CHAPTER-V

MANAGEMENT OF WATER RESOURCES
1 INTRODUCTION

As groundwater is not isolated from surface water, a study of groundwater development and management necessarily encompasses many aspects of surface water flow. Surface water occurs in readily discernible drainage basins. The boundaries are topographic and may be easily delineated on a topographic map. The groundwater occurs in aquifers that are hidden from view. At a given location the land surface may be underlain by several aquifers. The development and management of groundwater is more complicated than that of surface water, simply on the bases of the mode of occurrence.

The study area is sloping towards west and two rivers viz; Sarbi and Venkatapur drain the area. The laterites are the rock formations. These rock formations possess primary and secondary openings for free movement for surface water to infiltrate and free movement of infiltrated subsurface water as groundwater. The area is part of the Western Ghats of South India and receives good rains during rainy seasons. Most of the rainwater infiltrates and part of it flows as surface drainage and join and lost into the Arabian Sea. The infiltrated groundwater also flows towards sea that is towards west as base flow. It is evident from the explanation provided in the earlier chapters that there is possible sea water intrusion into the aquifer. Thus, it is felt necessary to study about the prevention and control of sea water intrusion.

2. PREVENTION AND CONTROL OF SEA WATER INTRUSION

Once saline water intrusion occurs it is difficult to eradicate. While planning for groundwater development from fresh water zones underlain or bordered by saline zones it is essential to first decide on the safe limit upto which the interface may be allowed to move by applying suitable formulae depending on the prevailing conditions.
Todd (1980) suggested five measures to control sea water intrusion and they are;

- Reducing the pumpage, cyclic pumping, and rearrangement of pumping pattern or redistribution of extraction points in order to restore a sea ward hydraulic gradient.
- Artificially recharging the intruded aquifer to maintain proper water levels and hydraulic gradients by eliminating over draft conditions.
- Developing a pumping through in the region adjoining the coast, in order to limit intrusion.
- Creating a fresh water ridge by injection wells or other artificial recharge methods.
- Constructing artificial sub surface barriers like dykes or injecting material such as cement grout or bentonite mud through bore holes.

All the methods suggested are relevant in managing sea water intrusion into fresh water aquifers. Over last fifty years these methods with slight modifications are being employed with little success throughout world. Of these a few popular ones are mentioned here;

**INJECTION METHOD**

In this method a line of injection wells parallel to the coast injects water into the aquifer. The Fig. 5.1 shows this for an unconfined aquifer system. Water levels behind the barrier can be drawn down below sea level with no fear of salt water encroachment. This method results into a ridge in the potentiometric surface.

**ARTIFICIAL RECHARGE METHOD**

Opening pits or trenches or bins could perform artificial recharge in the area of pumping well fields. The Fig. 5.2 shows the arrangement of artificial recharge basins. This method helps to maintain the elevations of the potentiometric surface above sea level.
PUMPING WELL METHOD

A row of pumping wells could be installed parallel to the coast. These could create a trough in the potentiometric surface lower than either sea level or the well-field areas behind the trough. The trough wells would pump salty water, which would not be suitable for most uses. However, wells behind the trough would pump fresh water (Fig.5.3).

There are numerous workers who have worked on prevention and control of sea water intrusion. Recently Ballukraya and Ravi (1998) and Nazimuddin and Baba (2002) have proposed some measures in prevention and control of sea water intrusion.

In Bhatkal and Shirali area the groundwater occurs in the highly porous and fractured weathered laterites under phreatic conditions. The cities are developed close to the coast. The groundwater is extracted or developed by dug wells and rarely by bore wells. The monsoon season spreads over June, July, August and September. The annual average rainfall is around 5000 mm. The aquifers around the study area are easily and quickly filled or saturated with water. There are number of dug wells whose potentiometric surface during monsoon months is close to the ground level or over flows. After monsoon season i.e. during December, January and February months the potentiometric surface in the dug wells goes deeper and some dug wells go dry in April and May months.

This over flow of dug wells during monsoon and their drying out during summer is clear indication of highly permeable rock formation (laterite), which acts as potential aquifers.

A masonry barrier is constructed to the river Sarbi and is called Kadvinkatte dam (Photo1.6). The water stored by this barrier is used through canal system for agriculture. The dug wells existing down river direction yield little water during summer months i.e. March, April and May. Those wells, which are away from the reach of the groundwater flow from the Kadvinkatte dam, go dry during summer months. There is free movement of groundwater towards sea, i.e. base flow towards sea. Due to this reason the dug wells...
yielding large quantity of water during monsoon months go dry during summer months. There is little chance of sea water encroachment in monsoon months. However, sea water intrusion is possible in summer months.

Most of the groundwater is developed by dug wells and not by bore wells. Even though there is sea water intrusion it is at deeper levels and not in the shallower levels. Thus, the dug wells away from coast rarely encounter any sea water intrusion. There is need to monitor the withdrawal rate in the dug wells close to the coast.

The qualitative and quantitative estimation of the depth of sea water and fresh water interface and rate of fresh water discharge to sea, upcoming of interface and rate of pumping in the study area are explained in last chapter.

The three popular methods regarding the restriction of sea water mentioned earlier in this chapter do not suit for the study area. However, a slight modification of the injection well method helps in maintaining the interface between sea water and fresh water closer to the coast. This method is explained below.

3. PROPOSED MANAGEMENT OF SURFACE AND GROUNDWATER RESOURCES

The fresh water should be made to flow to a canal or trench opened up parallel to the coast. The water is forced to flow into such canal or trench. The dimension of the canal or trench should be 3 to 4 meters in width, 10 to 15 meters in depth and length as many meters as possible. The length could be specified depending upon the distribution of withdrawal wells along the coast. The location of the canal or trench should be close to the coast and all the withdrawal wells should exist on the landward side of the canal or trench. The above explanation is diagrammatically presented in Fig. 5.4 [A, B AND C].

The Fig. 5.4 (A) is an areal view of the proposed management of surface water and its recharge to the ground to maintain sea water and fresh water interface close to sea. The sketch shows the canals carrying fresh water. The source for such canals
could be tanks or reservoirs may be natural or artificial that can store water during monsoon season. Such stored water is used in dry season and made to flow into the canals shown to carry fresh water to the trench or canal for recharging groundwater or to maintain sea water and fresh water interface. The canal carrying fresh water should be lined one otherwise fresh water will be lost on the way. The concrete lining should be performed to the canal till it reaches the recharging canal. Minimum sea coast distance of 100 meters is proposed for the construction of recharging trench or canal. The withdrawal wells are shown by the circle marks and their locations should be on the landward side of the recharging canal and not on the other side.

The Fig. 5.4 (B) is cross sectional view to show how the recharging trench or canal helps infiltering fresh water into the ground. The highly porous and permeable laterites help and with ease accept the infiltering water.

The Fig. 5.5 (C) is another cross sectional view to show that the recharging of freshwater to keep the interface close to sea and do not allow sea water intrusion into the fresh water aquifer. The entire wells existing on the landward side of the recharging canal is avoided by sea water intrusion and always yields fresh water.

The chance of sea water intrusion is more during dry season. Therefore, the recharging of fresh water need to be carried out during dry seasons i.e. in summer months. Natural recharging is possible during monsoon months and the chance of sea water intrusion is less or nil. The existing Kadavinkatte reservoir can be used as a source of fresh water in the study area. Many more similar reservoirs need to be constructed selecting suitable sites with the guidance of Geologists and Engineers. Further, the sites should be finalized by taking into account of the topography, drainage, lithological characters including structures possessed by them. The meteorological studies related to rainfall, surface flow and evaporation have to be studied in detail.

Once the reservoirs are made by constructing either earthen or masonry barriers for rivers and streams the stored fresh water can be used for recharging. Utmost care should be taken to avoid any fresh surface water joining the sea i.e. surface flow to sea should be avoided or minimized by constructing one or more barriers to the rivers before
it joins the sea. Control of fresh water movement to sea is possible, but it is difficult or not possible to control the base of fresh water to sea.

4. RESTRAIN OF SEA WATER TRANSGRESSION INTO THE RIVERS

During sleek period of river flow there is movement of sea water into these rivers (Chapter IV, section 13). This causes infiltration of sea water into the subsurface and contaminates the fresh water aquifers. This sea water transgression into the rivers could be controlled by putting sand or sand plus cement bags into the river bed/ channel. The dumping of bags could be made at selected place where the width of the river is less. Such places are shown in the Fig.5.5 for the two rivers of study area. The structure created by the dumping of the bags will help in controlling the movement of sea water into the rivers. This further helps in averting contamination of sea water into the fresh water aquifers.

The drawback of this process of lying the sand or sand plus cement bags is that during monsoon period these will be washed off due to strong current of water in the rivers. It is therefore necessary to lay down the bags again after monsoon season to prevent sea water transgression into the rivers. Therefore the construction of masonry barriages is advisable in the proposed spots/locations.

The proposed method could be used along any sea coast with similar situation of groundwater conditions. The author has proposed the management of the present area through some funding agencies and come out with concrete results.