

## EXECUTIVE SUMMARY

Water is vital to life and development in all parts of the world. Although water is very important key element for all activities related to life, it is scarce. In certain reaches, the surface water contributes to the subsurface water while in some other cases groundwater may emerge to surface as surface water. Surface water sources are limited in nature. Ground water is a precious and the most widely distributed resource of the earth. It is the largest source of fresh water on the planet excluding the polar icecaps and glaciers. The source of natural replenishment to groundwater is infiltration from precipitation.

The availability of fresh water is going to be the most pressing problem over the coming decades. Increasing demand and decreasing availability of fresh water is bound to result in water scarcity in near future. It is now widely accepted that the solution to the water scarcity lies only in efficient use of available water by good water management. Artificial recharge is necessary to save water in times of water surplus, for use in times of water shortage. Limited natural rainfall recharge and increased water usage calls for conservation as well as augmentation by artificial recharge.

An estuary is the tidal mouth of a river. In other words an estuary is the area in which mouth of river meets the ocean. Along the coastal line of India, numerous bays and gulfs are formed where big or small rivers meet, thereby forming estuarine zone. In many coastal areas, the ground water gets contaminated not only from sea to which one face of the aquifer is connected but also from the tidal water of the overlain estuary. The impoundments sited on the estuary reaches will create imbalance in both surface and ground water regimes. In coastal aquifer which is in contact with saline water from the sea on one side, a change in discharge of fresh water towards the sea from the land ward side and infiltration from the estuary, recharge from the rain or water body into the aquifer creates the complex problem

Construction of weir on river estuary provide a standing pool of water over radial collector wells and provide a surface barrier to prevent tidal water from entering collector well areas. The present study is related to groundwater fluctuations in Mahi estuarine area which is laying in part of three districts of Gujarat namely Anand, Vadodara, and Bharuch. The study area comprises an area of 2298.23 sq. km. The Mahi River is one of the major west flowing rivers, flowing through Central Gujarat and meeting Arabian Sea

in the Gulf of Khambhat near Kavi. Vadodara Mahanagar Seva Sadan and many industries near Vadodara are taking water from Mahi River for potable and industrial uses by constructing radial collector wells. The outflow of Mahi River in to the sea is being decreased due to construction of structures like Bajaj sagar, Kadana, Panam dams and Wanakbori weir. The tidal effect of sea in the Mahi estuary has increased the sea water intrusion in the land ward side. The groundwater has been contaminated over the period and the quality of the ground water is continuously deteriorating due to the increasing rate of withdrawal and the aquifer having not been recharged at the same rate on account of erratic rainfall pattern in Mahi estuarine area. Major portion of this area is comprises agricultural land. The groundwater system of this area is dynamic in nature because of monsoon recharge due to rain, irrigation return flow and groundwater pumping. The water level and water quality are also affected by natural recharge of surface water of River Mahi.

The present study attempts modeling of groundwater regime in the study area. The groundwater system of the study area is characterized by using inverse modeling and aquifer hydraulic conductivity values are obtained. The groundwater fluctuations are obtained during study period using model simulation. The software Groundwater Modeling System (GMS) 6.0 is used. Single layered unconfined aquifer is assumed. Mass balance of surface water and groundwater of unconfined aquifer is computed. The effect of fresh water pool, created by construction of weir, on adjoining groundwater table is investigated. Here an attempt is made to study the impacts of existing and future weir on artificial groundwater recharge in the region of Mahi estuarine area. The analysis has been carried out using Layer Property Flow (LPF) package of MODFLOW-2000 (based on Finite Difference Method) in GMS 6.0. Base map, fence diagram and longitudinal sections along Mahi River, along right as well as left bank have been prepared to study the geology of the study area. It is found that the general geology confirm to alluvial area consisting alternate layers of clay, sand, gravel, occasionally mixed with kankar.

The study area is divided in to 8 recharge zones, 23 Horizontal permeability and specific yield zones. 3D Grid created contains 75 columns and 75 rows is formed. The Groundwater model has been calibrated and validated. It is required to know the future behavior of the groundwater system in response to the applied hydrologic stresses. When the research was initiated there was a proposal to build a weir near Sindhrot. Sindhrot weir near Sindhrot village was constructed in the year 2007. The people on the

downstream demands another weir to construct at Badalpur. So here a study of different following scenario is conducted. Scenario A-Without Weir, Scenario B-With Sindhrot Weir and Scenario C-With Sindhrot and Badalpur Weir

The top elevation of both weirs is given as RL 8.5 m considering high tide level as RL 6.95 m at weir location. The full reservoir level is kept as 8.0 m. For the above mentioned three scenarios model was run and results obtained are analyzed. To study the artificial recharge scenario, nature of water mound for Sindhrot weir and Badalpur weir on different dates are plotted.

Pre-monsoon and post-monsoon water mound nature is studied. Area of influence is more at Badalpur weir as compared to Sindhrot weir. The Badalpur weir is about 41.66 km downstream of Sindhrot weir. To study the effect at same point time series curves are plotted at 12 different locations. Reduced water levels are found to be showing rising trend with weir compared to without weir. Finally predictions are made for effect of alternative locations of weir on recharge of estuary area.

The relation between salinity and distance from sea are obtained. Water quality of unconfined aquifer is studied with reference to natural recharge from river. To establish relationship between Total Dissolved Solids of groundwater (to judge salinity) distance from the place Kavi (starting of sea) and Reduced groundwater level Multiple linear regression analysis has been carried out. Equations are established by taking average groundwater quality of 12 years.

Year wise Average Equation for left bank is  $X_1 = 2582.76 - 27.52X_2 + 2.99X_3$

Year wise Average Equation for right bank is  $X_1 = 1382.95 - 14.20X_2 + 5.75X_3$ .

Year wise Average Equation for both bank is  $X_1 = 1712.72 - 4.16X_2 - 20.27X_3$

Where,  $X_1$  = TDS in ppm,  $X_2$  = Distances from sea (Kavi) in kms and  $X_3$  = Reduced groundwater Level in m.

The analysis indicates that as the distance from sea increases the water quality improves. The regression analysis leads to conclusion that the correlation coefficient 'r' for multiple linear relations between TDS of groundwater and two parameters i. e. distance from sea (Kavi) and Reduced Water Level (RWL) for left bank, right bank and both banks are found well within the range.

Water samples of 36 wells parallel to Mahi river in May and Nov. 2003 collected and tested for important parameters like EC, PH, TDS, Ca, Mg, Na, CO<sub>3</sub>,HCO<sub>3</sub>, Cl,SO<sub>4</sub>, K and TH The results are graphically represented as TDS, Cl and TH v/s distances from sea (Kavi) and distances from centre line of river. The analysis indicates that the water quality improves as the distance from sea or river increases.

Same model can be applied for western India Rivers and other similar rivers in the world.