CHAPTER I

INTRODUCTION

"This (water) marvellous element which can bring life to all things" (Quran), constitutes 71% of the earth surface. The water being so abundant is still a rare commodity, the freshwater which is available for human consumption is only 0.71%. This has necessitated a detailed appraisal of fresh water resources all over the world. The national and international policies on exploration, exploitation and management of water resources have been evolved in order to conserve the scarce freshwater resources and to facilitate its equitable distribution.

India has been well endowed with fresh water resources, but it has spectacle of scarcity with plenty, the quantification of the resource data base has not been done so far which is necessary for optimum utilization and management of the groundwater and surface water in an integrated manner. Efforts in this direction have been initiated by the government, prompted by unprecedented drought and floods in the different parts of the country (Ramesam, 1989).

The Ganga Basin which is literally floating over fresh water underground reservoirs is facing problems for supply of drinking water to some critical areas which has necessiated Water Technology Mission to tackle the problem (Karanth, 1987). In persuance to programme of regional assessment of groundwater the present study was carried
out in Ganga-Kali sub-basin as part of Ph.D. programme, which forms part of the Central Ganga Basin (Fig. 1). The study was directed to evaluate the aquifer system and groundwater resource potential of the Ganga-Kali sub-basin in parts of Aligarh and Etah districts. The choice of the area was made due to its representative character, the basin presents a dual situation that is one of water logging and soil salinisation in canal command areas and depletion of aquifers in western part of the basin (Fig. 2). The quantified data base generated for the Ganga-Kali sub-basin will provide bench mark data for environmental monitoring and hydrogeological management of the basin.

**Area:** The area is located in the semiarid ecosystem of the Central Ganga Basin. Geomorphologically, it occupies the Interfluves between the Ganga and Yamuna flood plain. The Ganga and Kali rivers form the eastern and western limits of the area. Administratively, it is located within Aligarh and Etah districts and is included in parts of survey of India toposheet No. 53I and 54I.

Systematic hydrogeological survey and sampling were carried out in an area of 1340 Sq km covering Latitudes 27°47' to 28°09' N and Longitudes 78°12' to 78°45' E. The area is well connected by rail and road from Aligarh and Etah which are district Headquarters. Almost all the villages are well connected by motorable roads. Atrauli and Kaganj are the important towns in the area with suitable camping facilities.
Methodology:

In order to generate quantitative data base on hydrogeological parameters and hydrochemistry, systematic groundwater surveys were carried out supported by laboratory investigations.

(i) The literature pertaining to study area was collected and background information on the state of art was generated.

(ii) Toposheet and LANDSAT Imagories of the study area were consulted to generated base map for the field survey. The LANDSAT T.M, F.C.C. relevant to the area were interpreted and various land forms were demarcated.

(iii) Rainfall data and various hydrological data pertaining to the area were collected. The rainfall data were analysed and the mean, standard deviation coefficient of variation and occurrence and frequency of droughts were determined for the period 1901 to 1989.

(iv) The reconnaissance survey of the area was carried out with selective ground checks. A network of 160 observation wells was established. The wells were located in such a way so as to cover 4 Sq. km. cells per well. Hydrogeological data and groundwater samples were collected from the observation and other wells in the area.

(v) Repeat measurements to monitor the changes in water level, for pre and post monsoon water level were made during 1988 and 1989.
(vi) The aquifer material (sand samples) were collected from various drilling sites and also from the river Ganga and the Kali beds through trenching. The aquifer materials were mechanically analysed and data obtained were plotted on grading curve and various parameters like effective grain size, sorting coefficient and hydraulic conductivity were determined.

(vii) Pumping test were conducted at two different sites to determine the aquifer characteristic i.e. storativity, hydraulic conductivity and transmissivity.

(viii) In all, 87 groundwater samples were collected from different groundwater structures like open wells, shallow and deep tubewells in duplicate to see vertical and lateral variation in quality. One group of sample was kept for physicochemical examination while the others were immediately acidified with 10 ml 6N HNO₃ and kept for trace element studies. To study the chemical quality of surface water bodies and its inter-relationship with groundwater samples were also collected from the Ganga, Kali and lower Ganga Canal.

(ix) Lithological logs of deep tubewells in the area were collected and fence diagram and various cross sections of the study area were prepared.

(x) The hydrogeological data of dug wells were processed, plotted and interpreted. Various maps like depth to water map, water table contour maps and water level fluctuation maps were prepared. Hydrographs for a period of 15 years were prepared to analyse the changes in the groundwater regime in time and space.
Water samples were analysed for major and trace elements to determine its quality for domestic and irrigation uses. Various hydrochemical facies were determined through trilinear diagram.

Concurrence and synthesis of hydrogeological, hydrological, hydromorphological, hydrometeorological, hydrochemical data was attempted to generate the model for groundwater regime of Ganga-Kali sub-basin presented in the present thesis.

State of Art:

The series of developments in hydrogeology between 1856 and 1955 helped to establish the principles of groundwater resource evaluation.

Darcy (1856) did experimental work on the flow of water in sand and derived formula known as Darcy's law, which expresses the relationship between the velocity of percolation, permeability of water-yielding material and hydraulic gradient. Darcy's law serves as the basis for subsequent attempt on quantification of groundwater resource.

Theim (1906) developed an equation for steady state flow conditions of groundwater. Thies (1935) gave the non-equilibrium formula for unsteady state flow to a well discharging from a confined aquifer. Several workers since then have formulated equations relating to discharge from an aquifer to the head difference under the different conditions like leakage from overlying aquitard, delayed yield, large
diameter wells, multi aquifer system etc. (Jacob, 1946; Boulton, 1963; Huntush, 1956; Walton, 1962; Pricket, 1965).

The last three decades have seen phenomenal growth in the science of hydrogeology. It is now not limited to resource aspects and hydrodynamics but encompasses physical chemical relations and responses, occurrence, movement and energy storage in the aquifers. Besides, the resource potential, the area is looked into its entire vertical profile from atmosphere to Lithosphere (Ramesam, 1987).

Development of information system and computerized groundwater data bases with telemetric link to ground instruments on real time basis, studies on recycling of resource, Krigging techniques for evaluating regional variable out of sparse data and groundwater modeling using finite difference and finite element models to solve groundwater flow and solute transport problem etc. are some of the modern fields in groundwater research (Marsily, 1986; Bear, 1987; Ramesam, 1987).

Systematic groundwater exploration was taken up in early fifties by the Central Groundwater Board, in India was initially confined to resource evaluation in the unconsolidated formations. The activity extended to the hard rock regions about 20 years latter. The techniques of exploration primarily consisted of geological reconnaissance, occasional geophysical survey and actual drilling. Today resource estimation at microlevel for some of the river basins through water budgeting studies are available (Ramesam, 1987).
Co-incidental with the water balance studies a few research project of problems specific or location specific nature have been under taken (Kamesam, 1987). In recent years monitoring of the effects of the withdrawals on the groundwater levels and regional decline in water levels has been gaining importance (Kao, 1986).

A concerted thrust on Research and Development in Groundwater with identified areas of research duly supported by requisite budget allocations however has been lacking. As the country is marching towards 21st century by which time the total annual replenishable recharge from rains to the groundwater body would have been fully utilized, the conservation of existing finite resource, its augmentation protection and judicious exploitation would require urgent attention.

Previous work in the Area:

Prior to the present investigation various agencies had undertaken hydrogeological investigations of the study area for different purposes.

The exploratory tubewell organisation, carried out exploratory drilling and short duration pumping tests in Atrauli area, (Anon, 1964), which indicate that transmissivity range from 636.48 to 2327 m²/day and the storage coefficient varies from 3.17 x 10⁻³ to 3.9 x 10⁻².
Rao et al. (1965) carried out exploratory drilling and also determined the aquifer parameters through pumping tests at Tikta Village. They reported the value of transmissivity as 914.55 m²/day and specific yield value 8.75 percent.

Dutt (1969) studied the hydrogeology and water logging conditions in Aligarh district. He reported that the seepage from the Ganga canal has created water logging conditions in the area. He also conducted short duration pumping test in Atrauli area and determined the value of Transmissivity and permeability as 576 m²/day and 22.2 m/day respectively.

In Bijauli area three to four-tier aquifer system occurs down to the depth of 143 m b g 1. These aquifers laterally merge with each other and behave as a single aquifer system; upto 1986 only 42% of total groundwater resources of Bijauli block had been developed (Ahmad et al., 1989).

Specific yield estimation at Charra village using radio active tracer techniques were carried out simultaneously. Pump test and grain size analysis were attempted to compare the results. The transmissivity and permeability values obtained through radio-active tracer techniques, the pumping test and grain size data analysis are in agreement and exhibit general correlation. However, the values of specific yield obtained by grain size analysis slightly differ with results obtained through the pumping test and radio-active tracer techniques (Raja et al., 1989).
Present Work in the Area:

The geomorphology, geology, hydrogeology, hydrochemistry and water balance studies of the area have been described under the present study to provide quantitative data base.

The geomorphological studies have helped in delineating various land forms such as paleo channels, meander Scroll, scars etc.

Geologically, the area comprises quaternary alluvium. The Neogene Siwaliks sandstone occurs as sub-crop at 360 metres b.g.l. and forms good aquifer zone between 360-410 metres b.g.l. Below 410 m the groundwater is saline in nature. The Siwalik sandstone unconformably overlies the Upper Proterozoic Bhander Limestone of Upper Vindhyan Group which in turn directly overlies the Bundelkhand granitic massif at a depth of 2062 below ground level.

Hydrogeologically, the area has two to three-tier aquifer system down to 150 meter b.g.l. which laterally merges into single bodied aquifer system. The study shows that the aquifer upto 90 meter depth are unconfined and below 90 meter they are confined in nature.

The ground-water of the basin is potable, hard, alkaline in reaction and moderately mineralised. It is alkali bicarbonate typo, suitable for drinking and irrigational purposes. However, the results of chemical analysis show that the groundwater from the shallow aquifers is having concentration of heavy toxic trace elements (slightly higher than the permissible limit which may prove detrimental to human health.
The water balance studies indicate availability of surplus groundwater resources of 169.4 M.C.M. in 1340 square Kilometre basinal area, capable of supporting 588 deep and 3670 shallow tubewells in addition to the existing tubewells. Further, it is suggested that the aquifer lying below 150 meter be thoroughly explored both quantitatively and qualitatively to meet the demand for future water supply.

The area has 48% development but still the scenario is that the basin is partly grey and partly white which is due to faulty management and exploitation policies in the area. The present study will provide the bench mark data for environmental monitoring and hydrogeological management of the basin. It will also serve as a standard for modeling the temporal changes in fragile ecosystem of the Ganga basin which is having a potential danger of pollution from Narora Atomic Power Plant which is located about 12 km in the upstream side of the basin and also the petrochemical complexes emerging in the Gangetic Plain.