2.1 GEOGRAPHIC SETTINGS

Chandigarh the “CITY BEAUTIFUL” is a Union Territory and is fast emerging as one of the most advanced cities of India. It is located at the foothills of the Siwaliks. It lies between latitudes 30° 40' 3” N and 30° 47' 45" N and longitudes 76° 42' 20" E and 76° 50' 59" E and falls in Survey of India topographic sheet numbers 53B/9, 53B/10, 53B/13 and 53B/14. The city is spread over an area of 114 km², out of which 36 km² is rural and remaining 78 km² is urban. Figure 2.1 shows the location of the study area. The city is divided into 63 dwelling sectors. It is surrounded by Patiali Ki Rao in the north west and Sukhna choe in the north east direction in the Ghaggar river basin. The city also has the distinction of being the joint capital of Punjab and Haryana states even though it does not form part of any of the two states. The concept of setting of new capital of the then Punjab, after the partition of the country in the year 1947 was initiated by (late) Pandit Jawahar Lal Nehru, first Prime Minister of India and a French architect, Le Corbusier was entrusted the job of planning the city. It is planned with well designed network of water supply and sewerage system. As per bye-laws of the city, every dwelling unit is required to be connected to water supply and sewerage network. While planning the city, a particular emphasis was laid on provision of green spaces and parks throughout the city.

2.2 CHRONOLOGICAL DEVELOPMENT OF CHANDIGARH

Originally the city was planned for a population of 5 lacs. But with the development of Phase-I and Phase-II of the city, the population has grown exponentially. Accordingly, the need for augmentation of the infrastructure also increased. The city has undergone phase-wise development in the past. The enhanced water demand in the recent past and the non-availability of the suitable surface water sources to augment the water supply system has increased the pressure on the groundwater resources.
2.2.1 Built-Up Area

The Phase-I of Chandigarh was developed with sectors 1 to 30, which was completed by 1975. The tubewell based water supply system was planned for the Phase-I of the city. Development of Phase-II comprising sectors 31 to 47 was started simultaneously with the completion of the Phase-I. As on date, the Phase-I and Phase-II sectors are fully developed. However, the development of Phase-III sectors, comprising sectors 48 to 56 is still in progress. The chronological development of the city with respect to the increase in the built-up area is shown in Figure 2.2 and 2.3. Figure 2.4 indicates exponential growth in the built up area of the city.

![Figure 2.4 Growth of built-up area in Chandigarh](image)

2.2.2 Population v/s Water Demand

The population of the city was 9.00 lac as per the Census of India, 2001 and the projected population by the year 2031 is 14.8 lac (Census, 2001). Table 2.1 shows the decadal increase in water demand vis-à-vis growth in population.
Figure 2.2 Built-Up Area in 1961 and 1971

Legend
- Lake
- Built-Up Area
- Roads
- Choes
- UT Boundary
Figure 2.3 Built-Up Area in 1981 and 1991
Table 2.1 Population v/s Water Demand

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Year</th>
<th>Population (in Lacs)</th>
<th>Total Water Requirement (MLD)</th>
<th>Availability of water (MLD)</th>
<th>Gap/ Shortfall (MLD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1991</td>
<td>6.42</td>
<td>377</td>
<td>304</td>
<td>73</td>
</tr>
<tr>
<td>2</td>
<td>2001</td>
<td>9.00</td>
<td>530</td>
<td>395</td>
<td>135</td>
</tr>
<tr>
<td>3</td>
<td>2011</td>
<td>10.54</td>
<td>620</td>
<td>395</td>
<td>226</td>
</tr>
<tr>
<td>4</td>
<td>2021</td>
<td>12.5 (P)</td>
<td>720</td>
<td>395</td>
<td>276</td>
</tr>
<tr>
<td>5</td>
<td>2031</td>
<td>14.8 (P)</td>
<td>870</td>
<td>395</td>
<td>317</td>
</tr>
</tbody>
</table>

(P) Projected population, (Source: PHED, 2011)

At present the city receives 395 MLD of water out of which 70 MLD is derived from the groundwater resources. It can be seen from the table 2.2 that the gap between the demand and supply of water is expected to increase further. As there is little likelihood of increased water supply from the Bhakhra Main Canal (Surface water source) due to interstate water sharing policies, the city is expected to depend more on the groundwater resources to meet this gap in supply and demand.

2.3 HYDRO-GEOLOGY OF THE STUDY AREA

The hydro-geological setting of Chandigarh in Ghaggar Basin has been outlined in CGWB (2002) and Sharma (2007). Figure 2.5 depicts the geological map of the study area. Chandigarh is occupied by semi consolidated formations of upper Siwalik system of middle Miocene age and is exposed in north eastern fringe whereas Indo-Gangetic Plain in the rest of the territory is occupied by the alluvium of Pleistocene age. The piedmont deposits at the foot of Siwalik Hills are occupied by cobble, pebble and boulder, associated with sand, silt and clay. The piedmont deposits are followed by alluvial plain composed of clay, silt and sand. The soils in the area are loamy sand at surface and calcareous sandy loam in subsurface layers of geological formations. In northern parts, the soil is sandy to sandy loam whereas, it is loamy sand to silt loam in southern parts. The salient hydro-geological features are:
CHANDIGARH

Legend

□ CHANDIGARH BOUNDARY
-------- CHOCS
LOOSE GREY MICACEOUS SAND AND
PEBBLES ALONG STREAM COURSES
BLUE GREY TO LIGHT GRAY MICACEOUS SAND,
PEBBLES WITH INTERBANDS OF PURPLE/RED CLAY
— NEWER ALLUVIUM
HOLOCENE

RED SOIL, ADMIXTURE OF CLAY, SILT AND SAND WITH
KANKAR. GREY MEDIUM TO COURSE MICACEOUS SAND WITH
KANKAR INTERBEDDED WITH CLAY AND SILT
— OLDER ALLUVIUM
MID TO LATE
PLEISTOCENE

Figure 2.5 Geological Map of Study Area
a) The Siwalik range trending NW-SE forms the north eastern boundary of Chandigarh. These hills often attain a height of 200m above the immediate surroundings. The Siwalik Hills are exposed in a small patch in the north eastern side.

b) South western slopes of the foot hills are covered with loose talus material deposited by hill torrents forming alluvial fans. These alluvial fans coalesce to form piedmont Kandi formation running parallel to the hill ranges. The surface gradient is NE to SW and varies between 37 m/km near foot hills and 9m/km away from hills.

c) The Kandi formations merge into Sirowal formations in south and south west. The land surface in Sirowal tracts has an average gradient of 3m/km.

d) The Sirowal merges with the main alluvial plain towards south and south west. The alluvial deposits belong to Quaternary age and comprise layers of fine sands and clays.

Figure 2.6 shows the geomorphological settings of the study area. The northwestern part of the city comprises piedmont slope while the northeastern part comprises residual hills.

2.4 DRAINAGE

As indicated in figure 2.1, there are two major streams which originate from Siwalik ranges and forms the natural drainage of the city. The Sukhna choe flows north to south, drains the eastern part and joins the Ghaggar river. The other important stream is Patiala-ki Rao which flows north east to south west and drains the northern parts of the city. Both these streams are ephemeral in nature and carry high flows during monsoon. The N-choe flows through the Leisure Valley and drains major parts of the city. It flows from north east to south west direction and traverses north central part of the city. Another choe, Choi Nala originate from Sector-31 and drains southern part of the city.
CHANDIGARH

Figure 2.6 Geomorphologic Setup of the Study Area
2.5 CLIMATE AND RAIN FALL

The climate of the Chandigarh is humid subtropical continental type with summers and winters exhibiting extreme temperature interspersed by monsoon. The normal annual rainfall of Chandigarh is 1074 mm. About 80% of normal annual rainfall is received during south west monsoon from end of June to middle of September. July and August are the wettest months of the year. During rest of the year 20% of annual rainfall occurs during winters. The mean maximum and minimum temperature are 40 ± 4 °C in June -July and 6 ± 2 °C in December - January, respectively. Mean monthly temperature and distribution of rainfall throughout the year are presented in table 2.2. The highest relative humidity touches 80% during July – August whereas, the lowest relative humidity values of 26% recorded during April - May.

Table 2.2 Climate data for Chandigarh

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average temperature high °C</td>
<td>20</td>
<td>23</td>
<td>28</td>
<td>35</td>
<td>38</td>
<td>39</td>
<td>34</td>
<td>33</td>
<td>33</td>
<td>32</td>
<td>27</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>Average temperature low °C</td>
<td>6</td>
<td>8</td>
<td>13</td>
<td>19</td>
<td>23</td>
<td>25</td>
<td>24</td>
<td>23</td>
<td>22</td>
<td>17</td>
<td>11</td>
<td>7</td>
<td>16.5</td>
</tr>
<tr>
<td>Precipitation - mm</td>
<td>33</td>
<td>39</td>
<td>30</td>
<td>9</td>
<td>28</td>
<td>14</td>
<td>280</td>
<td>308</td>
<td>133</td>
<td>22</td>
<td>9</td>
<td>22</td>
<td>1,058</td>
</tr>
</tbody>
</table>

Source: Chandigarh, 2009

The wind velocity is maximum during May at 8.4 km per hour while it is minimum during September at 3.2 km per hour. The average annual evaporation for Chandigarh works out to be 21.10 mm. The lowest monthly evaporation for city works out to be 7.2 mm during January and highest of 36.3 mm during May.
2.6 LANDUSE/LANDCOVER MAP

Figure 2.7 shows the landuse/landcover map of the study area. Table 2.3 compiles the percentage area covered under each class of landuse. Built-up class is the major category of landuse in the study area which covers about 80 percent of the total area.

<table>
<thead>
<tr>
<th>Landuse/Landcover</th>
<th>Percentage Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense forest and Parks/Plantation</td>
<td>7.70</td>
</tr>
<tr>
<td>Built up</td>
<td>77.70</td>
</tr>
<tr>
<td>Water body</td>
<td>4.70</td>
</tr>
<tr>
<td>Agricultural use/vacant land</td>
<td>8.15</td>
</tr>
<tr>
<td>Industrial</td>
<td>1.75</td>
</tr>
</tbody>
</table>

2.7 WATER LEVEL FLUCTUATIONS

The water level fluctuations in the deep and shallow aquifers of the study area were presented in Figures 2.8 through 2.10. The water level in the study area was found to be showing a declining trend in the deep aquifers in the study area. Whereas, a rising trend was observed in shallow aquifers in the south west region. The depth of water level in deep aquifer was reported to be 15 to 70 m below ground level and in the shallow aquifer, it ranged from 2 to 17 m below ground level (CGWB, 2002). Figure 2.8 indicates that in pre monsoon, the depth of water table was found to be less than 10 m in deep aquifers in the south west area and more than 20 m in the north east area. However, the water table rises slightly in the post monsoon throughout the area of study. Figure 2.9 shows the area under more than 20 m deep category decrease in the post monsoon. In case of shallow aquifers, it showed an increasing trend in south west area and a decreasing trend in the north east region of the study area as presented in Figure 2.10.

2.8 SUMMARY

Due to the increasing population and urbanization in Chandigarh, there is enormous pressure on the groundwater resources of the area. There is no single agency in the area dealing with groundwater management. In order to have proper management of groundwater in the study area, the diverse database including hydro-geological and groundwater quality has to be brought on a single platform for development of proper groundwater management tools. The present study is, therefore, an attempt to improve the status of database management and groundwater quality in Chandigarh.
CHANDIGARH

Figure 2.7 Landuse/Landcover Map of the Study Area
CHANDIGARH

Legend
Depth to Water Table in m

\(<10\) dH la-ie

\([10-12]\)

W -16 |_ "lyj Boundary D 0^0^ *m

Figure 2.8 Depth to Water Table in Deep Aquifer System Pre Monsoon
Figure 2.9 Depth to Water Table in Deep Aquifer System Post Monsoon
Figure 2.10 Water Table Fluctuation in Shallow Aquifer