Converting dried-up bore wells as groundwater recharge wells

Groundwater is the major source of drinking water and irrigation in many rural areas of India. In recent decades, groundwater abstraction using bore wells (also known as tube wells) from deeper aquifers increased manifold. Over-exploitation of groundwater and its depletion over the years have resulted in drastic fall in groundwater levels and drying-up of existing wells in many areas. Construction of farm ponds, percolation tanks, earthen dams and minor water harvesting structures are some measures to enable storage and direct use of water and contribute to recharging and augmenting groundwater.

These conventional structures suffer substantial evaporation losses from stored water. To overcome this shortfall, techniques of constructing recharge shafts, cavity tube wells and injection wells were developed in recent decades. Recharge shaft involves drilling a shaft of 45–50 cm diameter into the aquifer; filling the shaft with gravelly filter material and directing rain water to pass through the filter material before it recharges the aquifer medium[1,2]. These were primarily developed and tested for areas underlain by alluvial sandy deposits. Unlike a shaft, a recharge cavity structure has deeper tube well of 15–20 cm diameter into the aquifer, beyond the clay layers, to tap the sand layers as medium for recharging and storing rain water[2]. Recharge cavity is more suitable in coastal and sandy aquifer systems. Functionally similar to a recharge cavity, *Bhungroo* is indigenous technology developed and being scaled up recently in coastal Gujarat[3]. In this, a tube is inserted into the ground through underground sand layers. Rain water, that inundates plain coastal farm lands, is fed into this tube to recharge sandy layers. The recharged water is drawn for irrigation during dry season of the year. The Central Ground Water Board (CGWB) recommended construction of gravity recharge wells, injection wells and shafts depending on aquifer capacity and formation[4]. In all these structures, a graded filter, filled with boulders, stones, pebbles and sand is provided at the ground surface to rid the run-off water from sediment loads. Such filtration systems had earlier been evaluated for groundwater recharge structures in laboratory simulation suggesting optimum dimensions[5,6]. All these methods of recharging deeper geological aquifers have the unique advantage of recharging huge quantities of run-off from rainfall events of relatively short span of time. But all these methods involve drilling a new shaft or tube well as well as constructing the filter media, which escalate the total cost of the system to an unaffordable level to small farmers and poor rural households.

As part of an action research project titled 'Sustainable Ground Water Management (SuGWM)' during 2012–2016, the present author experimented on converting some of the dried-up bore wells located in agricultural lands in Kotanka village (located at 77°30′32″E to 77°32′45″E long and 14°47′00″N to 14°45′20″N lat) in the Garladinne Mandal of Anantapuram district of Andhra Pradesh. This district has an annual average rainfall of 530 mm, which is lowest among all districts in Andhra Pradesh. A major part of the district is underlain by Archaean crystalline rocks which include granites, gneisses and Dharwarian schists. The groundwater in these formations occurs in weathered zones (generally <15 m depth) under water table conditions and in fractured zones (generally up to 100 m depth) under semi-confined conditions. Potential fractures are encountered between 40 m and 100 m depths[7]. The yield of bore wells was found to be from 1 to 3 l/s.

Kotanka village has a geographical spread of 21 sq. km inhabited by 580 households (2225 population). Baseline surveys in 2012 revealed that all 96 open wells in the village had dried up. Of the 372 bore wells in the village, 147 had completely dried up and a good number of the remaining wells were low yielding. Normally bore wells are of 150 mm dia and extended to a maximum depth of 120 m. PVC casing pipe is provided to a depth of 10–12 m below ground level to prevent collapse of top soil and weathered zones. Many farmers abandoned dry wells by capping the casing pipes and dug more new wells without much success in striking water.

The capacity of an existing dry well to absorb rain water depends on the cumulative capacity of multiple fracture zones spread along the depth of the well. In slug test of aquifer, a small quantity of water is added or removed and change in hydraulic head is monitored to determine near-well aquifer characteristics. Since slug test has limitation to check the cumulative recharge capacity of various fractures of the bore well, a simpler 'input test' or 'tanker test' was designed. A tanker full of water (approximately, 5000 litres) was released into the bore well casing pipe using a 6.25 to 7.50 cm diameter pipe and a change in water level in the bore well was observed. The water input rate was approximately 2.5 to 3.0 l/s. If the bore well had absorbed all the tanker water, it was considered suitable for converting as a recharge well. In case the bore well was found overflowing, the well was considered unfit for recharge. Though this was apparently a crude method to decide the recharge potential of a bore well, the test has a rationale to obtain a practical value.

Moreover, any illiterate farmer can easily carry out the test and at a low-cost. All the wells may not be capable of absorbing water. By employing this test one can effectively identify wells suitable for groundwater recharge avoiding ineffective investments. During initial years, only dry bore wells were selected, but later, based on the response of local farmers, few low-yielding agricultural bore wells were also included for carrying out rain water recharge. During 2012–2016, 23 bore wells were converted as recharge wells, including three dry bore wells used earlier for pumping drinking water to the village community. Care was taken to ensure that these selected wells not only pass the input test but were spread across the village.

The bore well recharge structure was designed considering three factors, viz. area of the catchment upstream of the well; texture of soil in the catchment; and possible maximum intensity of rainfall, which determine quantity and quality of run-off water. Higher amount of sediment loads was observed in red sandy soils whereas high intensity of run-off with less sediment load was observed in black soils. Recharge rate of the bore well was determined by (i) surface area and filtration capacity of the filter bed, and (ii) cumulative absorption

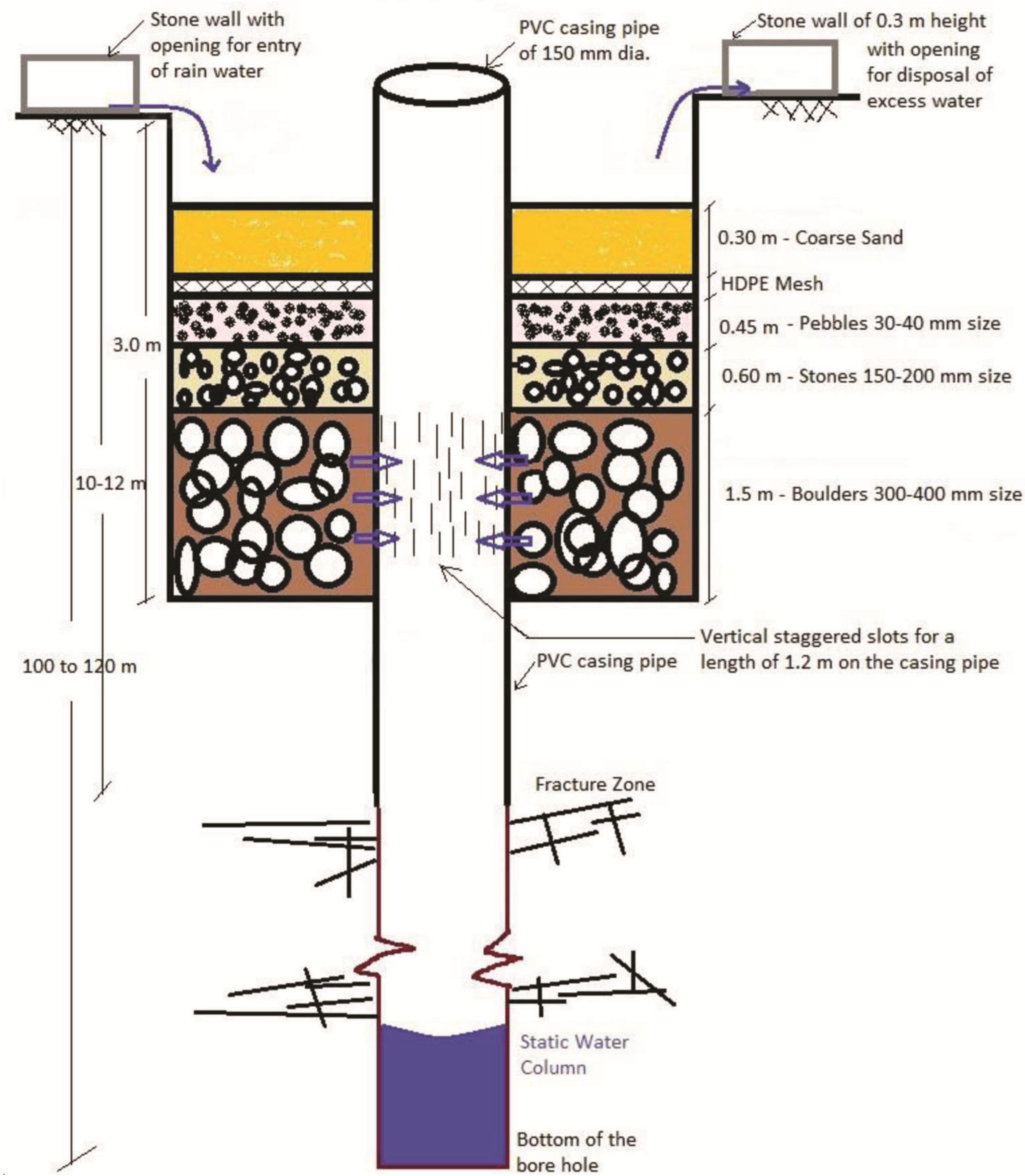

Figure 1. Cross-section of a typical bore well recharge structure.

capacity of the fractures in the aquifer tapped by the selected bore well.

An important observation from the field implementation is that – the design of the structure needs to be amenable for easier construction and workability. The filter pit was designed in a cubic shape with dimensions of 3 m × 3 m × 3 m (Figure 1). These dimensions permit the use of an earth moving machine to make the pit without disturbing the existing casing pipe. Cubic shape offers larger surface area on all sides and bottom for the rain water to percolate to shallow ground water. It was observed that procuring filter media materials (such as boulders, stones, pebbles and coarse sand) in multiples of full-tractor loads was easier and cheaper in the local market. Hence, the design thicknesses of different filter media were adjusted rounding-off the quantities of respective materials to full-tractor loads. Local sources of stones from hillocks or pebbles from barren agricultural lands, were used widely to reduce the cost of construction. While one structure costs

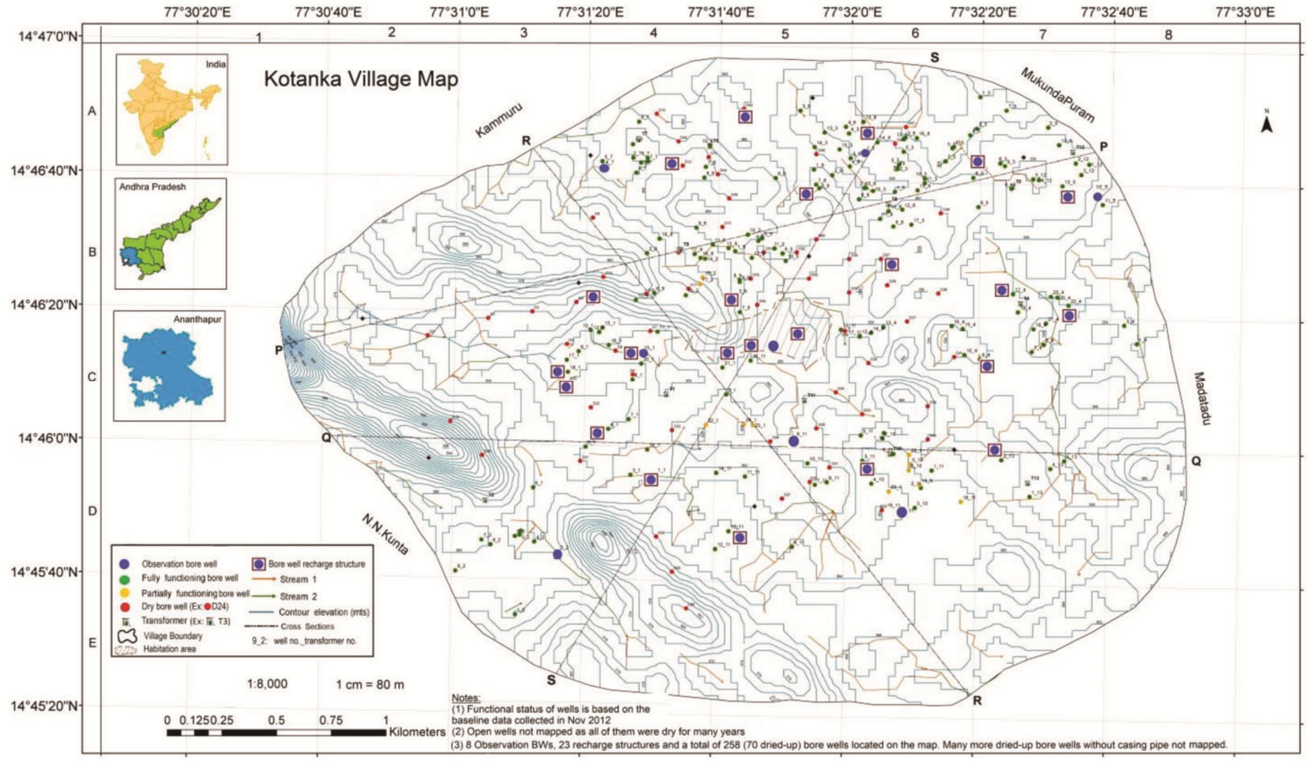

Figure 2. Location map of observation bore wells and recharge structures.

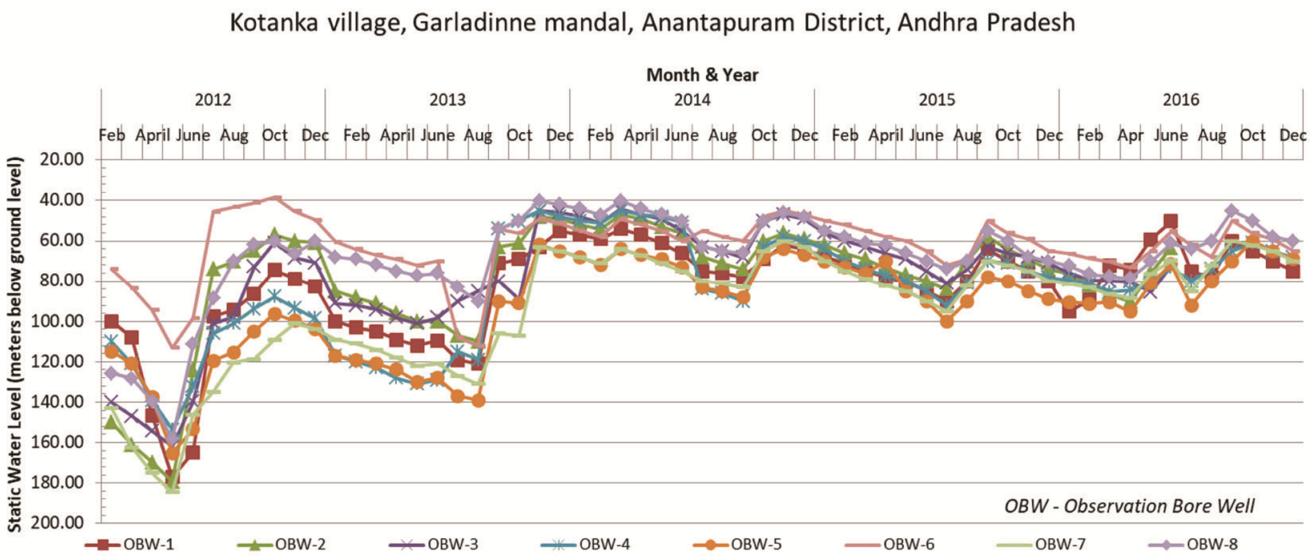

Figure 3. Static water levels in eight observation bore wells.

Rs 30,000, the farmers who benefitted contributed Rs 12,000 and the SuGWM project contributed Rs 18,000.

In addition, the action research project encouraged use of micro irrigation methods by farmers, renovated farm ponds and de-silted percolation tanks with active participation of people. In order to periodically monitor the changes in the ground water reserves, eight observation bore wells (OBWs) were identified and static water levels recorded every month from February 2012. Figure 2 presents the locations of OBWs as well as bore well recharge structures constructed in the village. A scientific approach in recharging rain water to the ground coupled with efficient use of water by farmers in agriculture gave tangible benefits in terms of increase in static water levels in many bore wells in the village and revived many dry wells. Figure 3 presents the water level trends in OBWs in the village from February 2012 to December 2016 (ref. 8). To convince other farmers about the efficacy of this technology, yield demonstrations were organized for groups of farmers in farm lands where bore well recharge structures were built. After participating in one such demonstration, the National Bank for Agriculture and Rural Development (NABARD), with technical support from SuGWM project, replicated the technology in the Karimnagar district of Telangana state in 2016.

The bore well recharge technology was found effective in hard-rock hydrogeological conditions, especially in low-rainfall regions with intense rainfall events. By recharging a few identified bore wells, groundwater condition could be revived to enhance agricultural productivity and farmers' income. Contamination of deep groundwater due to the use of untreated surface run-off is a potential concern in this technique. Thus, it is highly desirable to avoid the technique in areas where higher levels of biological and chemical contaminants are noticed in run-off water. In contrast to known methods, the technique involves re-using existing dry wells that significantly reduce the overall cost of the structure. The method of testing the suitability of existing well for recharge is quite simple. The technology has the potential of scaling up across south India which has many dry and low-yielding tube wells.

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ACKNOWLEDGEMENTS. The SuGWM project was financially supported by European Union (EU), Brussels and Bread for the World (BfdW), Berlin. The author acknowledges their financial support in conducting this research. The author also thanks the Water and Livelihoods Foundation for help in carrying out the field study and analysis of findings.

Received 15 June 2017; revised accepted 10 May 2018

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Towards DNA-based technological advancement in *Listeria monocytogenes* detection

Human listeriosis caused by *Listeria monocytogenes* (LM) is a serious public health concern. The disease leads to several health issues like abortion, stillbirth, septicaemia, meningitis and meningoencephalitis. The main targets are pregnant women, neonates, elderly or immunocompromised people[1]. LM has recently been reported as one of the most virulent pathogens with high rates of mortality (30%) and hospitalization (91%)[2]. It is a major cause of death (about 1600 cases) with an annual death rate of 255 in the United States alone. Such information for several countries including India is lacking. The ability of the pathogen to survive over a wide range of pH (4.3–9.8), salinity (up to 20% w/v) and temperature (0.5–45°C) makes it ubiquitous. It commonly contaminates raw food/products, and other food items through cross-contamination thus targeting humans. Therefore, the rapid detection of LM across diverse environments has great merit for food-processing industries, environmental quality control, and public health establishments.

Conventionally, detection and identification of LM involves culture-based methods that rely on the use of nutrient media for selective growth of the pathogen in targeted samples. Although morphological and biochemical confirmatory tests are sensitive, they are labour-intensive and time-consuming (5–7 days)[3]. Immunological techniques applied subsequently, viz. enzyme-linked immunosorbent assay (ELISA), enzyme-linked immunofluorescent assay (ELFA) and immune-magnetic separation have detection limit of 10^5 cfu/ml (ref. 4). The immuno-detection techniques also suffer from certain disadvantages, viz. the quantity of sample, availability of pure antigens and cost-intensive chemicals that limit exploitation of such approaches for pathogen detection. Due to advancement in biotechnological tools/techniques, molecular biology (genomics/proteomics)-based approaches have become more popular, especially for food and medical microbiology, as they exploit pathogen differences at the genetic level. These methods can selectively amplify the *Listeria*-specific gene signals and are thus capable of detecting LM even at low copy numbers. This communication not