2.1 THE HERITAGE CITY VARANASI

Present research work has been carried out at Varanasi, which is believed to be the oldest living city of the world. Varanasi is located in the north–central plains of India at 25° N latitude and 82° 30’ E longitudes, some 250 km south of Himalaya foot-hills. Mark Twain, the well known author and philosopher noted “Banaras (a mispronunciation of Varanasi) is older than history or tradition, older even than legend, and looks twice as old as all of them put together” (Agrawal, 2002). It has been the fountain head of Indian knowledge, culture, spiritualism and learning since times immemorial and students flocked here for higher education from all over India. Since middle ages (12th Century to date) it also became a centre of excellence in arts and crafts including music, dance, silk, gold-embroidery, etc. No other city in the entire world could have a more justified claim for being a “Heritage-City”.

The importance of river-waters to the city is amply shown by the fact that it was planned to be bounded by perennial river-streams on three sides: Varuna on north, Assi on south and the mighty Gangaji on east, flowing south to north as a rare deviation from the general direction of flow from NW to SE. The left (or western) bank of Gangaji and right bank of Varuna, had continuous bathing ghats built in masonry to bound the rivers and attracted a lot of bathers from all over the country as also cultural and other on-the-river and on-the-bank activities.
The stable population of the city used to veer around 0.30 million till India became independent in 1947. Besides, there used to be some 10,000 pilgrims and visitors on a normal day rising to 50,000 or more on auspicious occasions. The population has grown rapidly after 1940s. It was 0.5 million in 1961 and 1.03 million in 1991. It is estimated to have crossed 1.4 millions in 2006. Besides there are at least 25,000 pilgrims and tourists on normal days and their number crosses 100,000 on auspicious occasions.

2.2 BACKGROUND INFORMATION ON GANGA

(a) Physical Features of the Ganga Basin

The main riverine systems of the Indian sub-continent are shown in Fig. 2.1. The dominance of the overbearing influence of the Himalayas is evident from the fact that the three major river systems, the Sindhu, the Ganga and the Brahmaputra originate in the lofty heights of the Himalayas. The countries which are co-riparian or share the basin of the Ganga are, India, Nepal and Bangladesh.

The Ganga Basin is one of the most densely populated river basins of the world and as of 1983 sustains life of 200 millions in India, 12 millions in Nepal and 30 millions in Bangladesh. The total drainage area of the Ganga upto Goalundo is 1,66,834 sq. kilometers of which 1,28,411 sq. kilometers are in India. The vastness of the Ganga Basin is reflected in the diversity of its physiography, climate, soils, agricultural development and other related characteristic.

The average annual rainfall over the Ganga Basin varies from 78 cm in the upper part, 104 cm in the middle course and 182 cm in the lower delta of Bangladesh. Most of the rainfall occurs during the South-West monsoon
Fig. 2.1

MAJOR RIVERS OF INDIA

Ganga River
season. Large scale modern irrigation projects have been initiated over the last one hundred years. Irrigation for production of food is the main use of the water. The total cultivable area of the basin is 21,109 sq. kilometers. The cultivable net sown area covering eight States in India is $0.6 \times 10^6$ hectares (Rao, 1975). The present surface water availability in the Ganga basin is about 446 million acre feet (MAF) in India.

(b) Course of the river Ganga

The river Ganga occupies a unique position in the ethos of the people of India. Emotional attachment to the river and to the centre of pilgrimage on its banks, runs deep and long into Indian history. Ganga originates at Gomukh (Fig. 2.2) at a height of nearly 4000 meters on Himalayan ranges before entering the plains. Emerging as Alakananda, from an ice glacier beyond the Mana pass, 8 km away from the pilgrimage centre Badrinath, the Ganga courses its way to the Bay of Bengal covering a distance of 2525 km through U.P., Bihar and West Bengal. During its long course, it embraces many small torrents and tributaries of valid origin. The Ganga follows the ghatline and on the extreme west separates the sources of the Jadhganga, one of the headwaters of Bhagirathi from the Hopgadh, in its turn an affluent of the Sutlej.

First to join Alakananda on its long journey is Dhauli at Vishnuprayag. The combined stream flows south west to the Chamoli region receiving at Birahi the Rudra Ganga, Patal Ganga and Birahi Ganga. Then flowing in the southerly direction to Nandprayag, it joins Nandakini coming from the east. It turns south west again to Karnprayag, 72 km from Vishnuprayag, where it joins Pinder from the Kumaon Himalayas. The stream then flows westward and receives the river Mandakini from the
north at Rudraprayag. Turning south west it flows by Srinagar to Devprayag, 59.2 km downstream, to receive its biggest tributary, the Bhagirathi. There is a common belief that this is the real GANGAJI that emanates from the Gomukh glacier. The united stream, now known as Ganga, flows and ends its roaring journey across the hills and break through the Shiwalik range near Rishikesh to enter the plains.

From Haridwar downstream, the river is fed by Ram ganga at Farrukhabad, the Yamuna at Allahabad and the united stream moves towards Varanasi. Downstream of Varanasi, the Varuna joins the Ganga on the left bank at Khalispur. The river then flows to Ghazipur, where it joins the united stream of its two major tributaries, the Sai and the Gomti. Further downstream of the Gomti confluence, the Ganga receives the Basu Nadi on the left and the Karamnasa on the right bank at Naubatpur. Before reaching Buxer, Ganga is joined by the Thora on the right bank. It then enters Bihar passing through Ballia. At the U.P. – Bihar border, the Ghaghara which is formed by the confluence of Sarda, Sarju, Gori and Kali joins the Ganga on the left bank. In Bihar, the Ganga receives the Sone, the Gandak and the Punpun. The Gandak, which originates from Nepal and is formed by seven holy Gandakis join the Ganga on the left bank at Hazipur. After passing through Patna, it receives waters from the Patna canal and the combined stream of the Punpun, the Morhan and the Dordha at Fatuha and moves to Munger. The united stream of the Harohar, the Dhanayam, the Mohani and Dharhara Nadi join on the right bank and the Bari Gandak on the left bank. Then on its way to Bhagalpur then the Ganga passes through Calcutta as the Hugli river taking the water of Damodar the Rupnatwan and Haldi rivers and it reaches the destination Ganga Sagar.
2.3 DRAINAGE AND SEWERAGE

As the name implies, and from the age-old concept, the old city of Varanasi was bounded by River Assi in south, Gangaji on east and River Varuna in the north. This was the shape the city occupied till 1950s and included the jurisdictions of Varanasi Municipality, Hindu University, Varanasi Cantonment Board and Manduadih Railway Settlement, each of which managed their own civil services and infrastructural planning.

In earlier ages, the water-supply in the city was from wells, tanks and rivers, either used near the water sources or transported by head-load. The British established a pumping station on Gangaji and a water treatment plant based on slow-sand filters near end of 19th century. The pumping-station and water-treatment plant were expanded and modernized in stages and today handle some 250 MLD. Under World-Bank directions Varanasi Jal Sansthan (Water-Board) has been set-up to manage these in place of the earlier municipal body. Besides, the water-supplies in the University, Cantonment, Railways-Township, Ram Nagar and Mughal Sarai are managed separately by respective municipal bodies and are all ground-water based.

With introduction of piped water-supply near end of 19th century, problems of domestic wastewaters started coming-up and a masonry trunk-sewer was laid along the high-level main road from Assi to Rajghat (the northern or down-shop end of the city) by the British in 1917. With a large capacity of over 100 MLD, this old brick-sewer still serves as the main waste-water conduit for the city, though due to leakages, overflows, faulty connections, and haphazard growth of the city, a lot of sewage and sullage
escape to the storm-water drains, which hence keep flowing all through the year, even when there have been no rains for months (Fig. 2.3).

The British only built a trunk-sewer and a few branch-sewers along the main roads. Later the sewer-network kept on being expanded. The only thing that the sewer system did was to shift the point of discharge from being near bathing ghats to down stream of the main-city.

2.4 INDUSTRIES AND WASTE WATERS

The only large industry in Varanasi city is the Diesel Locomotive Works in Manduadih area employing over 4,000 workers and manufacturing diesel locomotives. Its industrial and township waste waters and the treated effluents are discharged into one of the surface drains to join Gangaji. However, operating in the city are some 3,000 registered small scale units (silk, metal-products, chemical-products and machine tools over 200 units each; food-products, plastics and wood products over 100 units each; tobacco products and leather products over 25 units each). There may be even larger numbers of unregistered units. Also there are over 5,000 house-hold handicraft units; over 2,000 brocade. 1000 embroidery, 500 zari and zardosi (gold-thread work), 1000 woollen carpet, 150 woollen toys and rest miscellaneous. Though many of them discharge small quantities of highly objectable pollutants including dyestuffs, pigments and heavy metals, to the sewers, or more often to the surface drains. The analysis of the city sewage of drain-flows clearly establishes presence of such pollutants.
Fig. 2.3: SEWER DIRECTLY CONNECTED WITH RIVER GANGA AT VARIOUS GHATS OF VARANASI
2.5 POLLUTION OF RIVERS AT VARANASI

Till the installation of three sewage treatment plants (80 MLD Activated Sludge plant at Dinapur, 12 MLD Activated Sludge plant at DLW Manduadih, and 8 MLD Trickling Filter plant at BHU) in early 1990s, all the pollutants generated in the city were reaching Gangaji directly or through surface storm-water drains or through Assi and Varuna rivers. In early 1990s the river Assi had also essentially become a drain due to changes in land-use upstream. These flows were earlier sewage/sullage of the city.

It may also be noted that the total estimated flow is about 150 MLD out of which 50-60 MLD is expected wastewater generated from 250 MLD water-uses. Probably this 50-60 MLD were reaching the rivers through leakages and seepages that were really "diffuse" and hence not easily visible to be directly estimated or were percolating underground or evaporating from stagnant pools.

Over-all one could say that the entire pollutant loads of the city were dumped into Gangaji; one would think that with such high pollutant loads joining the river, Gangaji to be a stinking mess, particularly along the left (city-side) bank. It may be noted that all the drains and diffuse-flows join from the left-bank without any diffuser or out-fall arrangements and the highly polluted inflows often stagnate or hug along this bank. Also, all bathing ghats (Fig. 2.4), the intense activity and even the "holy-dip" are essentially located along this very bank. And yet as the water-quality data for 1993, before the commissioning of the GAP (Ganga Action Plan) show, the mighty Gangaji was able to handle the load to a large extent, though not completely and probably the major concern shall only be coli forms and pathogens.
Fig. 2.4: PEOPLE BATHING, USING SOAPS AND POLLUTING THE RIVER GANGA WATER ON VARIOUS GHATS AT VARANASI
The pollution of Ganga river water is mainly due to washer man (Dhobies – Fig. 2.5), buffaloes (Fig. 2.6), and people defecating (Fig. 2.7) on the bank of river Ganga and ashes left out after the burning of the dead bodies (Fig. 2.8) on various ghats.

2.6 VARANASI AND WATER SUPPLY

Varanasi is a core of the oldest living cities of the world. It is situated on the left bank of the holy river Ganga. The municipal limits of the city cover an area of around 75 sq. km. The decadal growth of the city’s population has been about 28 per cent (Table 2.1) which is not very high in comparison to other growing cities, but the urban growth in Varanasi has been haphazard and unplanned. This has resulted into stress on existing civic amenities of water supply, sewerage and road transport. The drinking water supply and the sewerage infrastructure in the city are about two hundred years old. An overview of the population and sewerage is presented below:

Table 2.1: The population of Varanasi City.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population (Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>0.355</td>
</tr>
<tr>
<td>1961</td>
<td>0.469</td>
</tr>
<tr>
<td>1971</td>
<td>0.582</td>
</tr>
<tr>
<td>1981</td>
<td>0.708</td>
</tr>
<tr>
<td>1991</td>
<td>1.050</td>
</tr>
<tr>
<td>2001</td>
<td>1.240</td>
</tr>
<tr>
<td>2006</td>
<td>1.600 *</td>
</tr>
</tbody>
</table>

* Approximate

Source: Times Group magazine 2006 entitled Bracing for Tomorrow.
A response connect initiative: p.3
Fig. 2.5: WASHermen WASHing THE DIRTY CLOTHS, USING DETEGENTS AND POLLUTING THE GANGA WATER AT VARANASI
Fig. 2.6: BUFFALOES BATHING IN RIVER AND POLLUTING THE WATER OF GANGA AT VARANASI
Fig. 2.7: PEOPLE POLLUTING THE RIVER BY MAKING WATER AND NIGHT SOIL ON GANGA GHATS AT VARANASI
Fig. 2.8: creating pollution by filtering the dead body ashes on the ghats of Ganga River at Varanasi
Fig. 2.9: DRINKING WATER INTAKE POINTS FROM RIVER GANGA AT VARANASI
The initial settlement of the city was restricted to the areas around the ghats of river Ganga. Slowly they expanded to Varuna River in the north and Banaras Hindu University in the south. In an area of about 76 sq. kms., there lives a population of about 1.6 million people*. It is said; approximately 50,000 people visit the city every day. Approximately 1,00,000 cattles also live in the city. This meant another big growth in the sewage system and increase in sewage flow into Ganga in the city.

2.7 PRESENT WATER SUPPLY AND SEWAGE:

The present supply of drinking water in Varanasi city is stated to be about 230 mld (million liter per day) out of which 110 mld is lifted from the river ganga and 120 mld from the tube wells. It is assumed that additional 150 mld world bank scheme would ultimately lead to a water supply capacity of 380 mld. This capacity of 380 mld water supply would result into $380 \times 0.7 = 266$ mld of sewage flow as per Jal Nigam Varanasi. The present installed capacity of the sewage treatment plant at Varanasi is only 100 mld.

From the point of view of pollution of Ganga and the deterioration of water quality in bathing areas of Varanasi, the discharge of the drains and other large number of smaller outlets along ghats have been very critical. Cremation (Fig.2.10) of large number of dead bodies (50,000 approx. annually) and disposal of dead human bodies and animals (Fig. 2.11) into the rivers has always been matter of concern. The scene of industrial pollution in the city is not very much alarming.

* The Times Group-2006 Bracing for Tomorrow: A response connect initiative, p3
Fig. 2.10: CREATING POLLUTION ON THE GANGA GHATS BY BURNING THE DEAD BODIES AT VARANASI
Fig. 2.11: POLLUTION THE GANGLA RIVER BY THROWING THE DEAD BODIES ON THE GHATS OF VARANASI
2.8 CLIMATIC CONDITION

The weather of Varanasi is classified under moisture deficit index of 20 to 40 per cent and falls in the belt of semi-arid to humid climate having hot summer and cold winter. The normal precipitation of Varanasi is about 1100 mm and value of potential evapotranspiration is about 1500 mm. Approximately 80 per cent of the total precipitation is received from June to September as monsoon season, 6 per cent from October to December as post monsoon season, 3 per cent from January to February as winter season and about 3 per cent from March to May as summer season or as pre-monsoon season rains. Average maximum temperature 43.5°C and minimum 7.2°C are recorded in the month of June and January respectively. However, the highest temperature in the year 2005 June was recorded as 47.0°C *.

2.9 MAIN CAUSES OF POLLUTION OF GANGA WATER AT VARANASI

a. Silting:

Because of the less amount of water in the river basin velocity of water is restricted which results in silting. The reason for less water flow may be attributed to the fact that in the upper stretch of the Ganga from Varanasi (Ramanagar) to Allahabad, there are six lift canals lifting water for irrigation and other purposes which results in reduced velocity and less water in the river.

In the lower stretch from Varanasi to Ballia there are approximately 50 lift canals lifting water from the river which results less flow and generates turbidity in the river water.

* Temperature recorded in Metrological lab. Deptt. of Geophysics, BHU & observatory, Govt. of India, Babatpur Airport, VARANASI.
The silt which is deposited on the river banks during flood is again thrown back into the river for the purpose of cleaning the Ghats for the people.

b. Sewage system:

Varanasi, even after implementation of the Ganga Action Plan 1st, has only 100 MLD capacity of drain to discharge, whereas, the city generates approximately 250 MLD of sewage everyday which worsens the pollution status of Ganga. The intermittent supply of electricity to these pumping stations also hampers the proper discharge of sewerage.

c. Awareness and management activities:

People are the main source of pollution at any place. Ganga is not an exception to it. The people need to be educated properly and timely. Though these activities of creating awareness among the people are taking place hither and thither but they are unplanned and do not work at regular basis, therefore, majority of people are unaware of the activities of management to keep the Ganga water clean.

d. The pilgrims:

A floating population of pilgrims (approximately one lac) use to visit Varanasi everyday. They also add to the load of pollution of city and the river Ganga also. They don’t have any arrangement to clean the Ganga Water.

e. Corruption:

The various people who are involved in cleaning the Ganga water, most of them do not have inner zeal to clean the river to make it less
polluted and purified. Because of the vested interest they do not allow the various development plans to function properly and to achieve its goal in stipulated time and resources.

2.10 GANGA ACTION PLAN (GAP-I)

The Planning Commission, Government of India recommended ecosystem development as the thrust areas of the sixth five year plan (1980-85). A team of science and technology experts related to eco-development was formed from the Universities located on the Ganga basin, Academicians’ scientists from National Laboratories governmental and non-governmental agencies.

The planning commission had initiated the coordinated eco-development project on the Ganga through a network of Universities located on the river stretch from Narora to Calcutta. The project was later transferred to Deptt. of Environment for managing the programme. The working group under the chairmanship of Dr. C.R. Krishnamurthi with eight other members was constituted on Aug.31, 1982 for a term of three years. Fourteen Universities which initiated their studies between 1983 and 1984 were expected to complete their studies by 1987. The result obtained from these studies was synthesized in order to obtain a chemical, physical and biological profile of the river.

2.11 EFFECTS OF GANGA ACTION PLAN-I AT VARANASI

a. Sewerage and pollution of Ganga:

Even after the completion of Ganga Action Plan at Varanasi the sewerage pumps installed along the Ghats of the Varanasi, sewerage flows into Ganga, through the outlets and over flooded drains causing pollution
of the religious bathing area of Varanasi. During power outages and floods sewerage pumps do not function. Some important facts are appended below regarding sewerage system and departments responsible for it. The GAP-I was launched at Varanasi on June 14, 1986. Out of 34 schemes of the project (costing Rs. 494.5 million), 13 schemes (costing Rs. 332.971 million) related with the sewerage and sewage treatments were entrusted to the U.P. Jal Nigam. The 13 schemes completed by Jal Nigam costed Rs. 379.794 million.

b. The Sewerage infrastructure under GAP-I at Varanasi

<table>
<thead>
<tr>
<th>Name of Sewerage Treatment Plant</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>DINAPUR</td>
<td>80 MLD</td>
</tr>
<tr>
<td>BHAGWANPUR</td>
<td>08 MLD</td>
</tr>
<tr>
<td>DLW</td>
<td>12 MLD</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100 MLD</strong></td>
</tr>
</tbody>
</table>

The installed capacity of sewage treatment plant at Varanasi is 100 MLD, whereas, the city would generate 250 MLD of sewage and the pollution status of Ganga would worsen. The other water ways, the Varuna and Assi, have already turned into sewage channels.

Varanasi has a sewer net work of 315 km in the city. The sewerage is supposed to be separate sewer system but storm water enters the system during monsoon season. Six old pumping stations are along the left bank of the river Ganga at Varansi out of which one Konia pumping station was built during GAP-I for intercepting the sewage and pumping it back into the sewer.
The drain listed below and the Assi Nala carry only the waste water during the dry weather. A number of storm water channels / drains are discharging into the river Ganga, Varuna and Assi. The pumping stations built during GAP-I aim at intercepting and diverting the sewage flow.

c. Main drains flowing into the river Ganga:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the Drain</th>
<th>Approximate Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Shiwala Ghat</td>
<td>343</td>
</tr>
<tr>
<td>2.</td>
<td>Harishchandra Ghat</td>
<td>120</td>
</tr>
<tr>
<td>3.</td>
<td>Mansarovar Ghat</td>
<td>222</td>
</tr>
<tr>
<td>4.</td>
<td>Narad Ghat</td>
<td>600</td>
</tr>
<tr>
<td>5.</td>
<td>R.P. Ghat (Ghora Nala)</td>
<td>1653</td>
</tr>
<tr>
<td>6.</td>
<td>Jalesan Ghat</td>
<td>200</td>
</tr>
<tr>
<td>7.</td>
<td>Manikarnika Ghat</td>
<td>200</td>
</tr>
<tr>
<td>8.</td>
<td>Trilochan Ghat</td>
<td>1627</td>
</tr>
<tr>
<td>9.</td>
<td>Telia Ghat</td>
<td>480</td>
</tr>
<tr>
<td>10.</td>
<td>Raj Ghat</td>
<td>150</td>
</tr>
</tbody>
</table>

2.12 GANGA ACTION PLAN (PHASE-II)

After the GAP-I was implemented the performance was inadequate. However, Jal Nigam (implementing Agency) did not accept the failure and they assigned the reason to the growth in population and pollutant load since the design of work. They proposed a GAP Phase-II with more pumps, some new sewers, addition of sewage treatment capacities etc. at four times the cost of Phase-I without any change in technology.

Meanwhile, a very conscious NGOs (Clean Ganga Abhiyan) developed alternative design and plans to tackle the problem. Power and
mechanical requirements of these alternatives designs and economics were much lower than Jal Nigam proposals. It was send to GPD (Ganga Project Directorate) in 1995.

In a parallel development on the political plain, the municipal corporation of Varanasi highly dissatisfied with the performance of the GAP-I adopted a resolution adopting the alternative design developed by the NGO and sent it to GPD for financial support. The central government favoured and wished to support Jal Nigam’s proposal, but it could not happen due to constitutional veto. Some of the corporators took the matter to the High Court in 1997. The High Court appointed a committee headed by Dr. G.D. Agrawal as chairman to examine the two alternative projects and decide which was better in the public interest of Varanasi citizens. But some (MEF) approach the Supreme Court of India and obtained an order staying appointment of proposed committee.

However, due to political unsteadiness and subsequent administrative changes, the matter was delayed until July, 2001 supporting U.P. Jal Nigam Varanasi. Ganga Ji and citizens of Varanasi continues to wait for several years for some serious sensible efforts to clean Ganga water.