumption, urbanization, and climate change, all of which alter recharge patterns, reduce groundwater storage, and increase salinity intrusion and disruption of groundwater-surface water interactions.[14]

Groundwater has a major advantage—it is spread out across many areas and stored in large amounts underground. Most of this water is clean and naturally protected from surface pollution.

Many places around the world, like some regions in Africa and small islands, have shallow groundwater that isn't fully used yet. This is often because of economic, political, or institutional challenges. In addition, deeper underground reserves of fresh water could provide great opportunities for future use.

In times of drought, which are becoming more common due to climate change, people in dry areas will rely more on groundwater because it can help cushion water shortages.

Groundwater also plays a key role during natural or human-made disasters like earthquakes, floods, or industrial accidents. It serves as a backup water supply. In situations of migration or conflict, wells that provide groundwater can offer emergency drinking water.

CLIMATE CHANGE IMPACT ON GROUNDWATER

Climate change introduces significant uncertainties to the availability and management of water resources. According to estimates by the Intergovernmental Panel on Climate Change (IPCC), the global mean surface temperature has risen by 0.6 ± 0.2°C since 1861 and is projected to increase by 2 to 4°C over the next century. Rising temperatures directly intensify the hydrological cycle by increasing evaporation from water bodies and transpiration from vegetation. These changes influence the amount, timing, and intensity of precipitation, and indirectly affect water flux and storage in both surface and subsurface reservoirs—such as lakes, soil moisture, and groundwater.

Beyond these direct effects, climate change can also cause secondary impacts including seawater intrusion, deterioration of water quality, and shortages of potable water. Surface water resources are more directly affected by long-term climate variables like air temperature, rainfall, and evapotranspiration. In contrast, the impact on groundwater systems is more complex and less understood.

Increased rainfall variability may lead to more frequent and prolonged periods of extreme groundwater levels, while rising sea levels heighten the risk of saline intrusion in coastal aquifers. Groundwater dynamics are influenced by both direct interactions with surface water systems (e.g., rivers and lakes) and indirect processes such as recharge, which is sensitive to climate variability.

Understanding the effects of climate change on groundwater requires accurate assessments of both changes in climatic variables and their influence on recharge processes. This necessitates the use of Global Climate Models (GCMs), which simulate climate dynamics on a global scale. However, to assess groundwater impacts at a regional or basin scale, these models must be downscaled and integrated with hydrological models that account for the full water cycle.

The outputs from such coupled climate-hydrological models, particularly groundwater recharge estimates, are essential for formulating effective adaptation strategies. This paper reviews national and international efforts to quantify the impact of climate change on groundwater and offers guidance for future research and development, especially within the context of India's hydrogeological conditions.[14] The impact of climate change on the groundwater regime in India is projected to be profound and potentially severe. Groundwater remains the primary source of drinking water in rural areas, supporting approximately 85% of the rural population's water needs. India possesses an estimated replenishable groundwater potential of 45.22 million hectare-metres (Mha-m) per year, but the unsustainable extraction of this vital resource has led to a significant decline in groundwater levels across many regions.

This overexploitation is particularly acute in states such as BULDHANAN,NAGPUR,WARDHA, where groundwater development has surpassed the national average. In Gujarat, for instance, the groundwater table in Ahmedabad is reportedly declining at a rate of 4 to 5 meters annually. In parts of Delhi, the water table has dropped by more than 10 meters, while in Kerala—despite its heavy monsoonal rainfall—systematic declines in groundwater levels are observed across the state.

The environmental consequences of these trends are compounded by their carbon footprint. Under optimistic scenarios, a 1-meter drop in the groundwater level could increase India's total carbon emissions by over 1%, as more energy and fuel would be required to extract the same volume of water. More conservative and realistic projections, accounting for the extent of groundwater-based irrigation, suggest that emissions could rise by as much as 4.8% per meter of groundwater decline [(Mall et al., 2006)].

To address these challenges, it is critical to:

- Conduct detailed aquifer mapping to understand local and regional groundwater systems.
- Identify the saline-freshwater interfaces within a few kilometers of the coastline to monitor and mitigate seawater intrusion.
- Assess the impact of glacial melt on aquifer recharge in the Ganga basin, which has implications for both domestic and transboundary groundwater systems.
- Focus particularly on arid and semi-arid regions, where groundwater resources are most vulnerable.

CASE STUDY OF VILLAGE

Vidarbha in eastern Maharashtra comprises districts like Nagpur, Amravati, Yavatmal, Chandrapur, Wardha, and Bhandara. With its diverse topography and heavy dependence on agriculture, Vidarbha has experienced higher variations in water levels below the ground due to differing rainfall, overdrawal, and poor recharges in groundwater. Case studies from representative districts in the subsequent section are described to determine regional groundwater problems.

1.Bhandara District:

On the contrary, Bhandara with its abundant surface water bodies shows relatively even groundwater levels. Recent industrial development, however, has led to nitrate and heavy metal contamination of shallow aquifers. Water samples collected in Pauni and Tumsar blocks had shown nitrate content exceeding WHO standards due to fertilizer runoff primarily.

Taluka	Pre-Monsoon Depth (mbgl)	Post-Monsoon Depth (mbgl)
Bhandara	1.92	0.85
Pauni	10.25	4.75
Mohadi	5.43	2.67
Sakoli	6.21	3.12
Lakhani	4.89	2.14
Lakhandur	7.35	3.98
Tumsar	6.78	3.45

Bhandara district, while currently enjoying relatively stable groundwater levels, faces challenges related to over-extraction, seasonal fluctuations, and pollution. These challenges threaten the long-term sustainability of groundwater resources and the well-being of the district's population. Sustainable management practices, coupled with government interventions and community participation, can help mitigate depletion risks and ensure water security for future generations. The integration of modern techniques such as GIS-based groundwater mapping and remote sensing can further aid in monitoring and managing groundwater resources efficiently. Policy reforms and increased investments in water conservation infrastructure are necessary to maintain groundwater sustainability in the long run. This includes strengthening regulations on groundwater extraction, promoting efficient irrigation techniques, investing in rainwater harvesting and artificial recharge projects, and protecting groundwater quality from pollution. By implementing these strategies, Bhandara District can ensure the sustainable management of its groundwater resources, safeguarding water security and promoting the long-term prosperity of the region.(34)

2. Amravati District:

Water is the most important parameter to influence the climate and human life. The necessary treatment to the water should be given if the water is found to be of bad quality depending upon the different parameters according to WHO & BIS. The effects of different industrial area, mines, etc have the effect on the quality of water. It is very necessary to check the ground water quality. There are many parameters in terms of physical, chemical and bacteriological are studied by many researchers

Some region of AMRAVATI is taken below

Sr. No.	Sample no.	Site name
1	S1	Prabhat colony
2	S2	Ekviravihar
3	S3	Ambadevi
4	S4	Morshi
5	S5	Navsari

Parameter	Unit	WHO values	S1	S2	S3	S4	S5
Temperature	°C	-	29	30.3	29.2	31.1	29.6
pH	Nil	6.5-8.5	8.06	8.1	7.95	7.85	7.68
Odour	Unobjectionable (Y/N)	Y	Y	Y	Y	Y	Y
Taste	Agreeable (Y/N)	Y	Y	Y	Y	Y	Y
Color concentration	Hazen	5	0.025	0.007	0.015	0.013	0.009
Transparency	%	NIL	98.8	95.4	99.1	97	99
TDS	Ppm	500	419	349	493	453	187
Conductivity	uS/cm	50	139	448	214	190	396
D.O.	Ppm	NIL	3.8	2.9	2.9	2.2	2.2
Salinity	Ppm	NIL	6.7	2.32	5.78	5.69	2.56
Hardness	Ppm	300	194	164	223	198	290
Total alkalinity	Ppm	200	180	195	213	196	220
Total acidity	Ppm	NIL	240	220	216	165	230
Fluorides	Ppm	1.0	0.58	0.46	0.6	0.56	0.7

After the whole assessment, comparisons of the results obtained, with the standards it is found that the quality of groundwater of Amravati city is good and the water is fit for human consumption in most of the regions. No specific parameter was found to be exceeding the prescribed limit by higher values. The exceeding parameters in some cases like the hardness, alkalinity and low fluoride concentrations can be given proper treatment in order to make it suitable for drinking purposes. Aesthetically speaking, the quality of groundwater is agreeable without any odour, displeasing taste or colouration. For industrial application, the water needs to be treated for dissolved oxygen and hardness[9]

3 CHANDARPUR district:

Groundwater is the most vital natural resource used for drinking purpose by many us people around the world, especially in arid and semi-arid areas. This resource cannot be used sustainably unless the quality of groundwater is assessed. The present investigation deals with the study of physicochemical parameters i.e. Temperature, pH, Electrical Conductivity, Turbidity, Total Solids, Total Dissolved Solids, Total Suspended Solids, Dissolved Oxygen, Alkalinity, Hardness, Chloride, Sulphate and Fluoride in water samples of dug wells and bore well in Chandrapur city, Vidarbha Region, Central India. The sample were collected from six different sapling location of Chandrapur city. This all dug well and bore well are in daily use and some are used for drinking purpose. All the results were compared with the standards prescribed by Bureau of Indian standards 10500-2012. Most of results are within permissible

Table No. 2: Water Quality - Physical & Demand Parameters

Sr. No.	Location name		pH	Temp (°C)	Turbidity (NTU)	TSS (mg/l)	TDS (mg/l)	TS (mg/l)	EC (S/cm)	DO (mg/l)
1	Shashtri Nagar	Dug well	6.8	25	2	62	393	455	653	4.1
		Bore well	9.4	24	5	54	332	386	345	2.5
2	Arwat	Dug well	7.2	27	6	37	385	422	1519	3.9
		Bore well	8.9	23	6	47	432	479	1836	3.0
3	Rayatwari	Dug well	6.9	24	2	51	461	512	578	4.0
		Bore well	8.7	23	5	62	434	496	349	2.8
4	Babupeth	Dug well	7.5	25	3	45	354	399	542	4.4
		Bore well	9.3	25	7	32	448	480	900	3.0
5	Durgapur	Dug well	8.0	26	6	41	434	475	1267	4.1
		Bore well	9.5	24	5	29	326	357	1005	2.2
6	Tukum	Dug well	7.5	25	4	37	372	409	897	3.5
		Bore well	9.2	23	5	54	438	492	600	1.8
IS 10500-2012 Standard			6.5-8.5	-	1	-	500	-	-	-

Table No. 3: Water Quality- Inorganic Parameters

Sr. No.	Location name		Total Alkalinity	Total Hardness	Calcium Hardness	Magnesium Hardness	Chloride	Sulphate	Fluoride (mg/l)
1	Shashtri Nagar	Dug well	65.2	290	210	80	45	1.0	0.2
		Bore well	158.5	480	340	140	62	2.2	0.4
2	Arwat	Dug well	46.4	440	350	90	71	0.5	0.4
		Bore well	120.7	350	265	85	54	3.0	0.3
3	Rayatwari	Dug well	61.8	340	280	60	86	2.1	0.4
		Bore well	149.6	360	250	110	38	3.4	0.2
4	Babupeth	Dug well	78.5	310	250	60	54	2.2	0.2
		Bore well	168.1	290	270	50	77	3.6	0.3
5	Durgapur	Dug well	66.8	290	230	60	49	2.5	0.5
		Bore well	172.3	375	310	65	58	3.8	0.4
6	Tukum	Dug well	49.8	265	230	35	62	1.3	0.5
		Bore well	164.0	280	220	60	45	2.7	0.5
IS 10500-2012 Standard			200	200	-	-	250	200	1

In this present paper the physicochemical characteristics of ground water of Chandrapur city Vidharbha region has been evaluated. The data indicate that the groundwater quality of Chandrapur city, not so polluted. Most of the parameters were either more than permissible limit and parameters like pH, turbidity and hardness is above permissible limit and all other parameters slightly below permissible limit. Therefore, the ground water of Chandrapur city is not potable to direct can be used for cooking and drinking only after drinking purpose, but after simple treatment this simple prior treatment. To maintain quality like installation of RO, boiling of water or deep of groundwater, the continuous monitoring of the alum stone for 1-2 min in water, that water physic-chemical parameters should be done.[1]

4 AKOLA DISTRIST:

Open well water and ground water samples were collected from several sampling points within a 30-kilometer radius of the Akola district region between August 16 and December 16, 2021. Twenty water samples were tested in the lab for physical and chemical qualities.

The laboratory conducted tests to analyze pH, EC, ORP, BOD, hardness, alkalinity, chlorides, TDS,

DO, and other parameters. All of the data were compared to the drinking water quality standards set by the WHO (World Health Organization) and ISI. When the findings are compared, some of the water samples fail to meet one or more of the drinking water quality standards listed above. Many samples included excessive levels of TDS. The significance, utility, and ineffectiveness of these criteria in forecasting ground water surface water quality characteristics were discussed.

Sr.No	Location	pH	Conductance(Ʊ)	ORP (mv)	TDS (mg/L)	DO (mg/L)	Chlorides (mg/L)	TH (ppm)	Mg (mg/L)	Ca (mg/L)	BOD (mg/L)	COD (mg/L)
1	Umari	7.93	578.6	49.2	507	6.31	250.3	387	96	203	2.09	17.2
2	Adsul	7.6	632	52.7	512.5	6.29	241.9	412	98	256	2.06	18.5
3	Panchgavhan	7.9	618	44.8	499	6.48	355	368	103.5	224	2.11	17.1
4	Khandala	7.96	483.5	54.8	501	6.58	209	300	111	184	2.10	17
5	Gordha	7.7	464.7	51.5	512	6.48	185	336	98	216	2.11	16.1
6	Deori	7.26	704.2	60.5	512	6.65	149.6	256	101	75	2.19	20.4
7	Mundgaon	7.6	687.2	55.5	499	6.01	101	278.1	88	82	2.06	22.5
8	GajananNursary	7.93	731.5	65.9	465	6.11	231.8	246.2	95	60	2.16	20.8
9	Pote Vidyalaya	7.46	584	54.25	499	6.74	243.4	239	96.5	67	2.16	20.3
10	Mahindra Akot	7.86	456	53.5	522	7.12	41.7	306	82.6	130	1.95	22.2
11	Nakashi	7.57	425.5	51	489	8.1	267.4	98	88.5	15	2.09	20.7
12	Mazod	7.7	417	52.5	411	8.27	69.7	186	101	55	2.21	20.62
13	Indira nagar	7.35	416	51.17	512.5	8.33	43.5	258	92.5	50	2.21	20.52
14	Wadegaon	7.65	400	52.5	512	8.08	93.1	300	97	84	2.09	21.0
15	Channi phata	7.4	520.1	55.5	525	8.05	62.3	283	78	63	1.97	22.9
16	Chikhalgaon	7.77	422	54.5	425	7.85	47.4	113	93	59	1.90	22.1
17	Patur	7.45	520	53.2	375	7.85	36.1	98	73.5	31.2	2.11	22.25
18	Pardi	7.4	477	60.7	462.5	8.05	33.6	83	101	31	2.09	22.57
19	Khanapur	7.45	438.2	51.2	322	7.91	35.4	102	95	41.5	2.17	22.4
20	Tapalpatur	7.39	528.6	54.2	287.4	7.95	41.7	106	88.6	32	2.09	22.2

It has been determined, based on the many characteristics that were investigated, that the total dissolved solids (TDS) in certain regions is high. It is possible that gastrointestinal issues will arise from a high TDS value. The two different water sources are both suitable for human consumption.[3]

5 YAVATMAL DISTRICT:

30 ground water samples of 10 villages in Pandharkawada Tahsil of Yavatmal district, Maharashtra (India) were analyzed for their suitability for irrigation purpose. The mean values of 3 samples taken from each village have been reported in the present study. Ground water was classified according to Sodium absorption ratio (SAR), Percentage Sodium, Residual sodium carbonate and electrical conductivity. Only one village Shibala fall in very high salinity and medium sodium hazard water which has alkaline in nature and require proper management practices.

Keywords: Pandharkawada, SAR, Yavatmal

AKOLA BAJAR	S1
BORGAV	S2
DAHELI	S3
ECHORI	S4
GHODDARA	S5

Sr.No.	Parameter	S-1	S-2	S-3	S-4	S-5
1.	pH	7.40	8.04	8.13	7.57	7.45
2.	EC	1352 .4	356. 8	526. 4	845. 6	553. 6
3.	Sodium	1.43 2	0.52	4.21 56	4.23 6	4.23 6
4.	Potasium	0.08 3	0.18 4	0.08 2	0.10 9	1.42 8
5.	Calcium	3.80 4	1.08 97	0.83 5	1.18	1.21 1
6.	Magnisiu m	4.47	0.44 55	0.86 4	1.07 4	1.75 6
7.	Carbonat e	0.00	0.00	0.00	0.00	0.00
8.	Bicarbon ate	8.24	2.28	6.29	8.78	9.45
9.	SAR	0.63 2	0.72 4	4.32 4	4.67 5	4.64 3
10.	PS	15.4 2	27.8 9	64.9 8	61.9 8	69.0 7
11.	RSC	-1.27	0.20 8	4856	4.78 9	6.29 8

The study revealed that only three villages has low salinity and low sodium hazards water. Ground water is suitable for irrigation purpose. Some village i.e. daheli,ghoddara has medium salinity and low sodium hazards water and require proper management practices. 5 samples from borgav Both(B) villages represent high salinity and low sodium hazards water. This could be used for irrigating semi-tolerent crops without any harmful sodium effect. Only one village akola bajar fall in very high salinity.[15]

6 WARDHA DISTRICT:

Ground water is one of the most useful water sources found in earth. The importance of the hydro chemical analysis underlies the fact that the chemistry of ground water can directly be rated with the source of water, climate and geology of the region.

Contamination of such water is responsible for creating health hazards. In this paper chemical analysis of the ground water has been carried out for hinganghat tehsil in wardha district. The water sample collected from different location in hinganghat Tehsil, Wardha (India). The ground water samples were analyzed for the following Hydro-chemical parameters; pH, Electrical Conductivity (EC), Total Alkalinity (TA), Total Hardness (TH), Chloride, Nitrate, Sulphate, Dissolved Oxygen (DO) and Total Dissolved Solid (TDS). The results Obtained shown that it is free from anomalies and suitable for human and cattle consumption as well as irrigation purpose in hinganghat tehsil, Wardha districts, Maharashtra, India.

GW1- Hinganghat	Hinganghat
GW2	Aajanti
GW3	Nandori
GW4	Alipur
GW5	Yenora

Sr.No	Parameter	GW1	GW2	GW3	GW4	GW5
1	Temperature	25.3	25.8	26.1	25.4	27.1
2	pH	6.7	5.9	6.6	5.7	6.2
3	Conductivity	1105	1130	717	682	398
4	Alkalinity	650	810	450	620	190
5	Total Hardness	220	190	160	340	230
6	TDS	120	109	125	135	190
7	DO	2.34	1.90	2.95	2.32	1.24
8	Chloride	132	175	190	120	210
9	Nitrate	11.2	10.5	9.6	8.5	7.5
10	Sulphate	42.2	40.6	60	38	79

The present area of study shows detailed report of hydro - chemical analysis of ground water samples of Hinganghat tehsil Wardha district, MS, India. The study is analyzed 5, parameters of 10 different locations which are essential to identify ground water quality the water parameter results are compared with the standards of BIS, ICMR and WHO. In overall ten location ground water sample parameters are showed best results which are within the limitations of BIS, ICMR and WHO standards.[7]

DISCUSSION:-

Vidarbha area of Maharashtra underground water survey reveals subsurface water problems and locational disparities in groundwater quality and availability. Vidarbha districts like Nagpur, Chandrapur, Amravati, Yavatmal, Bhandara, and Gadchiroli have a predominant agrarian economy largely depending on groundwater for irrigation and drinking purposes.Groundwater levels in the area present a declining trend, especially in areas such as Yavatmal, Washim, and Amravati, due to unpredictable rainfall, over-drawal, and a lack of recharge processes. The area receives moderate rainfall but with hard rock geology, natural percolation is limited, leading to a lack of groundwater storage. Seasonal deficiency prevails in most areas, with borewells running dry during summer periods.Quality problems are also on a high scale. In parts of Bhandara and Chandrapur, excess fluoride and iron levels are normally present, affecting potability and public health. Further, in industrial regions like Nagpur and Chandrapur, groundwater pollution by industrial effluent disposal and mining activities has been noticed, which affects the environment.Traditional water-saving measures such as farm ponds, percolation tanks, and check dams are being reclaimed with the help of government programs and NGOs. But the pace is uneven between districts. More focus is also being laid on sustainable agriculture practices such as diversification of crops to reduce water stress.The study emphasizes the need to include an integrated groundwater management plan tailored to Vidarbha's unique hydrogeological setting. Scientific aquifer mapping, community participation in water management, and promotion of water-conserving irrigation methods like drip and sprinkler systems will help ensure long-term sustainability.

CONCLUSION:-

The thorough analysis of groundwater in different districts of Vidarbha forms a worthy perspective of the volume of water, quality, and utilization of water in Vidarbha. Groundwater can be seen to be a source of livelihood for irrigation, drinking, and daily livelihood activity, particularly in rural and semi-urban regions. The study, however, presents a serious trend of declining levels of groundwater, inadequate recharge, and degrading water quality in a number of districts.Semi-arid climate, as well as uneven and patchy rainfall, have a major impact on natural groundwater recharge in Vidarbha. Hard rock geology also impedes water storage, leading to seasonal deficits. Yavatmal, Washim, and Amravati districts reflect major groundwater stress, largely from over-exploitation for irrigation and absence of proper water conservation methods.Groundwater pollution is another severe issue. The presence of fluoride, iron, and other minerals in Bhandara, Chandrapur, and surrounding areas is health-damaging. Ind ustrial pollution and dump-site lying in and around Nagpur and Chandrapur also vitiate the quality of groundwater and impact human health as well as soil productivity.Despite all this, the report also provides some solutions. Recharge can be facilitated through watershed development, rainwater harvesting, and rejuvenation of traditional water storage systems. Using advanced irrigation methods like drip and sprinkler irrigation can minimize groundwater dependence. Awareness campaigns and active public participation to render water use responsible and sustainable are also needed.

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