ABSTRACT

Ever increasing demand for water has led to over exploitation of groundwater in several regions. Managed Aquifer recharge (MAR), which is a deliberate method to increase the groundwater storage, need to be practiced in aquifers that are over stressed. Check dam constructed across the rivers is one of the methods of MAR. In arid or semi arid regions the rivers flow only for a few days in a year (non perennial rivers) during the monsoon. The average rainfall is generally non uniform and most part of it falls in a relatively short period of time. Hence, large quantum of this rainfall reaches the sea as runoff and also results in flooding during peak monsoonal rains. In such a region, MAR by the check dams will help in harvesting this surface runoff, by increasing the contact time between the water and the river bed to facilitate the infiltration. This improves the groundwater recharge and reduces the runoff into the sea. Though there were many methods to assess the efficiency of MAR, each method had given results in various perspectives. Hence, the present study was carried out to accurately assess the impact of MAR on groundwater potential by an integrated study comprising hydrological, hydrogeological, microbiological, groundwater modeling and socio economic studies in Chennai, Tamil Nadu, India. For this purpose, primary data were generated through field investigation, laboratory work and secondary data required for this study were collected from government and private agencies. Field investigations were carried out from July 2010 to December 2013 which includes topographical survey, subsurface investigations, periodical groundwater level measurement, daily water level measurement from check
dam, periodical water sampling from check dam and wells and socio-economic survey. Immediately after water sampling electrical conductivity, pH and alkalinity were measured. Laboratory work includes soil, water analysis and groundwater modeling. Secondary data includes collection of topographic sheet, meteorological data, groundwater level data and hydraulic particulars of the check dam. Thematic maps were prepared based on the secondary data.

Subsurface characterization was carried out by ground penetrating radar (GPR) imaging, electrical resistivity survey, drilling of borehole and infiltration test. Further, the sediment samples collected from boreholes and infiltration test sites were also used to characterize the nature of the subsurface. The impact of recharge from the check dam was understood by the study of water level fluctuation, electrical conductivity (EC), major ions and isotopic variations as well as estimation of recharge by different methods. Impact of check dam on the quality of groundwater of this region is also assessed by geochemical, trace, pesticides and herbicides and microbiological analysis. The consequence of the check dam taken up for this study on the Arani river basin was estimated by water balance method by extrapolating the estimated storage and recharge to other check dams. The success of a technical solution based on a scientific study can only be assessed based on the feedback from the user. Hence, structured questioner was prepared in order to get the opinion of the local community on the usefulness of the check dam.
Based on the assessment using water level fluctuation, electrical conductivity (EC), major ions and isotopic (oxygen-18 ($\delta^{18}$O) and deuterium ($\delta D$)) variations as well as estimation of recharge, after the construction of check dam in this region the wells within a distance of about 1.25 km are in zone I are considered to be highly benefited by the check dam. The percentage of recharge rate calculated for the wells located in zone I varied from 68% to 71%. The groundwater level in this zone has increased by 3.5 m due to storage of water in the check dam. The zone II extending from 1.25 km to 1.75 km is moderately benefited by the check dam recharge. The percentage of recharge rate calculated for the wells located in zone II varied from 37% to 55%. The groundwater level in this zone has increased by about 1 m. The groundwater of the zone III which is not directly benefited by the check dam has the ambient electrical conductivity of the region and percentage of recharge rate varied from 11% to 22%. This region is least benefitted by check dam storage. In addition to the recharge from rainfall, 1.3 Mm$^3$, 1.3 Mm$^3$ and 0.71 Mm$^3$ of water stored from the check dam was contributed for groundwater augmentation during 2010-2011, 2011-2012 and 2012 to 2013 respectively. The results of water quality analysis indicate that the group of wells with high to moderately benefitted by the recharge from check dam were found to be suitable for both drinking and irrigation purpose. Water stored by the check dam is suitable for both these uses during the entire period of study. Thus, it is clear that the recharge from the check dam has resulted in improvement of groundwater quality in its surroundings. Whereas, the groundwater from the wells located far away from the check dam is either suitable only for drinking or irrigation purposes. It is also evident from this.
study, that reduction of turbidity, total coliforms and pathogens are observed in groundwater collected from wells adjacent to the dam during the natural recharge process. Further groundwater modeling shows that the groundwater level has increased by about 3m at 100m from the check dam and by about 1.5 m at 3000 m in October 2013. Hydrogeological and hydrological measurement shows that the wells located within about 1.25 km are benefitted by the recharge from check dam as there is no marked difference was identified beyond this region. Result of the groundwater modeling shows that after construction of check dam the region up to about 3 km is benefitted by the recharge from check dam. Socio economic assessment indicates that check dam at this location provide respondent with better livelihood. Based on the expenditure of construction of check dam and annual maintenance the cost of water recharged by the check dam was estimated to be Rs. 0.7 per 1 m$^3$. Quantification of volume of water harvested by this check dam helped to understand that the proposed MAR initiative by the construction of nine check dams across Arani River will only result in harvesting about 6% of runoff. As only a small fraction of runoff is harvested, due to this there will not be any major environmental issues.