CHAPTER 1

INTRODUCTION

1.1 GENERAL

It is well known that the groundwater is the largest source of fresh water available in the world. Consistently increasing demand for water has led to over exploitation of groundwater in several regions. Excessive extraction of groundwater for irrigation where it is slowly renewed is the main cause of the depletion and climate change has the potential to exacerbate the problem in some regions (Hertig & Gleeson 2012). Managed Aquifer recharge (MAR), is a deliberate method to increase the groundwater storage, which needs to be practised in regions where groundwater depletions is widespread due to over extraction. Different methods of MAR techniques are Aquifer Storage and Recovery (ASR), Aquifer Storage Transfer and Recovery (ASTR), Soil Aquifer Treatment (SAT), percolation pond, check dam, River Bank Filtration (RBF) and Rain Water Harvesting (RWH). Criteria for adopting a particular method of MAR depend on the local condition (topography, drainage, land use, etc.), aquifer type (confined, unconfined and semi-confined) and quality of the water (storm water, recycled water). In general, ASR, ASTR and SAT are suitable for confined aquifer. Percolation pond is found suitable for unconfined aquifer. Check dam and bank filtration techniques are suitable for non perennial and perennial rivers respectively. Rainwater harvesting is best suited for built up areas. Many researchers have studied the benefit of adopting various MAR techniques. Pirnie et al (2011) assessed that the water
recovered from ASR does not require any treatment for iron and manganese in aquifers of Texas, USA. ASTR was successfully implemented by recovering water for domestic supply by injecting storm water in an aquifer in Australia (Pfeiffer et al 2005). Assessment of the use of SAT technology in improving the quality of tertiary treated wastewater in Kuwait was carried by Akber et al (2003). Importance of percolation tanks for sustainable development of groundwater in hard-rock aquifers of India was studied by Limaye (2011). Impact of recharge from a check dam on groundwater quality and assessment of suitability for drinking and irrigation purposes was carried out by Parimalarenganayaki & Elango (2013b). Comparison of lake bank filtration over the rapid sand filtration was analysed in Nainital, India and it illustrated that bank filtration is more efficient in reducing the microbiological load (Dash et al 2008). A hydrological impact of RWH in Arvari River basin, Rajasthan, India was assessed by Glendenning & Vervoort (2010).

1.2 REVIEW OF LITERATURE AND NEED FOR THE STUDY

Assessment of hydrological impact of various methods of MAR is important to efficiently manage the available water resources. Impact of MAR methods on groundwater quantity and quality were assessed with various indictors by different researchers. Water level was used an indicator to assess the impact of check dam as a method of MAR by Pandey et al 2004. Microbiological load reduction using river bank techniques was assessed by Shamrukh & Wahab (2008). Isotopes and geochemistry was also used to assess the groundwater recharge induced by MAR (Palanisami et al 2004; Kattan et al 2010; Yang et al 2012). Benefits on livelihoods by MAR methods were assessed by Fromant (2009) and Mudzengi (2012). Effect of MAR structure on groundwater potential was also assessed by groundwater modelling (Rao et al 2004). Though the researchers have used different methods to assess the efficacy of MAR by check dams there is a wide difference in their findings. Groundwater level measurements were used by
some researchers which indicated that the recharge has increased due to construction of check dams from 6% to 40% (Neumann 2004; Gale et al 2006; Muralidharan 2007; Alderwish 2010). With regard to groundwater quality some studies indicated no significant improvement due to recharge (Gale et al 2006). Whereas, certain studies ((Palanisami et al 2006; Bijukumar & Abraham (2009); Samarah et al (2009)) indicated decrease in concentration of ions in groundwater due to the recharge from the check dam. Bijukumar & Abraham (2009) found that the groundwater quality has deteriorated due to recharge from check dam. Improvement in groundwater quality is dependent on the quality of water stored by the check dam. The impact of dams on livelihood emphasise the need for an integrated assessment to solve the problem of inequitable distribution of water among upstream and downstream users. The detailed review of research work carried out on MAR by check dams revealed, different methods gives varied assessment of efficacy of such structures (Parimalarenganayaki and Elango 2013a). This may also be due to the fact that most of these studies are based on observations carried out over a short term period. Hence, in order to accurately assess the impact of MAR on groundwater potential, an integrated study comprising all the possible technique is required. Such type of study only can help to decide about the requirement of number of MAR structures in a river basin to overcome the problem of water shortage. Based on the review of literature it is evident that, there is no significant work on integrated approach with long term data to assess the impact of MAR. Hence, the present study was carried out to assess the impact of check dam as the method of MAR using hydrological, hydrochemical, isotopic and microbiological analysis as well as by groundwater modelling. This study was carried out in and around a check dam located north west of Chennai city, India.
1.3 WATER SUPPLY SCENARIO IN CHENNAI

Chennai is the fourth largest metropolitan city in India. Arani, Koratallai, Cooum and Adyar are the four important rivers draining in and around Chennai. The population of this city is about 7 million according the census taken in the year 2012. The water demand for the present population is approximately estimated to be 1000 million litres per day (MLD). About 930 MLD of water is supplied from various sources including five surface reservoirs namely Sriperumbadur, Chembarambakkam, Poondi, Redhills, Cholavaram (Figure 1.1) and by extracting groundwater from the well fields (Panjetty, Minjur Tamarapakkam, Kannigaiper, Flood Plain, Poondi) (Figure 1.1) located north of Chennai.

![Figure 1.1 Chennai city and its surroundings with sources of water supply](image)

A part of the supply is met by the two desalinated plants (Minjur in north of Chennai, Nemmelli in south of Chennai) with a capacity of 100 MLD each and water transferred through pipes from Veeranam reservoir located 250 km south of the city. Further, 12 MLD of water is diverted from Krishna River through a canal from Kandalur reservoir (located 152 Km north of Chennai). The approximate contribution towards city water supply from the surface
reservoirs, well fields, desalination plant, Veeranam tank and Krishna River is 51%, 1%, 17%, 19% and 11% respectively. Additional water requirement in future is likely to be met from the new desalination plants, planned new reservoirs in north Chennai and additional water release from Krishna, Cauvery Rivers (CMDA 2004).

1.4 GROUNDWATER USAGE

Over extraction of groundwater from the alluvial aquifer north of Chennai over the last two decades to meet the city’s water requirement, especially during summer period when the surface storage dwindles, has led to seawater intrusion. Seawater has intruded up to a distance of about 9 km the year 1987 (CGWB 2007). To overcome the problem of seawater intrusion, pumping from the well field located closer to the coast namely Minjur and Panpetty was reduced or completely stopped. In order to meet the demand, new well fields Kannigaiper, Tamarapakkam and Poondi have commenced its operation in the year 1986. However, as the yield from these well fields was much less than the originally planned capacity, Minjur and Panpetty well field were also in operation pumping at the rate of about 12 MLD. This has led to increase in the extent of seawater intrusion which is currently at a distance of about 12 km from the coast (Sathish et al 2011; Nair et al 2013). Though there is a great demand for additional requirement to meet the city’s water supply, huge volume of water goes as a runoff through these rivers into the sea during intensive monsoonal rains. Whereas, during summer the people suffer for want of sufficient water supply. In order to mitigate this problem of decline in groundwater and ingress of seawater intrusion, MAR through check dams was initiated across Arani and Koratallai (Figure 1.2) by Public Works Department (PWD), Government of Tamil Nadu and the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB).
Figure 1.2 Locations of check dams across Arani and Koratallai rivers and well fields

Arani originates near Karvetinagar, at an altitude of 600 m above msl, in Andhra Pradesh. Arani River is about 131.6 km length and the drainage area of the basin is 1470 km², of which 763 km² lies in Tamil Nadu. The Koratallai River originates from Panappakkam reserve forest in Andhra Pradesh State. The total length of the river from its origin to the Bay of Bengal is about 155 km. The total catchment area is 4273 km², and 3242 km² of these lie in Tamil Nadu (Rao et al. 2004). These check dam will thus store part of the runoff that otherwise will be discharged into the sea. Nine check dams were constructed across Arani River and 7 check dams were constructed across Koratallai River during the period between 1972 and 2013. Two more check dams are proposed to be constructed across Koratallai River. The present study was carried out in a check dam across Arani River, located at Paleshwaram village (Figure 1.2) which was constructed and maintenance by the PWD, Government of Tamil Nadu.
1.5 OBJECTIVES

The objectives of this study are

- To understand the interaction between surface water and groundwater for delineating the area benefitted by the check dam
- To determine the water quality for domestic and irrigational use and to assess the influence of recharge from check dam on the quality
- To quantify the areal extent benefitted by numerical modelling
- To assess the socio economic benefit of check dam

1.6 STRUCTURE OF THE THESIS

The thesis comprise of eight chapters. Chapter 1 introduces the review, need and objectives of this study. Chapter 2 describes the various methodology adopted for this study which includes field, laboratory investigations and secondary data collection. Subsurface characterisation by geophysical and borehole logging is discussed in chapter 3. Effect of check dam on groundwater recharge by several methods is explained in chapter 4. Impact of check dam recharge on groundwater quality is discussed in chapter 5. Assessment of regions benefitted by the check dam recharge using groundwater modelling is discussed in chapter 6. Socio economic benefits to the livelihood and cost benefit analysis are discussed in chapter 7. Chapter 8 highlights the conclusions, limitations and future work of this study.