Introduction to Artificial Recharging to Ground Water

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Introduction

India is heavily dependent on ground water resources. Recent estimation indicates that this source provides 80 – 90% of domestic water supply in rural areas, 50% of the urban and industrial demand and 50% of the irrigated area through over 17 million energized wells. In drought years, ground water represents the primary reliable source for irrigation.

With the Indian economy growing at impressive rate of about 7.5% per annum in the recent past, it is expected to continue doing the same in the foreseeable feature. The need for commodities, especially water has to be recycled in every form, as water is being a finite amount and is under threat.

The changing socio–economic situation in India is leading towards higher level of ground water exploitation which has already started showing adverse effects. In rural and urban areas people are drilling deeper and deeper bore wells. Small streams are getting dried up even during monsoon months. In hilly areas deforestation and reduced ground cover do not facilitate percolation of rain water and arrests feeding of springs. As a result, excessive stress on ground water extraction, drinking water availability during summer months has been critical in some areas. Access to safe drinking water is being threatened due to high levels of Fluoride, Arsenic, Iron, Salinity hazards etc in ground water. Pollution of ground and surface waters from agro–chemicals and from industry poses a major environmental health hazard. It is needless to emphasize that poor drinking water and sanitation infrastructure leads to high levels of water related diseases and death. Thus ground water is being over – exploited and water pollution together with inefficient management of surface water is becoming a matter of great concern in India.

Integration of issue of fresh water supply and demand, legal and socio-economic aspects at the local level, technological innovations and institutional frame work has to be addressed at all levels. Water harvesting and ground water recharging is the method which has maximum potential to alleviate this problem and is the one which can be implemented as grass-root level with participatory approach which does not require large scale investments and very sophisticate infrastructural facilities.

Rain Water Harvesting

It is the deliberate collection and storage of rain water that runs off a natural and manmade catchment surfaces which may include roof-tops, rocky surfaces, court yards, hill slopes and impervious, or semi impervious land surfaces. Storages of collected rain water can be done in tanks (above and below ground), lined pits small dams or in the

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sandy beds of seasonal rivers. The harvested rainwater could also be charged into the aquifer, replenishing the ground water, commonly known as ground water recharging.

Traditional water harvesting systems have been over looked, especially in the region of water scarcity. The current water scenario calls for renewal of the traditions with better technological innovative measures.

There are two broad aspects of rainwater harvesting:

1. Storage of rainwater on surface for future use.
2. Recharge of harvested rainwater into ground water system.

Design Considerations

For designing Rainwater Harvesting Structures, the following factors need to be evaluated-

1. Hydrometerological characters of the area like rainfall duration, general pattern and intensity of rainfall, rainfall distribution and seasonal variation in time and space.
2. Assessment of land use pattern (industrial, residential, urban agglomeration or green belts) of the area which contributes run – off.
3. Hydrogeological frame work of the area which includes geomorphology of land surfaces, aquifer characteristics underlying the area, ground water level configuration and chemical quality of water.
4. Socio- economic conditions of the area which will have a direct bearing on the type of Rainwater Harvesting Structure catering various needs of the community.
5. Willingness of the community and spontaneous participatory attitude to maintain such structures which may in the long run ensure the sustainability of the system to be created.

Facets of Rain Water Harvesting

1. Roof-top rainwater harvesting is the suitable water harvesting technique which consists of catchment area(roof), conveyance system(guttering, downspouts and piping), filtration(appropriate screening), storage (cistern- ferro-cement, PVC or of any other suitable material, disinfection(filtration, chlorination) and distribution system.

2. Run-off Harvesting: Roads, parks, driveways, landscapes, open fields and pavements and other open areas can be utilized to harvest the rainwater run-off. Although in areas of low rainfall, this technique has wider application, the water collected may be highly contaminated and hence unfit for direct domestic use. If it is intended to recharge this water into the aquifer system, it has to be passed through effective and suitable filtration system.

Some Important Issues Related to Rain Water Harvesting

To have a sustainable Rainwater Harvesting system, the following aspects need to be considered:

1. Technology aiming at maximizing efficiency of collection and storage of harvested water at minimal cost giving due importance to the various scientific and social factors.
2. Water quantity/ water security specially in drought period.
3. Water quality and necessary treatment options to suit the community. Atmospheric pollutants such as sulphur-dioxide, nitrogen oxide and hydrocarbons which may cause acid rain may be very unsafe to drink, specially in industrialized urban areas.
4. Overall government policy and scope for people's participation in making the program successful

Ground Water Recharging through Rain Water Harvesting

Ground water recharging in unconfined aquifers as also in confined aquifer can be very advantageous where the aquifer system is highly depleted. It can improve the quality of water in some cases. However, it has got the best application for enhancing the recharge potential in an area where large scale ground water withdrawal is affected. To combat with continuous stress on ground water resource, augmentation by artificial means through Rain Water Harvesting can provide an effective solution.

The performance and economy of ground water recharge hinges on maintenance of a high infiltration rate. However, it has been observed that the recharge rate decreases with time. The initial decrease is attributed to dispersion and swelling of soil particles after wetting; the subsequent increase occurs due to elimination of entrapped air by solution in passing water and the final gradual decrease takes place from microbial growths clogging the soil pores.

Concept of Augmenting ground water Reservoirs

- ***Ground water/Sub surface reservoirs***

a) Subsurface reservoirs are technically feasible for storing surplus monsoon run- off
b) It can store substantial quantity of water.
c) Subsurface geological formations are considered as better 'warehouse" for storing water as compared to structures designed to store water on the land surface.
d) Other considerations for creating subsurface storages are favorable geological structures and physiographic units, whose dimensions and shape will allow retention of substantial volume of water in porous and permeable formations.
e) These are environment friendly and economically viable at the suitably located sites. It is free from adverse effects like inundation, displacement of

local people, evaporation loss and sensitivity to earthquakes at the suitably located sites.

f) The deeper water levels may be raised resulting in reduction in lifting cost and energy savings.

❖ ***Basic requirements for Artificial projects***

- Availability of non – committed surplus monsoon run – off in space and time.
- Identification of suitable hydrogeological environment and sites for creating sub surface reservoirs through cost effective artificial recharge techniques.

❖ ***Source water Availability***

It is basically assessed in terms of non - committed surplus monsoon run – off. This component can be assessed by analyzing the monsoon rainfall pattern, its frequency, number of rainy days and maximum rainfall in a day and its variation in a day.

Topography of the area:

Topography of an area plays a vital role in selecting a site for artificial recharge. Terrain conditions (hilly/undulating/flat), natural drainage density, slope of the streambed etc. are to be understood.

One can adopt the techniques of artificial recharge to ground water in a particular area, if the information desired above for that area is known.

Hydrogeology of the area:

Detailed knowledge of geological and hydrological features for selecting the site and the type of recharge structure is required. Data to be considered are geological boundaries, hydraulic boundaries, inflow and outflow, storage capacity, porosity, hydraulic conductivity, transmissivity of aquifers, natural discharge of springs, natural recharge, water balance, lithology and depth of the aquifer and tectonic boundaries. The aquifers best suited for artificial recharge are that, which absorb large quantities of water and do not release them quickly. This implies that vertical hydraulic conductivity is high, and horizontal hydraulic conductivity is moderate. The availability of sub-surface storage space and its transmission capacity further govern the extent of recharge. The top 3 m of the unsaturated zone is not considered for recharging, since it may cause adverse environmental impact e.g. water logging, soil salinity, etc. The post-monsoon depth to water level represents a situation of minimum thickness of vadose zone available for recharge which can be considered vis-a-vis surplus monsoon run off in the area.

Long Term Water Level Analysis:

If it is observed that water levels in an area decline only during pre monsoon period (and post monsoon trend neutral) then it may be considered to be due to increased

rate of pumping in winter and summer periods as compared to corresponding period of earlier years and not due to over all deficit of ground water resources and which by the natural process of recharge of aquifer gets back to the ground water level of earlier years during the monsoon period. If both pre and post monsoon water level trends are declining, then it may be either due to deficient rainfall over a period or due to over development of ground water. However, if it is observed that over a period of years rain fall was normal or near to normal, then it can be confirmed that the long term decline in water levels are due to over development of ground water and the need for artificial recharge to ground water by rain water is justified.

Hydrometerological Studies:

This is undertaken to decipher the rainfall pattern, evaporation losses and climatological features. This can bring out the extent of evaporation losses in post monsoon period, which would be helpful in designing the storages of particular capacity with a view to have minimum evaporation losses. The data on rainfall intensity, number of rain-days, etc. helps in deciding the capacity and design of the artificial recharge structures.

Identification of the area:

The artificial recharge projects are site specific and even the replication of the techniques from similar areas are to be based on the local hydrogeological and hydrological environments. The first step in planning the artificial recharge project, is to demarcate the area of recharge. The artificial recharge to ground water is normally taken in following areas:

a) Areas where ground water levels are declining on regular basis.
b) Areas where substantial amount of aquifer has already been desaturated.
c) Areas where availability of ground water is inadequate in lean months.
d) Areas where salinity ingress is taking place.

Techniques of Artificial Recharge to Groundwater by Rainwater:

A wide spectrum of techniques are in vogue for recharging the ground water by rain water The artificial recharge techniques can broadly be categorized as direct surface techniques, direct sub surface techniques, combination of both the techniques and indirect techniques.

a) Different Surface Techniques:

Under direct surface techniques are flooding, ditch and furrow systems, gully plug, check dam, nala bund, percolation tank, and gabion structure.

b) Direct Sub-Surface Techniques:

These are dug wells, tube wells, recharge shafts with or without injection well.

c) Indirect Techniques:

Induced recharge: These include induced recharge from surface water sources, e.g. – pumping from the aquifer hydraulically connected with surface water. The cone of depression developed due to pumping intercepts surface water body and a hydraulic connection gets established with the surface water, which starts providing part of the yield, during pumping . The greatest advantage of this method is that under favourable hydrogeological situations the quality of surface water generally improves due to its path through the aquifer material before it is discharged from the pumping well.

Recharge structures:

- **Ponds/ small lakes etc:**

In old water bodies with porous material as the base and where both direct rainfall and ground water act as the source, a lot of sedimentation almost covers the base. One may think of desilting the ponds for increasing the storage capacity and also to enhance the rate of recharge into the ground water through the pond water.

- **Check dams and Nala Bunds**:

This is to be constructed on a streambed, which has got gentle slope and by this the utilization of the stream width and the quantum of flowing water will be more. To have long life of the structures and to avoid any accident, the design of the structures need to be finalized following the hydraulics. Recharge shafts on the streambeds, are to be filled with pebble and gravel (from bottom) and at the top by sand, which will act as filter media and save the structure from collapsing.

- **Percolation tanks:**

In undulating terrain if percolation tanks are located near any stream then there is possibility that water from percolation tank, after percolating may reach stream without giving any benefit of recharge. In such situation depending on the availability of water, a few check dams / nala bunds are to be constructed on the streambed located near to the percolation tank. While deciding the height of percolation tank/check dams / nala bund water demand of the people of the down slope/down stream side is to be kept in mind and certain amount of water is to be allowed to flow as over flow for these people.

- **Dug well:**

In case of artificial recharge of roof top rainwater through abandoned dug well, the dug well need to be properly cleaned up to the base so that the recharged water can easily disperses into the aquifer. Clogging of the base and sides with sediments will not allow recharged water to enter the aquifer at the desirable rate.

As a result the water required for recharging will overflow the dug well and submerge the surrounding area. It is always safe to avoid very old abandon

dug well. The dug well which becomes dry in pre-monsoon period are better structures for recharge. Care is to be taken to filter the rainwater by passing through sand bed before allowing it to enter the dug well.

- **Recharge well/shaft:**

Wherever planning is to be made for artificial recharge to ground water by roof top rainwater through recharge well/shaft, the rainwater needs to be silt and sand free. Otherwise it will spoil the recharge structure and also the aquifer. By filtration of rainwater through sand, in addition to sand and silt most of the bacteria are also removed. Hence filtration of rainwater by sand is most effective.

- **Recharge pit / trench:**

In many urban areas during monsoon if there is heavy shower, due to poor drainage systems water gets stagnant over large areas, then one may think that this stagnant water may be utilized for recharging the aquifer through recharge pit and/or trench (if the condition of the aquifer is suitable) supported by recharge shafts and/or wells. Before taking such decision rainwater available in urban area has to be analyzed for heavy metals and bacteria at different stages of pre-monsoon and monsoon periods. If the water is found suitable then only, water could be utilized for artificial recharge to the ground water. Moreover, rainwater may have oil and grease from the surface over which it flows and this will pollute the ground water. In such cases scheme of artificial recharge should not be taken.

- **Tube well:**

i) Hand pump fitted shallow tube well:

The abandoned shallow tube well may be used for artificial recharge by roof top rainwater harvesting. In that case it is very much necessary to ensure that the slots/ strainers are not clogged. If it is clogged then it will not allow recharged water to enter the aquifer and as a result the water will come out and submerge the surrounding area. The shallow tube well, which becomes inoperative due to decline of water level below the slots are better structures. The rainwater before recharging through shallow tube well needs to be filtered through filter bed so that the water is silt free, otherwise it will clog the slots and will not allow water to recharge the aquifer.

ii) Deep tube well:

In case of recharge of confined aquifer at a particular depth by deep tube well the design of the recharge well should be such that the shallow aquifer/aquifers is/are to be separated out from that particular confined aquifer by proper clay/cement sealing. If it is not done then the water of the shallow aquifer/ aquifers may develop continuity through the shrouded gravel required for construction of the tube well with that of the deeper aquifer and if the shallow aquifer/aquifers is/ are

not feasible for artificial recharge then during artificial recharge to the deeper aquifer the upper shallow aquifer/ aquifers will also be recharged and may create negative effects like water logging and soil salinity etc on the environment. In areas having salinity problem in ground water or ground water contamination or pollution problem in shallow aquifers and if such type of shallow aquifers is not separated from the deeper fresh water aquifer to be recharged and then water from upper shallow aquifers will either make the deeper aquifer saline or pollute.

Concluding Remarks

With continuous stress on ground water exploitation to support drinking water, agricultural and industrial water supply needs, it is imperative to replenish and conserve ground water for future use. It is in this context, artificial recharging to ground water projects have to be implemented in a comprehensive manner in coming years. Our collective efforts in this regard can only bring sea-change in the overall water availability scenario on sustainable basis.