WATER HARVESTING AND PURIFICATION MECHANISM

Dr. Venkatesha Raju K
Dr. Chandankeri Ganapathi Gurlingappa

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Regd. Office:
F-10/24, East Krishna Nagar, Near Vijay Chowk, Delhi-110051
Ph. No: +91-11-79669196, +91-9899073222
E-mail: info@booksarcade.co.in, booksarcade.pub@gmail.com
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INTRODUCTION TO BOREWELL RECHARGE TECHNOLOGY

Dr. Venkatesha Raju K
Associate Professor, Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- venkatesharaju.k@presidencyuniversity.in

Rainwater harvesting refers to the collecting and storage of rainwater as well as other operations intended to gather surface and groundwater [1],[2]. Rainwater is a free supply of almost clean water [3],[4]. Losses from seepage, evaporation, and all other hydrological or engineering innovations are avoided to save and use the limited water resources as effectively as possible. Water harvesting is often the direct gathering of rainwater. The collected water may be kept for immediate consumption or returned to the groundwater system [5],[6]. When surface water is sufficient to suit our needs, rainwater gathering has greater advantages. Over the last several years, significant portions of our nation have experienced ongoing monsoon failure and a resulting shortage in rainfall. Additionally, due to India's constantly growing population, groundwater usage has dramatically grown, causing the level of groundwater to continuously drop and the wells and tube wells to dry up. In addition to irrigation and home demands, it is essential to take necessary steps to satisfy the nation's population's need for drinking water, which also entails enhancing aquifer water quality. In India, ongoing attempts have been made to enhance groundwater resources to fulfil the country's growing water supply needs, particularly in the previous several decades. Groundwater development has already reached a critical point in certain high-demand locations, leading to an extreme shortage of resources. Lowered groundwater levels and storage in the water supply are caused by overuseof the groundwater resources.

Artificial Recharge

Artificial recharge is now widely recognized as a cost-effective way to supplement groundwater supplies in locations where ongoing overexploitation without consideration for their recharging potential has led to a variety of unfavourable environmental effects. Any human-made plan or construction that increases the amount of water in an aquifer may be regarded as an artificial recharge system. Artificial groundwater recharge, also known as planned recharge, is the human process of replenishing underground aquifers. To store the extra water that is present above the earth's surface, it is forced to seep into the soil. Artificial groundwater recharge assists in controlling several additional issues in addition to the specific purpose of addressing groundwater scarcity.

The Idea of Recharge

Unless the water supply is sustained for extended periods, the soil will not get entirely saturated with water. There could not be any recharge during the first infiltration or even between two consecutive infiltrations if water is only provided sporadically. Redistribution is the term used to describe how water changes in the soil between two infiltration events. Even without a hydraulic connection being made between the ground surface and the underlying aquifer, recharge may still occur.

Advantages

- The amount of land needed to store water is minimal.
- Water that has been stored is mostly shielded from evaporation and impurities.
- Dilution results in an improvement in groundwater quality.
- Direct use of rainwater is made possible by collecting rooftop water in a sump and recharge pit.
- Other than replenishing the groundwater. This aids in lowering the water cost and significant outlays on tanker purchases of water in places of shortage.
- The building that is suggested for rainwater collection is easy, affordable, and environmentally beneficial.

The Groundwater Recharge Movement in India

Groundwater has been extensively used in India as a consequence of technological advancements in well-building and pumping techniques. The dependency on groundwater has grown significantly over the last several years in many areas of India because of the erratic nature of the monsoon and because there aren't enough or aren't enough surface-water supplies in the arid and semi-arid regions. It is crucial to implement adequate storage and management of the accessible groundwater resources since there is a risk that they will be overused in these locations. Although artificial groundwater recharge techniques have been widely employed for many years in affluent countries, they have just lately been applied in poor countries like India.

In the states of Maharashtra, Gujarat, Tamil Nadu, and Kerala, a variety of methods for artificial groundwater recharge have been used. Studies on seven percolation tanks in the Sina and the major river basin in Maharashtra were done. Artificial recharge investigations have been conducted in two locations in Gujarat. Artificial recharge was done in the central Mehsana region of north Gujarat utilizing injection wells, connecter wells, infiltration pipes, and ponds. In India, certain states have used watershed management strategies to reduce soil loss from erosion and also to help groundwater recharge.In India, there are now approximately 12 million groundwater wells, up from less than 1 lakh in 1960. Local governments and people are heavily relying on local water collection and recharge systems due to obvious indicators of aquifer depletion and ongoing irregular rainfall. Increasing groundwater availability is the main goal of this groundwater recharge movement for better domestic supply security, drought resistance, and protection of rural livelihood. To maximize benefits and reduce costs, the groundwater recharge movement in India, which was started by local elites and later supported by the government and NGOs, must be nurtured but also carried out with systematic study and development programs trying to cover its physical, environmental, and economic.

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CHAPTER 2

BOREWELL RECHARGE

Dr. Chandankeri Ganapathi Gurlingappa
Professor (Selection Grade) Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- chandankeri@presidencyuniversity.in

Natural water resources may readily be restored to nature since water is classified as a renewable energy source [1],[2]. However, excess of anything is indeed harmful; the rate at which natural groundwater is utilized, or rather exploited, does not correspond to the rate at which it is replenished [3],[4]. Groundwater beds get depleted as a consequence, which causes chaos during droughts and increases irrigation needs [5],[6]. Agriculture is a major component of India's economy. Farmers seek to meet the country's population's needs for food while also exporting excess to the global market. Borewells are excavated using high-grade PVC pipes to reach the aquifer where groundwater may be harvested to fulfil the rising demand for agriculture and drinking purposes.

A Problem Is a Large Number of Borewells

Borewells are methods of extracting water from the earth. The sole alternative for replenishing the depleted groundwater is precipitation, however, this natural process of rainwater seeping through fittings and cracks beneath the earth is a very sluggish one. According to research, barely 5–10% of seasonal precipitation seeps into the groundwater in hard-rock locations. Additionally, when there is insufficient rainfall, there is insufficient subterranean water renewal. Environmental and water conservationists collaborated and developed the Borewell recharging system. The plan was straightforward: create and use techniques for rainwater collection, then use borewells to send collected surface water directly into the aquifer.

Powering Up the Borewell

Technically, borewell recharge depends on the utilization of collected surface water (obtained from adjacent water bodies or via rainfall), when runoff water starts to travel through a built-in filter constructed of big and tiny stones. Water then travels through a further layer of sand before entering the borewell pipe via a fine mesh that has been wrapped around the drilled casing pipe. Before the water enters the borewell, the fine mesh guarantees that both large and small pollutants are removed.

Direct Recharge - In the direct recharge technique, the casing pipe of the tubewell is encircled by a percolation pit that is typically 10 feet by 10 feet in size. The holes in this casing pipe are then filled with nylon mesh after being perforated with a drill machine. The borewell is crossed by the water despite the mesh's ineffective assurance. The pre-cast RCC (Cement) rings are now positioned around the borewell casing so that the collected water will seep through them and into the nylon mesh of the casing pipe, where it will spread out via the mesh's holes. Filtering materials such as sand, gravel, crushed stone, jelly, and other similar substances are subsequently placed in the space that exists between the well's walls and rings. Rainwater is channelled into this well from a nearby water body, such as a catchment pond, where it is filtered before continuing to seep into the casing pipe and filling the bore well.Only when the borewell has gone dry or is producing very little water is direct borewell refilling advised. If there is excess surface water, it may even be recharged directly into a running borewell rather than being flushed down the drain and squandered. Although it is strongly advised against allowing unfiltered surface water to flow into the ground as this might pollute the water below or cause the aquifer to get clogged with contaminants like hazardous minerals like fluoride and chemical waste from industry.

Unreliable Recharge

- The following are some indirect recharging methods for borewells:
- The pit is excavated within a 20-foot radius of the casing pipe rather than around it, with a minimum space of 3 feet remaining between the recharge well and the borewell.
- Here, in indirect borewell recharge, the water travels through the earth, reaches the pipe, and then seeps in via nylon mesh and casing pipe holes, much like the direct borewell recharge technique, which also has holes covered with nylon mesh and the well is filled with filtering materials.
- For well-functioning borewells that haven't dried up yet, indirect recharge is the most effective method. In the event of dry seasons of the year, this will guarantee that surface water will always be available.
- The benefits of direct borewell recharge
- The direct borewell recharge method's sophisticated technology has made it possible to get groundwater of the appropriate quality that is suitable for drinking and agriculture. The following are some positive effects of this technique:
- There is a sizable store of water for sudden needs during the season's driest periods. Using this technique, borewells of any condition may be filled.
- The general public may easily comprehend this straightforward process for purifying surface water and moving it into the earth.
- If done carefully, it is environmentally beneficial.
- This method avoids negative social effects like population displacement or loss of agricultural land by harvesting rainwater, which is a pure form of water. It also minimizes water loss due to evaporation compared to other methods of storing surface water because of its close-knit design for collecting and transporting water to the basin.

Recharge Before Tackling the Borewell

Unquestionably, one of the finest projects of the 20th century was borewell recharge. Pre-recharging research is necessary to fully profit from this technique.

Management of Aquifers

Due to a lack of knowledge of the scientific properties of groundwater, certain public endeavors to recharge borewells are futile. One has to be aware of the potential of their groundwater aquifer before putting up with this technique. A scientific technique for figuring out the amount and quality of groundwater in a certain location is called aquifer mapping. The depth of recharge wells that may give the most recharge and use the most captured water can be determined with the aid of aquifer mapping.

- Calculating an aquifer's rate of recharge.
- This aids in determining the ideal quantity of recharge wells needed for a particular aquifer.
- Identifying the locations of natural recharge and discharge.
- Determining the duration and amount of water extraction.

Stream Contamination

Stream contamination has been elevated to a high priority due to unregulated effluents from urban and industrial regions. In particular, when adopting a direct borewell recharge approach, steps must be taken to guarantee that the collected water utilized to replenish the borewells is free of water contaminants. This is required to ensure that groundwater does not endanger people's health and the environment.

The Local Legal System

The legal guidelines established by federal or state authorities for the region where recharging is planned to be done must be studied and understood. This avoids unneeded disruption and resource waste brought on by disagreement.

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CHAPTER 3

GROUNDWATER STORAGE TANKS

Mr. Santhosh M B
Assistant Professor, Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- santhoshmb@presidencyuniversity.in

Eighty to ninety percent of the runoff produced during the monsoon is used to feed the rivers or rivulets on the Indian subcontinent [1],[2]. The main source of precipitation for groundwater recharge is also the monsoon [3],[4]. Except for the eastern coast, the nation experiences more than 75% of its annual rainfall during the monsoon season. Every year, there are between 12 and 100 rainy days, and between a few hours and more than 300 hours are covered in rain. In several areas of the nation, it is normal to see up to 60% of the average annual rainfall in a short period of a year [5],[6]. This causes excessive runoff and harms property, agriculture, and human life. Utilizing extra monsoon runoff in groundwater storage or reservoirs would not only boost water availability to satisfy rising water needs but will also aid in reducing flood damage. Technically viable options for storing excess monsoon runoff include subsurface reservoirs, which may hold large amounts of water. The subsurface geological formations might be thought of as a kind of "storage" for water that is collected from sources on the surface of the land. Favorable geological structures and physiographic units, whose size and shape will enable the retention of a significant volume of water in permeable or porous formations, are additional factors for developing subsurface storage in addition to adequate lithological conditions. For artificial recharge, subsurface reservoirs under favorable hydrogeological conditions will be both environmentally and financially sustainable.

The subsurface storages have the benefit of not being subject to negative impacts such as the flooding of a large surface area, the loss of arable land, the eviction of the local inhabitants, significant evaporation losses, and seismic sensitivity. To hold subsurface water, no enormous buildings are required. The current groundwater regime and abstraction structures are benefited from the subterranean storage of water as well. Many areas of the nation may see much deeper water levels as a consequence of natural occurrences or excessive groundwater development, which would lower lifting costs and save energy.

In brackish and saline environments, the quality of natural groundwater would significantly increase. Aquifers' ability to act as conduits may also aid in the natural subsurface transport of water to several needy areas, minimizing the need for an expensive surface water conveyance infrastructure. The effluence from such subsurface storage of different surface junction locations in the form of a spring line or stream emergence would improve the deteriorated ecosystem of riverine tracts, especially in the outfall zones, and would increase river flows. Small, reasonably priced structures, such as percolation tanks, check dams, surface spreading basins, pits, or subsurface dykes, are needed to stop surface runoff and recharge groundwater reservoirs. These structures may be built using local expertise.

Water Sources Are Accessible

One of the key requirements for groundwater recharge is the availability of source water, which is primarily measured in terms of excess monsoon runoff that has not been committed and is now being wasted. This element may be evaluated by looking at the variation in space and time of the monsoon rainfall pattern, as well as its frequency, the number of wet days, and the maximum amount of precipitation each day. Taking into account the fluctuations in rainfall patterns across time and geography, the uncommitted surplus would be defined as the committed water supply necessary for the existing water bodies and downstream rights.

Aspects of Hydrogeology

The location and the kind of recharge structure must be chosen with careful consideration of the local geological and hydrological conditions. Geological boundaries, hydraulic boundaries, inflow and outflow of waters, storage capacity, porosity, hydraulic conductivity, transmissivity, natural discharge of springs, water resources available for recharge, natural recharge, water balance, lithology, depth of the aquifer, and tectonic boundaries are some of the features, parameters, and data that should be taken into account. The thickness and lateral extension of the reservoir rock are two dimensions that must be known to evaluate the storage capacity of a subsurface reservoir. The amount of recharge is also governed by the availability of subsurface storage space and its capability for replenishment. It is necessary to evaluate the hydrogeological conditions in each location to determine how well the underlying hydrogeological formations can recharge. When determining the amount of water needed to increase subsurface storage by saturating the full thickness of the vadose zone to three meters below ground level, it is important to take into account the unsaturated thickness of rock formations that are found below that depth. Since it might have a negative influence on the ecosystem in terms of waterlogging, soil salinity, etc., the top 3 m of the unsaturated zone are not taken into consideration for recharging. The maximum saturation that formerly existed in a particular location may be estimated from the historical behavior of water levels, and the current endeavor should likewise strive to restore the maximum saturation for a certain hydrogeological setup. There are a few states, like Rajasthan, where the water level has historically been exceptionally deep. The saturation down to three meters below ground level is illogical, and states with undulating topography would have significant hydraulic gradients.

Impact Evaluation

Numerous sites of recharge and many points of outflow define the groundwater system. As a result of the natural flow pattern, which is determined by head difference, the groundwater system is dynamic and constantly changing. Therefore, the influence of artificial recharge techniques may not increase the water level since there is simultaneous addition to and removal from the groundwater system. As a result, the effects may also be seen in indirect effects other than an increase in water levels, as shown below.

- Ground water structures in the buildings' benefit zone become more durable
- Wells provide water during dry months.
- An increase in the number of pumping days or a long time of pumping.
- Less frequent pumping but the same command area
- Cropping practices in the benefiting zone might significantly alter.
- An increase in the area used by crops that need a lot of water
- Increased area with the same crop coverage
- Despite a monsoon failure, the area planted in crops has not changed.
- Due to an increase in soil moisture, green plant cover may rise in the zone of benefit and also along the edges of the buildings.
- Dilution might lead to an improvement in ground water quality.

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CHAPTER 4

ISSUES RELATED TO EXCESSIVE GROUNDWATER USE

Dr. Venkatesha Raju K
Associate Professor , Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- venkatesharaju.k@presidencyuniversity.in

A Decrease in the Level of Groundwater

The water table may drop as a result of excessive groundwater pumping, which is the most serious consequence. Water must be pumped from a well that extends below the water table to be extracted from the aquifers. If groundwater levels drop too low, the good owner may need to build a new well, deepen the existing well, or at the least, lower the pump below the water table. Additionally, when water levels drop, the well's capacity for producing water may also decline [1], [2].

The Consumer Will Pay More Money

The water must be hoisted from the depth of the groundwater to the ground surface as the groundwater depth rises. More electrical energy is needed to run water pumps if they are utilized to elevate the water. In this circumstance, utilizing the well may cost consumers money [1],[3].

Less Water Is Now Available In Water Bodies

Contrary to popular belief, there may be greater contact between groundwater and surface water in bodies of water like ponds, lakes, rivers, and streams. Seepage from the streambed to groundwater contributed to a percentage of the water flowing in rivers. Groundwater contribution is primarily influenced by physiographic, topographical, soil, geological, and climatic factors [4], [5].

Land Subsidence

Lack of support under the ground surface is the main factor contributing to land subsidence. When groundwater is overused, the soil may sometimes collapse, compress, and sink. This is dependent on several variables, including the kind of soil, soil compressibility, aquifer characteristics, water table levels, and earth geology. Most often, human activities, particularly excessive subsurface water withdrawal, are to blame [6].

Decline in Water Quality

The main reason for and danger to the pollution of fresh groundwater resources is saltwater intrusion. A large portion of the extremely deep groundwater and water below the oceans is salty, thus the water that is available in the aquifers is not fresh. Under normal circumstances, the line between freshwater and saltwater tends to be fairly stable, but under circumstances of excessive pumping, saltwater may move inland and rise higher, contaminating the water supply.

Advantages of Groundwater Replenishment

The following benefits of replenishing groundwater aquifers artificially:

1. Free subsurface storage space is available, and flooding is prevented.
2. Temperature differences are minimal and evaporation losses are insignificant.
3. Enhancing quality by penetration through a porous medium.
4. It has no negative societal effects, such as population relocation or the loss of limited agricultural land.
5. It is an environmentally friendly technique that prevents problems like flooding and soil erosion while also maintaining enough soil moisture in times of drought.
6. Natural and man-made disasters have little effect on the water that is held in the soil profile.

Blatant surface methods

The most popular and easiest form of groundwater recharge is this one. With this technique, surface water that has been held is transferred straight into an aquifer without any infiltration, and water spontaneously percolates via the unsaturated zones of the soil profile.

Flooding/Spreading Water

- This is a highly popular technique for recharging groundwater.
- This technique works well with mostly flat terrain.
- A thin sheet of water is stretched out.
- More vertical infiltration occurs at a higher pace.

The country's alluvial region is a potential use for this technology. The use of artificial groundwater recharge is an outstanding technique that can raise the groundwater table and make more groundwater available.

It is crucial for reducing surface runoff, increasing water availability for home and industrial use, improving drainage, reviving springs, and improving the quality of groundwater, among other things. Additionally, it is thought to lessen the effects of changing rainfall patterns caused by various meteorological conditions. Additionally, it is crucial to fulfilling regional and global demands for spatial water production and availability.

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CHAPTER 5

SYSTEMS FOR HARVESTING RAINWATER AND THEIR FEATURES

Dr. Chandankeri Ganapathi Gurlingappa
Professor, Department of Civil Engineering
Presidency University, Bangalore, India
Email Id- chandankeri@presidencyuniversity.in

A straightforward method for capturing and storing rainwater where it falls is called rainwater harvesting. Depending on the environment and the need, we may either utilize it to replenish groundwater or store it in tanks [1],[2].

- Quicker and easier system construction.
- Economically more affordable to build than other sources, like dams, diverts, etc. In places with insufficient surface resources or groundwater supplies, rainwater collection is the best solution.
- Reduces the pressure on treatment facilities by assisting in using the main water supply and preventing runoff from entering sewers or storm drains.
- Recharging aquifers with water helps dilute and improve the quality of existing groundwater.

Rainwater Harvesting System Parts

A rainwater harvesting system consists of parts for filtering, moving rainwater via pipes or drains, and storing collected water in tanks. The typical parts of a rainwater collection system are

Catchments

A catchment area refers to the region that immediately gathers rainwater and supplies water to the system. It may be a paved area, such as a building's terrace or courtyard, or an unpaved area, such as a lawn or open space. Water harvesting may also be done on a roof consisting of reinforced cement concrete (RCC), galvanized iron, or corrugated sheets [3], [4].

- *Coarse Mesh:* It blocks the flow of debris that is present in the roof.
- *Gutters:* A sloping roof's edge is surrounded by channels that catch and transmit rainwater.

Rainfall to the Holding Container

Gutters are often constructed locally from basic galvanized iron sheets and might be semi-circular or rectangular. Gutters must be supported so that when they are filled with water, they do not droop or fall off. The architecture of the house determines how gutters are attached; typically, iron or wood brackets are fastened to the walls.

Conduits

Rainwater is moved from catchments or rooftop areas to collecting systems through pipes or drains known as conduits. Frequently bought conduits are made of materials like polyvinyl chloride (PVC) or galvanized iron (GI).

First-Flushing

- A first flush device is a valve that ensures the initial flush gets flushed out.
- Avoid the storage tank during the rainy season as it tends to transport additional impurities from the air or catchment surface.

Filters

Rainwater collected from rooftops is filtered to eliminate suspended impurities. The many kinds of filters that are often used for commercial purposes include slow-sand filters, horizontal roughing filters, charcoal water filters, and sand filters.

Storage facility: There are many possibilities available for building these tanks in terms of their design, size, construction materials, and placement, and they are:

- Shapes include squares, rectangles, and cylinders.
- Construction materials include masonry, Ferro cement, reinforced cement concrete (RCC), and others.
- Depending on the amount of available land area, these tanks may be built above ground, partially underground, or completely underground. To guarantee the quality of the water held in the container, several upkeep procedures like cleaning or disinfection are necessary.

Rebuilding Structures

Through appropriate structures like drilled wells, bore wells, recharge trenches, and recharge pits, rainwater collected may also be utilized to top up groundwater aquifers [5], [6]. Several different recharge structures may be used; some encourage the percolation of water through soil layers at shorter depths (such as recharge trenches and permeable pavements), while others carry water to deeper levels from where it joins the groundwater (e.g. recharge wells). Existing buildings like wells, pits, and tanks may often be converted to serve as recharge structures, negating the need to build any new ones. Recharging of dug wells and abandoned tube wells, settlement tanks, recharging of service tube wells, soak ways/percolation pits, recharge pits, recharge troughs, recharge trenches, and modified injection well are a few of the few frequently used recharging techniques.

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CHAPTER 6

BOREWELL RECHARGING TECHNIQUES

Mr. Bhavan Kumar Mukrambhi
Assistant Professor, Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- bhavankumar.m@presidencyuniversity.in

Farmers in India often use one of two types of borewell recharging techniques. As follows:

Direct Recharge

In a direct recharge approach, borewell services create a percolation hole 10 feet by 10 feet in size. A tubewell casing pipe is formed around it, and then holes or perforations are produced using drilling equipment [1],[2]. Nylon mesh covering these holes makes sure that only water may get through them. To make sure that the collected water seeps into the nylon mesh, pre-cast RCC cement rings are placed around the casing. Materials including gravel, sand, broken stone and jelly fill the space between the well's rings and walls [3], [4]. This technique involves directing rainfall from catchment ponds into the well, where it is filtered and continues to seep into the casing to rehydrate the borewell. When the borewell merely supplies less water or has dried out, a direct borewell recharge is the best option. The fact that most of their places are dry from the heat makes it ideal for digging a borewell in Paripoorna Hostel In certain cases, a direct recharge mechanism may be installed even in a working borewell. It avoids wasting water by collecting extra surface water. Direct borewell recharge prevents unfiltered surface water from reaching the aquifers or from blocking them with hazardous contaminants, protecting groundwater pollution [5], [6].

Indirect Recharge

Instead of just constructing a hole around the casting, an indirect borewell recharge technique involves digging the pit 3 feet away from the borewell within a 20-foot radius. The subsequent steps are carried out following the direct recharge approach. A nylon mesh covering and holes are used to make the casing pipe. The well is filled with filtering elements to enable water to infiltrate and remove chunk pollutants. Groundwater permeates the pipe, seeps through nylon mesh, and drains into the casing holes. For well-performing borewells, an indirect recharge technique is recommended to guarantee a constant supply of surface water even during dry seasons. Any Paripoorna house repair firm can install it since the procedure is not too difficult.

Climate Change Caused By Global Warming

The environment and ecosystem are facing several issues as a result of climate change. Its effects on groundwater are seldom mentioned, however. The groundwater is indirectly impacted by recognized effects of climate change, such as floods and extended droughts. Long-term drought will lead people to over-extract groundwater, thus reducing the availability of water. Floods and other indirect effects of climate change, such as changes in land use patterns, may cause an uptick in human activity, which will raise groundwater demand.

Excessive Urbanization

Groundwater quality is impacted by rapid urbanization or population increase inside a city because of the surge of toxins coming from industry. Considering all of these aspects and the current groundwater situation, it is essential to take significant action to manage groundwater as well as its resources effectively on both the individual and statutory levels.

Borewell Recharge Technology's Advantages

Due to the harsh weather conditions and constant use, the majority of borewells have recently ceased functioning. All residential service providers may install the revolutionary borewell recharge technology to replenish the ground table with enough rainfall. Below are a few of its advantages:

- When rainwater harvesting is correctly handled, the water level is raised and it works excellently even for dried-out borewells.
- The mechanism used by borewell recharge technology has been well-tested and just requires a few easy procedures.
- The water quality rises as a result of natural filtering processes. Hardness, contaminants, and harmful elements like fluorides are greatly reduced.
- Given that all that is needed to put it up are natural resources, it is an economical solution that is very accessible to everyone.
- A refilled borewell will never run out of water. As a result, it is a long-term solution that is continually refilled with rainwater.
- It may be completely altered to fit the site's and the land's needs.
- The future for us is a borewell recharge technology, which is an environmentally favorable choice.

For irrigation and drinking, the direct recharge borewell recharging technique is the preferred choice. Due to its ability to provide water throughout the driest seasons of the year, it is put in several locations. Even the average man may easily comprehend how the direct recharge borewell works. Most significantly, this approach stops all types of negative societal effects, such as population decrease and the loss of agricultural land. With the greatest knitting design, any household service may set up a direct recharge borewell that minimizes water loss due to evaporation. Water may be collected and transported in large amounts using a direct recharge technique.

Water continuously evaporates from the seas and other open water bodies, travels over the land as water vapor in clouds, doubles down on the land as rain and snow, but then travels back via rivers and subterranean channels to the oceans to begin the cycle the hydrologic cycle again. A portion of the water that evaporates from the land is returned to the atmosphere by plant transpiration or soil evaporation. Another portion travels overland to reach lakes, stream channels, or the ocean. The remaining water is carried into the groundwater system by gravity-driven seepage through the soil. Once in the groundwater system, the water travels slowly until it reenters the surface phase of the cycle in reaction to hydraulic gradients or groundwater slopes.

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CHAPTER 7

INTRODUCTION TO PORTABLE WATER

Dr. Chandankeri Ganapathi Gurlingappa
Professor, Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id-chandankeri@presidencyuniversity.in

Water is the one of the basic needs and is required by all life on earth. It dominates most of the space on our planet, covering about 71% of the total surface area of earth [1],[2]. Hydrology is the study of the distribution, availability, consumption, and movement of ground water. Water exists in all three of its states, namely, solid (ice), liquid, gas (stream) explaining the importance of understanding the science and structure of water. Freshwater is a critical resource for the people of the Asian and pacific region [3],[4]. The abstraction of freshwater from river, lakes and underground reservoirs is increasing in line with population growth, urbanization, and economic expansion [5],[6]. The increasing abstraction is causing a growing imbalance between supply and demand that has already led to shortages and depletion of reserves. Moreover, the scarcity of water is being accompanied by deterioration in the quality of available water due to pollution and environmental degradation.

A sufficient food supply and a productive environment are essential for all living things, and water and water resources play a major role in these goals. The need for freshwater worldwide has been rising quickly as human populations and economies expand. Water scarcities also pose a danger to the availability of food for people and significantly lower biodiversity in both aquatic and terrestrial ecosystems. 1 Widespread water stress is being experienced in many nations as a result of the adverse consequences of the global population growth, the implications of climate change, and lifestyle changes. Thus, the pressing necessity for water conservation is becoming more and more apparent. Due to its significant impact on societal health and living standards, water is necessary for life. The distribution of water, nevertheless, varies greatly over the globe. To support essential human functions including nourishment, respiration, circulation, excretion, and reproduction, water is a crucially necessary chemical that is needed. A living space as well as one of the fundamental elements in the creation of a life environment, water is also.

When the planet receives rain, hail, or snow, the sun's heat forces water to evaporate, forming clouds of evaporating water droplets that fall to the ground and support ongoing life. The water cycle includes evaporation, precipitation, and sweating; it involves plants absorbing water from the soil and releasing a portion of it back into the atmosphere via transpiration.

The presence of water is one of the primary characteristics that sets our planet apart from other worlds. The construction of civilizations throughout history has been largely dependent on water, which has also played a major role in defining where people live. Air, sea, land, rivers, lakes, and seas are all sources of water in the globe. The hydrological cycle causes water in the atmosphere to migrate from the earth to the atmosphere, whilst subsurface waters make up the water on the land. 2 The human body is mostly constituted of water, which makes up three-quarters of our planet. Water is essential for all living things, and some of its key roles in the human body are as follows: it is a biological solvent that facilitates the transport and dissolution of vitamins and minerals in the body; it is crucial for controlling body temperature; it facilitates the function of the kidneys and other organs; it protects and acts as a cushion; it is essential for moisturising the skin; it removes toxins from the body; it is essential for cleansing the body; it is essential for maintaining body temperature; In addition to all of these functions, water is essential for executing many other key processes including circulation, excretion, and reproduction. Between 80 and 90 percent of our blood and 75 percent of our muscles are formed of water.

We experience discomfort if we are dehydrated, even for a brief period of time, since water is a necessary component of life. We start to appreciate how valuable water is when we lose extremely significant gifts, like the water we now have.

As a result of human activity, the concentrations of the substances in the natural composition of water resources (such as streams, groundwater, lakes, and seas, for example) rise above the ideal concentration levels. This degradation of the natural composition of water resources is referred to as water pollution. Water resources are necessary for the ecological, development of the economy, and continuation of life. This important natural resource is the one that is most vulnerable to environmental pollution and is also the one that is most adversely affected by it. To be fit for human consumption, water must be clean, have the correct balance of minerals and oxygen, and adhere to a number of other standards. When one litre of effluent contaminates and makes unusable eight litres of potable water, it becomes more obvious how badly the ecosystem's natural water cycle is threatened. When one takes into account the fact that there are now 1.4 billion healthy people without access to clean water, it becomes more apparent how serious the issue is. The main cause of the pollution of rivers, lakes, groundwater, and the seas is human activity; as a consequence, the natural ecological balance is compromised. The main pollutants found in water are acids and alkalis, detergents, household wastes and fertilisers, food industry wastes, various gases, heat, various metals, minerals, oils and dispersants, organic hazardous wastes, pathogens, and pesticides.

Not only does water pollution harm the water, but it also has an influence on the soil and, via irrigation, plants, vegetables, and fruits. The hazardous wastes are also exposed to animals via the polluted water, which has a negative impact on the long-term viability of food sources. "Use of bad-quality water; diseases brought on by water on living things; low productivity in agricultural activities; extinction of biodiversity in the aquatic environment; death; and rises in drinking and utility water treatment costs." The continuance of life depends heavily on water. In order to survive, we need water. Each and every action that is made on the water, therefore, must be essential. It is of utmost significance. In our view, man is at the core of the natural world. We are unable to discuss issues like the separation of man from nature, however. A person may have a livable environment if he or she has moral and ethical principles, respects the lives of other creatures, and behaves in a manner that upholds their right to life. Actually, the greatest polluting group in the world is made up of people.

The locations and resources that are used by everyone equally are those that are most severely impacted by pollution. The evaluation of water as a full medium may provide unfavourable outcomes due to the world's finite water supplies and the risky condition it is in.

For humans as well as all other living things, water is a need. The need for water, whose utilisation regions are rising as living circumstances change, is growing every day.

Importance of water:

- Man and animals consume water, also they consume vegetation for their food. Plants cannot grow without water
- The growth of vegetation also depends upon bacterial action, while bacteria need water to thrive.
- Good sanitation cannot be maintained without an adequate water supply system.
- Humans need water for drinking, cooking, cleaning, and washing.
- Water keeps an ecological balance.
- For balancing the relation between living things and the environment in which they live.

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CHAPTER 8

PORTABLE WATER AND WHOLESOME WATER

Mr. Santhosh M B
Assistant Professor, Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- santhoshmb@presidencyuniversity.in

Portable water is water safe enough to be consumed by humans or used with a low risk of immediate or long-term harm. Surface water and groundwater are both sources of drinkable water, sometimes known as drinking water [1],[2]. This water has received the appropriate treatment to the amount needed by state and federal standards. The two primary methods for converting wastewater into drinking water are indirect potable reuse (IPR) and direct potable reuse (DPR) [3],[4].

Pathogens and chemical contaminants must be closely monitored in potable reuse due to their higher concentrations in source water [5],[6]. In the past, people used to keep their water in clay pots to keep it clean and cold as well as in metal containers for a healthy living. People then started using filters, and now is the age of water purifiers. However, "potable drinking water" is still difficult to get in many parts of the world. In many small towns, the ladies in rural areas must travel an average of 25 kilometres or more to get potable water. In less developed countries like Africa, finding a safe drinking water source is quite difficult. Now the question of what exactly constitutes "potability" or "potable water" is raised.

Potable water is defined as water that can be used for drinking and preparing meals. Ultimately, when it has been fully filtered and cleansed, the contaminants and harmful microbes are eliminated. Reverse osmosis and UV filtered water purifiers are only two of the many methods available to clean water. Can we consider the potable water given by the plant to be drinkable? Is the water really contaminant-free?

Groundwater, rivers, and lakes are often the source of raw water, which is described as water that is unsuitable for consumption. Since industrial water cannot be considered as drinkable, the majority of Indian houses choose to boil the water before using it. Although the non-potable water may taste normal and similar to potable water, it may be harmful to your health. We'll now discuss several approaches to water treatment. The World Health Organization (WHO) categorises contaminants in drinkable water as organic, inorganic, radiological, and microbiological. It also provides standards for acceptable taste, smell, and appearance. Chemicals with a carbon base, such as insecticides and solvents, are referred to as organic pollutants and are introduced into waterways by industrial or agricultural runoff. They are capable of causing a variety of serious health issues, such as cancer and disruptions in endocrine function.

Radon, cesium, plutonium, and uranium are some examples of radiological dangers. Radon is the most common environmental cause of cancer death in North America and the main contributor to lung cancer among nonsmokers. There are persistent inorganic contaminants in the environment, including metals, cyanides, sulphates, and mineral acids. In addition to bio-accumulating in certain foods, heavy metals may cause neurological issues in people, particularly in the unborn and young. Arsenic may lead to cancer, skin blemishes, cardiovascular disease, diabetes, and cognitive decline. Cyanotoxins may also be introduced to drinking water by algae blooms caused by fertilisers like phosphorous and nitrogen.

A variety of illnesses, from mild gastroenteritis to potentially fatal diarrhoea, dysentery, hepatitis, typhoid fever, cholera, and cryptosporidiosis, can be brought on by waterborne pathogens, which include bacteria, viruses, protozoa, and parasites. These pathogens are typically introduced to water via faeces. Additionally, millions of people have waterborne tropical illnesses like trachoma, which is the most prevalent cause of avoidable blindness.

Wholesome Water: Wholesome water is pure water that does not contain any impurities. It only contains two- part of Hydrogen and Oxygen by Volume. Wholesome water is not found in water. Because water found in Nature contains many impurities such as Dust particles, Gases. Even rainwater is not included in wholesome water because it also absorbs various gases, dust, and other impurities. When flowing in the ground it carries silt, sand, and other dust particles. The removal of the turbidity, odor and smell is taken as good, and removal of dissolved substances is known as “chemical pure”. Chemically pure water is also corrosive but not wholesome water.

When water satisfies the conditions set out in regulations adopted under to Section 67 (Standards of Wholesomeness) of the Water Act 1991, it is said to be "wholesome" and safe for use in drinking, cooking, food preparation, and washing. These set out the standards that the water must follow in order to safeguard the public's long-term health. Limitations on these variables include:

- biological quality (including levels of bacteria and oocysts)
- chemical quality (including levels of metals, solvents, pesticides and hydrocarbons)
- Physical qualities (including colour, taste and odour).

Ion exchange water softeners may raise sodium levels over the legal limit for healthy water (200 mg Na/litre) in places with very hard water. This water shouldn't be used for drinking or food preparation since it might have negative health effects on young children, low-salt dieters, and those with other medical issues. However, G1 views softened wholesome water as an acceptable substitute for wholesome water when it comes to washing (including in washbasins, baths, showers, and bidets) and flushing toilets and urinals. This is in line with the Water Regulations Guide's recommendation that a water softener be installed after the draw-off to a drinking water faucet.

Water that is less than wholesome may be utilised for various tasks, such flushing the toilet. The water's final use determines the quality that may be utilised, thus the suitable quality must be determined based on risk. For instance, water used for flushing toilets may be of relatively low quality since there is little chance of a person coming into touch with it and because the water in the toilet bowl is already polluted. Similar to this, the water quality used to irrigate a garden with a watering can does not need to be of a high standard, but it should be taken into account when plants for human food are produced. On the other hand, water that could potentially come into contact with people directly or as an aerosol presents a higher risk and must, therefore, be of higher quality. For instance, water delivered by high-pressure hoses used for car washing will emit an aerosol and, in addition to potentially contaminating people, will also pose a significant risk of Legionella. It should be mentioned that bigger systems should integrate more protection than those for single residences since they have the ability to influence the health of a larger number of individuals.

The following are the requirements of wholesome water.

- It should be free from all types of bacteria.
- It should be colorless and sparkling.
- It should tasty, odor-free, and cool.
- It should not contain objectionable matters.
- It should not corrode pipes.
- It should have dissolved oxygen and be free from carbonic acid so that it may remain fresh.

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CHAPTER 9

SOURCE OF WATER

Mrs. Shwetha A
Assistant Professor, Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- shwetha.a@presidencyuniversity.in

For different water supply components, design flows, design times, and design population are variables impacting water demand and design capacity [1],[2].Demand for water is important.The following factors must be considered when creating a water supply plan for a specific area of the community:

- An assessment of the quantity of water that is available.
- The amount of water that the public needs (more important).

Surface water resources include streams, rivers, lakes, wetlands, reservoirs, and creeks. Surface water is any body of water that is above earth. Even though it contains saltwater, the ocean is regarded as surface water [3],[4]. The hydrologic cycle, sometimes known as the water cycle, includes the transfer of water to and from the earth's surface [5],[6]. Surface water takes part in this process. Surface water bodies are nourished by precipitation and water runoff. On the other side, aquatic bodies lose water due to evaporation and seepage of water into the earth.

Groundwater Resources: Groundwater is a source of water that is made up of surface water that has absorbed into the ground or rainfall that has fallen on it. The fact that groundwater can no longer go downhill once it has soaked into the earth and instead begins to move horizontally beneath the ground shows that it is not static. The level under the earth where a pool of water collects is known as the "water level," which is characterised by saturation and horizontal movement.

Groundwater: The water table has been rapidly declining, stream base flows have stopped, a significant number of open wells and drilled bore wells have dried up, and other warning signs have been provided by nature. Up until recently, subterranean water had been considered a valuable resource that could be used when all other water sources had run dry. The situation has changed. The careless manner in which loans are being given to drill an increasing number of wells, drill further into the earth, and withdraw water without stopping for the operation of industries, the construction of swimming pools, and the growth of crops like sugarcane that require enormous amounts of water, demonstrates gross abuse.

There has already been significant harm done, and additional misuse of this resource will lead to a water catastrophe. The inhabitants of rural India used to build tanks and wells to meet their own needs for drinking water, and they also took care to maintain these facilities. 9 This previous system of a self-sufficient economy has been replaced by a total reliance on the government, even to provide for necessities like drinking water understanding that, despite periodic recharge, ground water is a finite resource and should be used with caution. The issue of restoring sustainable yield cannot be solved by randomly digging bore wells. For humans and other living forms, access to clean drinking water is crucial. Over the last several decades, practically everyone in the globe has seen a steady and significant improvement in access to clean drinking water. However, according to some analysts, by 2025, more than half of the world's population would be vulnerable to water-related threats. According to a recent research, by 2030, water demand in certain emerging parts of the globe would be 50% higher than availability. Since it can be used as a solvent for a variety of compounds and makes industrial cooling and transportation easier, water is crucial to the global economy. Agriculture uses over 70% of the fresh water that is available.

The majority of fresh water on Earth is located in oceans and other big bodies of water, while 1.6% is found underground in aquifers and 0.001% is present in the atmosphere as vapour, clouds, and precipitation. 97% of surface water is contained in oceans. About 2.4% of the area is covered by glaciers and polar ice caps, whereas 0.6% is covered by other land surface water such rivers, lakes, and ponds. Living things and manmade items contain a relatively tiny portion of the earth's water. Water on Earth circulates continually via a cycle of evaporation, transpiration (evapo-transpiration), precipitation, and runoff before typically reaching the sea. Evaporation and transpiration on land contribute to precipitation there.

Just Rajasthan has more dry land agricultural land in the nation than Karnataka, a state with a severe water shortage, and only 27% of its arable land is irrigated. In order to increase the efficiency of water consumption and, eventually, the yield and productivity of crops, micro irrigation systems are encouraged to be used on more than 55% of the irrigated area. Despite its scarcity, the community's farming is not taking use of this resource due to a number of deficiencies.

Resources for Surface Water: Surface water is the liquid that is present in lakes and streams. This water is mainly utilised for hydroelectric power generation, recreation, irrigation, industry, transportation, and cattle. Surface water is used to provide more than 63% of the public water supply. Surface water supplies 58 percent of the water used for irrigation. Surface water systems provide over 98 percent of the water used by industry. Therefore, maintaining the quality and conservation of surface water is crucial.

The stream flow and water quality of the surface are continually measured by watershed organisations. In order to alert of floods and drought situations, stream flow is monitored. Given that surface water makes up the bulk of the water consumed in the United States, water quality is crucial. It gauges the water's suitability from a biological, chemical, and physical standpoint. Electrical conductivity, pH, temperature, phosphorus levels, dissolved oxygen levels, nitrogen levels, and bacteria levels are examined as indicators of water quality. Water quality may be severely influenced by both natural and human sources.

Sediment, trash, and pathogens may all naturally be carried by water that drains into the stream. The amount of suspended particles in a stream is measured by turbidity, which is also a gauge of water quality. The water quality decreases with increasing turbidity.

The quality of neighbouring waters may be negatively impacted by man-made toxins including gasoline, solvents, pesticides, and nitrogen from livestock that can wash over the land and drain into streams. The United States' Clean Water Act safeguards the stream's quality and imposes sanctions on anyone responsible for the decline in water quality. A stronger assurance of future water supplies for human use may be achieved by safeguarding and preserving the water supply.

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CHAPTER 10

WATER DEMAND

Mr. Bhavan Kumar Mukrambhi
Assistant Professor, Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- bhavankumar.m@presidencyuniversity.in

As the foundation for all subsequent processes, accurately defining the need from the outset is the most crucial and delicate aspect of the design [1],[2]. It is crucial to take your time and avoid rushing through it in order to: create a suitable design for the current population so that it is affordable to maintain and run; maintain a high standard of water; and have the flexibility to expand it in the future to meet a higher demand [3],[4].

To identify customs, special requirements, and rational future planning, it is necessary to have a thorough understanding of the geographical situation of the project region (as shown by satellite images), as well as to have several conversations with authorities, technical services, and users [5],[6].

Depending on how difficult the case is, the following stages must be followed more or less closely:

1) Identify the important kinds of requirements that the system connections must meet, such as residential connections, public building connections, irrigation, and street fountain connections.

2) Calculate the anticipated leakages and assess the average daily consumption of the needs.

3) Establish the current user count, the project's lifespan, and, in turn, the maximum user count. If required, specify a maximum user population and life duration for each component of the system (when the rise becomes too great).

4) For each category of demands, specify the daily pattern as well as seasonal change on a short- and long-term basis.

5) Describe the kinds of water points that are linked to the system, including the pressure and flow rates that are anticipated.

6) To find the users and the water stations, map the project area. As much as feasible, the distribution zone of the current or proposed water network must coincide with the zone that divides urban areas according to important categories and comparable qualities (population density). Give a description of each zone's dimensions (in hectares), current population, and anticipated dispersion locations. Following that, a projection for the project's lifespan should be made, and its results should be verified against the population density.

Demand categories

The most important forms of demand need to be identified in order to create a realistic system model. Typically, a client type with particular wants is associated with these sorts of demands. Leakages might be classified as a particular kind of demand or they can be a part of the demand patterns for each location. The following succinct description includes the major categories of requests and their specification:

Household connection: This is a direct water connection to a household's water network. It is thus expected that the populace may have immediate access to water whenever they want it, with typical peaks at certain times. It is essential to know whether there is a water metre, break pressure valve, or storage tank in order to describe the demand per capita and its pattern. The quantity and quality of taps, as well as the existence of a garden, may also have a big impact.

Public watering hole (also called tap stands or stand post) People must use jerrycans or buckets to get water in this situation since the distribution station is open to the public. The distance from their home, their mode of transportation, and the availability of a free alternative water supply (a river for washing) may all have a big influence on the amount of water gathered. The pattern could be very flat during the day and nonexistent at night, with the exception of leakages, if there are few spots available and people are waiting in line.

Special consumers like schools, hospitals, health facilities, military bases, or industrial complexes: These special consumers should only be utilised when they have a substantial water demand. They may be categorised as a typical customer if they are little (like a household). If there is a substantial demand, the amount and use pattern of water become quite specialised and must be determined case by case.

Irrigation: In certain instances, water from a piped network is utilised to irrigate a garden, orchard, or greenhouse. Then, it will depend on the region, the kinds of crops, and the weather, which may change significantly over the year. The water moves continuously for a few hours, thus the pattern is often rather flat.

Deficiencies and leaks Losses are the difference between what is generated and what is received (the water that can be "counted"); they often include of leaks, but they may also include public services (fountains, water gardens, fire-fighters), non-paying customers (illegal connections), and metering errors. Leakages come in two varieties: those that occur in the network and those that occur at the taps. The one in the network is often found where pipes link and is brought on by soil movement, improper compaction, and subpar fittings. If the soil is impermeable, water will leak from the ground, and if the road isn't paved, it will be easily discovered and hopefully fixed. Contrarily, it will be more challenging to locate them in porous soil (sand, limestone), hence a larger leakage rate might be anticipated. Additionally, networks built with fragile pipes like asbestos cement, GRP, or PVC are more prone to leaks. In addition, the ratio of water losses to delivered water will be higher the longer the network per user is, or more particularly, the lower the ratio of water demand to metres of pipe. As a result, a small network constructed with PE on clay-like ground may be anticipated to have no more than 5% leaks, as opposed to a large water network constructed with PVC pipes in a limestone region that is prone to earthquakes, where one can readily anticipate at least 20% leakages. Taps or float valves that leak are the second sort of leakage (like in flush toilets tank).

From 50 to 200 litres per day may easily be lost due to a decent drop-by-drop leak in a tap. Up to 10% of the taps and valves may be defective, depending on their quality. This type of leakage is primarily dependent on the quantity, quality, and rate of use of the taps and valves; a tap used for 12 hours per day will leak for only 12 more hours, while a tap used for only one hour per day will leak for 23 more hours. It should be noted that this second kind of leakage may not be regarded as a loss since it occurs at the user point, often after the water metre. Observing the consumption at night is a straightforward approach to gauge the extent of leaks, although this method may overstate leaks since pressure is greater at night than it is during the day.

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CHAPTER 11

WATER POLLUTION

Dr. Venkatesha Raju K
Associate Professor (Selection Grade) Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- venkatesharaju.k@presidencyuniversity.in

Simply speaking, water pollution is the contamination of water bodies. It involves the improper usage of waterbodies including reservoirs, lakes, ponds, rivers, and oceans. When contaminants are discharged into water, the water is often harmed. Both direct and indirect releases of pollutants are possible [1],[2]. A horrific problem called water pollution has the power to endanger the whole world. Since water is a natural solvent, most pollutants may easily dissolve in it and contaminate it. Along with other animals and plants, amphibians and other aquatic life are adversely impacted by water pollution. Numerous people die each day as a result of the polluted and infected water [3],[4]. Both natural and manmade activities have the potential to taint water. Volcanic eruptions, earthquakes, tsunamis, and other natural calamities are known to change and pollute water, which has an effect on aquatic ecosystems [5],[6].

Groundwater pollution: Groundwater is one of our most vital yet obscure natural resources. Rain turns into ground water when it penetrates into the interior of the earth, filling up aquifers, which are underground water reservoirs, with their contents. Then, groundwater is pumped to the earth's surface to supply drinking water. Groundwater gets polluted when contaminants from septic tanks and landfills, such as fertilisers, pesticides, and rubbish, flow into aquifers. An polluted aquifer may be rendered worthless for hundreds or even thousands of years and is no longer safe for human usage. Furthermore, toxins may be dispersed far from the original polluting source when groundwater seeps into streams, lakes, and oceans.

Surface Water: Our oceans, lakes, and rivers, as well as all the blue areas visible on a map of the world, are all made up of surface water, which accounts for around 70% of the earth's surface. Surface water from freshwater sources outside the sea makes up more than 60% of the water delivered to our homes. According to the Environmental Protection Agency of the United States, more than one-third of our lakes and almost 50% of our rivers and streams are filthy and unsafe for swimming, fishing, or drinking.

Nutrient pollution, which includes nitrates and phosphates that are essential for plants and animals to flourish, produces major contamination in fresh water sources as a result of agricultural waste and fertiliser runoff. Municipal, industrial, and individual trash dumpers that dump their rubbish into rivers all emit toxins into the environment.Ocean water

No matter how far inland or how close to the shore, land is where 80% of ocean pollution, also known as marine pollution, comes from. A variety of pollutants, including pesticides, fertilisers, and heavy metals, are transported from farms, industries, and towns via streams and rivers into our bays and estuaries, where they are then transported out to sea. While this is going on, maritime debris, especially plastic, is being swept in by the wind or entering via storm drains and sewers. Occasionally, both large and little oil spills and leaks pollute our waters, which are also continuously absorbing carbon pollution from the atmosphere. A 25% of the carbon emissions caused by humans are absorbed by the ocean.

Point source: It is referred to as point source pollution when contamination comes from a single source. Examples include wastewater (also known as effluent) released legally or illegally by a company, an oil refinery, or a wastewater treatment facility, as well as pollution from leaky septic systems, chemical and oil spills, and unlawful dumping. Limits on what may be released by a plant into a body of water are one way that the EPA controls point source pollution. Despite coming from a single location, point source pollution may have an impact on kilometres of rivers and the ocean.

Nonpoint source: Contamination that originates from dispersed sources is referred to as nonpoint source pollution. These might consist of waste that has been blown into rivers from land or runoff from agriculture or storm drains. Since there is no one, clearly identified source of nonpoint source pollution, it is difficult to control. Nonpoint source pollution is the main cause of water contamination in U.S. waterways.

Transboundary: Naturally, a line on a map cannot be used to limit water contamination. Water contamination caused by overflowing from one nation into another's waterways is known as transboundary pollution. Oil spills and other natural disasters as well as the gradual, downriver creep of industrial, agricultural, or municipal discharge may also cause contamination.

The agricultural sector is not only the biggest consumer of freshwater resources but also a major environmental polluter, using more than 70% of the world's surface water for farming and animal production. Globally, agriculture is the leading cause of water degradation. In the United States, agricultural pollution ranks first among causes of contamination in wetlands, second among causes in rivers and streams, and third among causes of contamination in lakes. Groundwater and estuaries are extensively contaminated as a result of it. When it rains, nutrients and pathogens, such as bacteria and viruses, from farms, livestock operations, pesticides, fertilisers, and animal waste are carried into our waterways. One of the primary contributors to nutrient pollution, which is caused by excessive nitrogen and phosphorus in the water or air, are algal blooms, a toxic soup of blue-green algae that may be harmful to people and animals. The greatest danger to the quality of the world's water is this.

Reclaimed water comes from waste. When you hear the phrase "it begins from our sinks, showers, and toilets," together with "it originates from commercial, industrial, and agricultural activities," think sewage (think metals, solvents, and toxic sludge). The expression also describes stormwater runoff, which occurs when rainstorm sweeps chemicals, oil, grease, and other materials from impermeable surfaces into our waterways.The United Nations estimates that over 80% of wastewater worldwide is released back into the environment without being cleansed or used for other purposes; in some of the least developed countries, this number is much higher, at over 95%. In the US, wastewater treatment facilities process over 34 billion gallons of wastewater each day. These facilities reduce the levels of pollutants, such as pathogens, phosphorus, and nitrogen in sewage as well as heavy metals and hazardous substances in industrial waste, before reintroducing the treated waters to rivers. Everything then works properly. But according to the EPA, our nation's ageing and easily overcrowded sewage treatment plants also release more than 850 billion gallons of untreated wastewater yearly.

Despite the fact that massive spills may get most of the attention, the majority of oil pollution in our rivers is due to consumers, including gasoline and oil that seep from millions of cars and trucks every day. Furthermore, of the estimated 1 million tonnes of oil that reach marine ecosystems yearly, almost half is thought to come from land-based sources such as businesses, farms, and cities rather than tanker accidents. Around 10% of the oil in the world's seas is caused by tanker spills, but only around 1/3 is attributable to ordinary marine business activities, including both legal and illegal discharges. Oil is also emitted spontaneously from the ocean floor via cracks called seeps.Radiation emissions from pollution—including those from radioactive waste—exceed those produced by the environment naturally. It is created by the mining of uranium, nuclear power plants, the production and testing of military weapons, as well as by universities and hospitals that use radioactive materials for research and medical care. Because radioactive waste may persist in the environment for a very long period, it can be exceedingly difficult to dispose of. Take care of the 56 million gallons of radioactive waste from the defunct Hanford nuclear weapons production plant in Washington. It is estimated that it will cost more than $100 billion to construct and take till 2060. Toxins that have been accidentally released into the environment or illegally disposed of represent a threat to groundwater, surface water, and marine resources.

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CHAPTER 12

PARAMETERS OF PHYSICAL WATER QUALITY

Mr. Bhavan Kumar Mukrambhi
Assistant Professor, Department of Civil Engineering,
Presidency University, Bangalore, India
Email Id- bhavankumar.m@presidencyuniversity.in

Although less often employed than some of the other water quality indicators on this list, turbidity indicates how murky the water is. Turbidity sensors are devices used to measure how effectively light can pass through water [1],[2]. High levels of turbidity may be caused by increased concentrations of silt, clay, and organic matter. The appearance of turbidity in water is its main disadvantage [3],[4]. No one enjoys drinking muddy water. Other problems that are exacerbated by high turbidity.

High particle concentrations may serve as a barrier for dangerous bacteria, making it more difficult to remove these contaminants and raising the cost of water treatment [5],[6]. Substances in suspension have the potential to damage fish gills, hinder growth, and reduce disease resistance. Heavy metals like mercury, cadmium, lead, and others may be drawn to different suspended particles and absorbed there. The amount of dissolved oxygen is also likely to decrease. Turbidity in water becomes apparent when sensors return readings of five or more NTU. Turbidity values in muddy water may be more than 100 NTU.

Temperature

Numerous aspects of water quality, such as odours, chemical reactions, solubility, palatability, and viscosity, are influenced by the temperature of the water. As a result, sedimentation, chlorination, and the biological oxygen demand are all impacted by water temperature. The ideal temperature for water is between 50 and 60 degrees.

Color

Plants are the primary organic material that decomposes and has the power to change the colour of the water. Inorganic substances like pebbles, dirt, and stones may also have an effect on the colour of the water. These colour variations may result in visual issues, but they have no impact on the water's flavour.

You may precisely evaluate colour by contrasting a water sample with coloured glass discs or approved colourants. When attempting to establish the colour of the water, it is essential to understand the difference between the apparent and actual colours.

A combination of dissolved and suspended solid colours gives an apparent colour. The true colour of the water may be identified once all suspended particles have been filtered out via filtering. Keep in mind that colour may be evaluated on a range from 0 to 70 colour units. Pure water has any colour components since it is essentially colourless.

Taste and odour

It is possible for the taste and odour of the water to change if foreign material is added to it. This material may consist of inorganic chemicals, dissolved gases, and organic compounds. This content is mostly derived from domestic, natural, and agricultural sources.

Solids

Solids may be in suspension or solution when they enter water. After a water sample has been run through a glass fibre filter, suspended particles will remain at the top of the filter. On the other hand, any dissolved compounds will pass through and remain in the water. To gauge the amount of solids in water, total dissolved solids are often measured. Measurements of total dissolved solids may be used to estimate the concentration of organic materials in the water.

Electrical conductivity

Another basic physical property you should be aware of is electrical conductivity, which measures how well a sample of water or a comparable solution can carry or conduct electrical currents. As the water's ion concentration increases, conductivity will increase as well. The conductivity of water is one of the most important factors for establishing the quality of the water since it makes it easy to detect levels of water contamination.

A high conductivity reveals that the water contains a number of contaminants. On the other hand, water that is potable or very pure essentially cannot conduct an electrical current. The two fundamental units used to measure electrical conductivity are micromhos/cm and milliSiemens/m, abbreviated as mS/m.

Parameters for Chemical Water Quality

pH

One of the first tests you should do to gauge the water's quality is pH. The pH of water may be measured with a cheap pH sensor or test kit, which will show how basic or acidic the water is. In acidic water, there will always be more hydrogen ions. However, the amount of hydroxyl ions is larger in basic water. There is a possible range of 0 to 14 on the pH scale. The water is regarded as neutral when you get a value of 7.0. Any readings below 7.0 are regarded as acidic, whereas any readings higher than 7.0 are regarded as alkaline.

Pure water has a pH of zero. But rain typically has a pH of 5.6, making it somewhat more acidic. Water is deemed to be safe to drink if its pH is between 6.5 and 8.5. Water with a slightly acidic or alkaline pH may harm fish membranes, irritate fish gills, and reduce the amount of fish eggs that hatch, among other effects on both plants and animals. Aquatic plants and animals die when exposed to water that has an excessive pH value. Due to the sensitivity of their skin to pollutants, low pH may be fatal to frogs.

Acidity

This is an evaluation of the quantity of acids in a certain solution. The term "acidity" refers to a substance's capacity to quantitatively neutralise a base at a certain pH level. Mineral acids, carbon dioxide, and hydrolyzed salts are often the cause of acidity. When acids are introduced to water, a variety of activities, including corrosion, biological activity, and chemical reactions, may be impacted. The acidity of water is determined via a pH sensor.

Alkalinity

Alkalinity is a gauge of a water's acid-neutralizing power. The most common purpose of evaluating the alkalinity of a sample of water is to decide how much soda and lime to add to the water in order to soften it. The water softening process may assist to lessen boiler corrosion. Alkaline water is defined as having a pH of at least more than 7.0. When bicarbonate, carbonate, and hydroxide ions are present, water becomes more alkaline. Your water's high alkalinity or acidity levels indicate that it has been contaminated in some way.

Chlorine

Chlorine is not naturally present in water, although it is often added to sewage for disinfection purposes. Base chlorine is a dangerous gas, yet its aqueous solution is completely safe for human consumption. Water that has a tiny amount of chlorine is regarded as clean and essentially pollutant-free. It is possible to measure the residual chlorine level using a spectrophotometer or a colour comparator test kit.

Hardness

Hardness occurs in water when the mineral content is high. If you don't maintain the dissolved minerals in your water, scale deposits might form on your hot water pipes. If you take a shower in water that has a lot of minerals, your soap may not lather up as well. The main sources of hardness in water are magnesium and calcium ions, which may enter via soil and rock. Groundwater is often tougher than surface water. The hardness of the water may be assessed with a colorimeter or test strip. You may be able to determine how polluted the rivers, lakes, and streams are by using this crucial water quality indicator. If the amount of dissolved oxygen is high, the water's quality may be safely assumed to be excellent. Dissolved oxygen is a result of oxygen's solubility. The key determinants of how much DO is present in water are its salinity, pressure, and temperature. An electrometric method or a colorimeter may be used to measure the concentrations of dissolved oxygen.

Biochemical Oxygen Demand

Organic materials are the only source of sustenance for bacteria and other microbes. The metabolism of this chemical consumes oxygen. If this process takes place in water, the dissolved oxygen in a sample of water will be depleted. If there is a substantial amount of organic matter in the water, high amounts of dissolved oxygen will be employed to guarantee that the organic matter breaks down. However, since aquatic life depends on DO in order to live, this presents problems. The biological oxygen demand may be determined using the dilution method. If the BOD levels are excessive, the water is contaminated.

Biological Parameters

Bacteria

Bacteria are single-celled plants that, given the correct pH, food-availability, and temperature circumstances, may ingest food and grow rapidly. Due to their rapid development, measuring the number of bacteria in a water sample is virtually impossible. In most cases, colder water will cause bacterial reproduction to proceed more slowly. High levels of bacteria in water have been linked to the transmission of dangerous waterborne illnesses like cholera, tularemia, and typhoid.

Algae

Algae are microscopic, pigment-based plants that take part in photosynthetic activities. These plants are able to maintain themselves by effectively converting inorganic components into organic stuff, which is performed using energy from the sun. While eating carbon dioxide, the algae continue to release oxygen. Algae play a significant role in stabilisation pond-based wastewater treatment processes. The primary cause of offensive tastes and odours is algal growth. Keep in mind that certain species of algae might seriously endanger public health. As an example, blue-green algae has been linked to animal deaths.

Viruses

Little biological agents known as viruses have the capacity to harm a person's health. Only very strong electronic microscopes can spot viruses. All viruses need parasites to live. Because of their microscopic size, most filters are unable to block the passage of viruses. Certain aquatic viruses may cause hepatitis and other health problems. Viruses may be difficult to treat, but the majority of water treatment facilities should be able to eliminate viruses during the disinfection process.

Understanding the three basic types of water quality standards may be useful when attempting to purify water and get rid of the many poisons that may be found in it. Regardless of whether your water has a high turbidity level, a low pH level, or a lot of bacteria, there are a few techniques you may take to completely eradicate these issues.

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