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Drinking Water in Guwahati City: A Plan for Sustainable Management

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ABSTRACT: The Guwahati Metropolitan area covering an area of 216.97 sq. km. has a population of 8,09,895 according to the 2001 census. However, in reality the present population may be above 14 lakhs. The main source of drinking water for the inhabitants of the city is ground water obtained from hand tubewell, deep tubewell and ringwell set up on their own for drinking and other domestic requirements. Although the Brahmaputra river flows along the northern boundary of the city, still the Guwahati Municipal Corporation (GMC), other statutory bodies and various governmental departments fail to provide piped water to a large section of the city dwellers due to non existence of necessary infrastructure. Moreover the results reveal that the concentrations of iron and fluoride are found to be above the permissible level in more than 70 and 20% water samples respectively. Again the study made it clear that drinking water supply is grossly inadequate and irregular in a large number of municipal wards of Guwahati city. The existing water supply facility neither covers the entire city nor fulfills the standard of per capita demand. A long-term sustainable drinking water management strategy for Guwahati can be conceived centering around multiple, large-scale, centralized, modern technology based water supply schemes based on the perennial source of the mighty river Brahmaputra.

INTRODUCTION

Early in the next century, more than half of the world's population will be living in urban areas. By the year 2025, that proportion will have risen to 60 per cent, comprising some 5 billion people (Haman and Brown, 2002). Rapid urban population growth and industrialization are putting severe strains on the water resources and environmental protection capabilities of many cities. Special attention needs to be given to the growing effects of urbanization on water demands and usage and to the critical role played by local and municipal authorities in managing the supply, use and overall treatment of water, particularly in developing countries for which special support is needed. Better management of urban water resources, including the elimination of unsustainable consumption patterns, can make a substantial contribution to the alleviation of poverty and improvement of the health and quality of life of the urban and rural poor (Goswami and Goswami, 1992).

STUDY AREA

Occupying the extreme southern part of Kamrup district of Assam on the south bank of Brahmaputra river, the Guwahati metropolitan area falls within the latitudes 26° 5′ E to 26° 12′ N and longitudes 91° 34′ E to 91° 51′ E covering a total area of 216.97 sq. km. The area shares its southern borders with the Meghalaya plateau, on the east it is flanked by the Boga Gosai Parbat (hills) which is an extension of the Khasi hills, on the west by the Jalukbari-Azara plain where the Deepar beel and adjoining low-lying areas lie and on the north by a flat plain interrupted by small hillocks. The location map of GMC area with its sixty wards of the study area is presented in Figure 1.

OBJECTIVES

The present study focuses on the following major objectives: (i) to study the physico-chemical characteristics of drinking water quality (ii) to examine the pattern of domestic water use in the study area (iii) to suggest appropriate measures for rational utilization of available surface water resources in the city, (iv) to suggest water harvesting and other location-specific solutions for a sustainable water supply in the area, and (v) to formulate a perspective plan for conjunctive use of both surface and groundwater in the metropolitan area based on scientific study of the existing humanized environment and its long term trends.

METHODOLOGY

The study-related water use data at household level are obtained from primary sources through an extensive questionnaire-based household survey, while the secondary data are collected from various relevant government departments and other agencies. The collected data are analysed using appropriate computer assisted analytical procedures, such as visual Fox Pro, Excel, GIS etc. (Harinarayanan *et al.*, 2000). The analysed data are presented with the help of a series of maps, tables and graphs using digital cartographic techniques.

After a careful study of the topography and other aspects of the city, 20 water samples were collected by random sampling technique from different locations and these were analysed according to standard procedure (APHA, 1998). The parameters studied are:

(a) *Physical parameter*: Temperature, Colour, Odour, pH, TS, TDS, TSS, Turbidity and Conductance.

(b) *Chemical parameter*: DO, Total hardness, Chloride, Nitrate, Fluoride, Na, K, Fe, and As.

Samples were collected twice in a year spreading over a period of 2 years (April, 2005 to March, 2007) in two seasons viz.

(a) *Wet season*: April to September

(b) *Dry season*: October to March

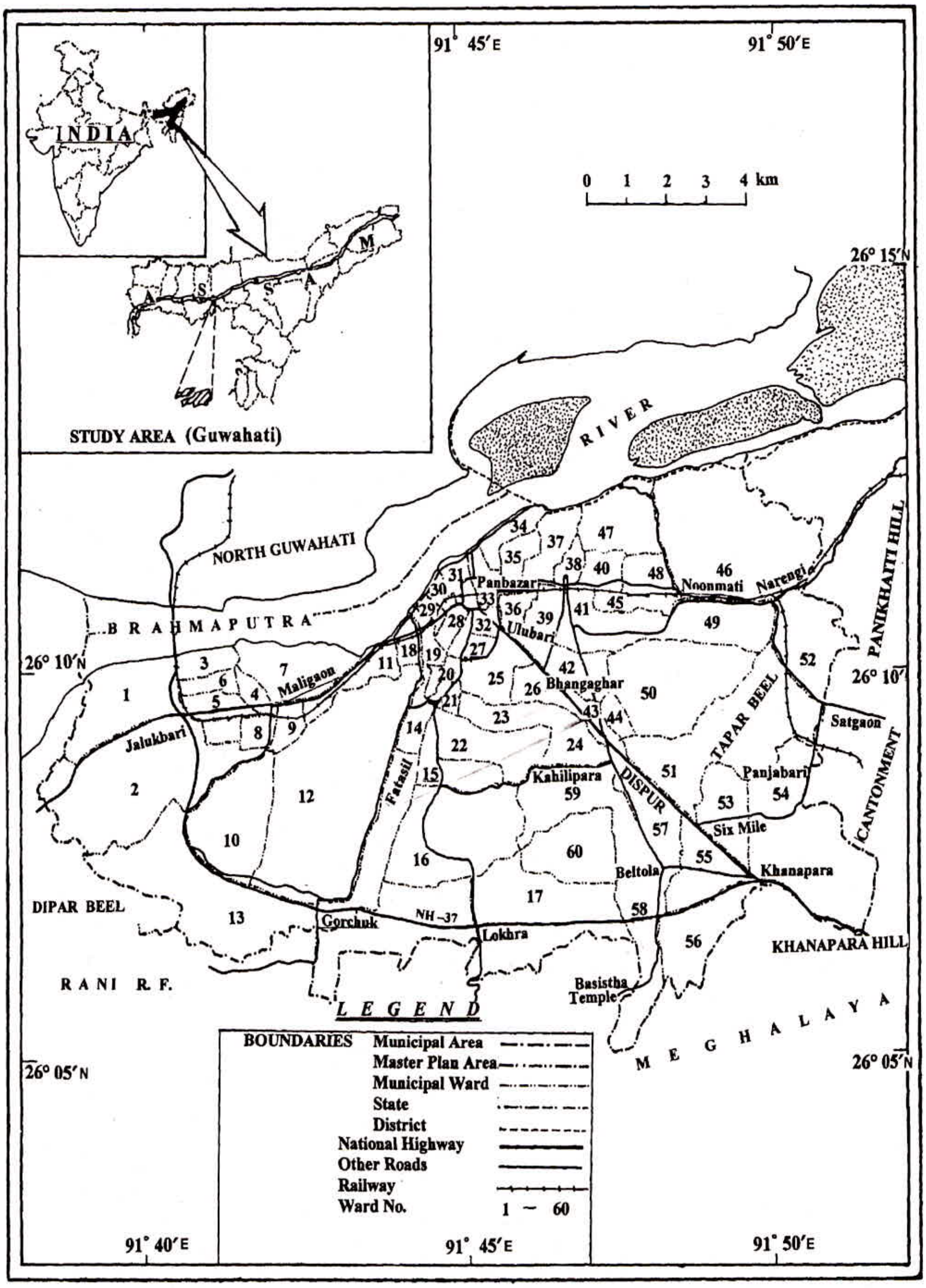

Fig. 1: Location-cum-ward map of Guwahati municipal area

Table 1: The Sampling Stations

Sl. No.	Source	Sampling Station	Sl. No.	Source	Sampling Station
1.	TW	Pandu	11.	RW	Sixmile
2.	TW	Santipur	12.	RW	Beltola
3.	TW	Bharalumukh	13.	RW	Tetelia
4.	TW	Birubari	14.	RW	Narengi
5.	TW	Panjabari	15.	RW	Chachal
6.	DTW	Noonmati	16.	MSW	Paltan bazar
7.	DTW	Khanapara	17.	MSW	Kamakhya
8.	DTW	Chandmari	18.	MSW	Panbazar
9.	DTW	Boragaon	19.	MSW	Jalukbari
10.	DTW	Bhangagarh	20.	MSW	Maligaon

(TW: Tube well, DTW: Deep Tube Well, RW: Ring Well, MSW: Municipal Supply Water)

RESULTS AND DISCUSSION

The results of analysis of the water quality parameters are shown in Tables 2a, 2b, 3a, and 3b.

From the above results, it is seen that the concentrations of the water quality parameters are within the WHO prescribed limits (WHO, 2004) except iron and fluoride. 70% of the samples are having iron content above the permissible limit. Iron is vital to life as an integral part of heamoglobin and the oxygen transport system. Excessive accumulation may be toxic to cells as it catalyses the production of hydroxyl radical. While deficiency is known to cause anaemia, excess may lead to haemochromatosis and platelet aggregation. Shortness of breath is a common symptom of iron deficiency (Sarma and Bhattacharyya, 2000, 2001). The fluoride concentration was above the WHO guideline values in 20% samples. Fluoride is beneficial to certain extent when present in concentration of 0.8 to 1.0 mg/l. But it causes dental fluorosis if present in excess of 1.5 mg/l and skeletal fluorosis beyond 3.0 mg/l. In the present study higher concentration of fluoride in 20% water samples may be responsible for fluorosis prevalent amongst the city dwellers. However no proper medical records are available (Sarma and Bhattacharyya, 1999). 15% of the water samples contain arsenic in the range of 0.001 to 0.004 μg/l. Furthermore the concentrations of the water quality parameters collected during wet season were found to be slightly high in comparison to dry season for most of the parameters. This may be due to rains and storm water runoff.

Table 2a: Results of Water Quality Parameters, Physical (dry season)

Sl. No.	Parameter (Average value)								
	Temp. °C	Colour	Odour	pH	TS mg/l	TDS mg/l	TSS mg/l	Turbidity NTU	Conductance μS/cm
1.	23	Colourless	Odourless	7.2	290	270	20	5.2	0.19
2.	23	Colourless	Odourous	6.9	300	210	90	6.8	0.18
3.	22	Colourless	Odourous	7.3	260	190	70	7.1	0.48
4.	24	Colourless	Odourous	7.5	250	220	30	1.2	0:65
5.	23.5	Colourless	Odourous	7.6	260	235	25	5.8	0.21
6.	23	Colourless	Odourless	7.3	200	170	30	2.3	0.11
7.	24	Colourless	Odourless	7.1	130	100	30	4.0	0.32
8.	23	Colourless	Odourless	6.8	146	120	26	3.5	0.95
9.	22.5	Colourless	Odourless	6.8	184	140	44	4.5	0.54
10.	23	Colourless	Odourous	7.3	256	222	24	2.8	0.33
11.	24	Colourless	Odourous	7.2	170	150	20	3.8	0.55
12.	24.5	Colourless	Odourless	7.2	165	120	45	2.2	0.34
13.	23.5	Colourless	Odourless	7.1	176	150	26	5.5	0.23
14.	23	Colourless	Odourless	7.4	177	140	37	4.8	0.12
15.	24	Colourless	Odourless	6.8	110	100	10	2.3	0.18
16.	24	Colourless	Odourless	6.9	90	70	20	3.3	0.13
17.	23	Colourless	Odourless	7.2	95	70	25	3.6	0.19
18.	24.5	Colourless	Odourless	7.3	100	95	5	2.7	0.18
19.	24	Colourless	Odourless	7.3	90	76	14	2.7	0.13
20.	23	Colourless	Odourless	7.2	90	80	10	2.3	0.11

Table 2b: Results of Water Quality Parameters, Physical (wet season)

Sl. No.	Parameter (Average value)								
	Temp. °C	Colour	Odour	pH	TS mg/l	TDS mg/l	TSS mg/l	Turbidity NTU	Conductance μS/cm
1.	25	Colourless	Odourless	7.2	270	250	20	4.2	0.29
2.	26	Colourless	Odourous	6.9	290	280	10	5.8	0.18
3.	25	Colourless	Odourous	7.3	320	290	30	7.1	0.18
4.	28	Colourless	Odourous	7.5	240	200	40	3.2	0.65
5.	25	Colourless	Odourous	7.6	220	200	20	3.8	0.41
6.	23	Colourless	Odourless	7.3	150	130	20	1.3	0.81
7.	25	Colourless	Odourless	7.1	145	110	35	4.8	0.42
8.	26	Colourless	Odourless	6.8	144	120	24	2.5	0.90
9.	26.5	Colourless	Odourless	6.8	225	190	35	1.5	0.64
10.	27	Colourless	Odourous	7.3	300	270	30	2.8	0.33
11.	26	Colourless	Odourous	7.2	185	150	35	2.8	0.75
12.	25.5	Colourless	Odourless	7.2	140	125	15	2.9	0.44
13.	25.5	Colourless	Odourless	7.1	135	110	25	5.6	0.13
14.	25	Colourless	Odourless	7.4	195	180	15	2.8	0.62
15.	25	Colourless	Odourless	6.8	160	150	10	2.9	0.38
16.	27	Colourless	Odourless	6.9	175	170	5	3.3	0.23
17.	26	Colourless	Odourless	7.2	100	90	10	3.6	0.29
18.	24.5	Colourless	Odourless	7.3	100	95	5	2.7	0.68
19.	25	Colourless	Odourless	7.3	90	76	14	2.7	0.33
20.	26	Colourless	Odourless	7.2	75	60	15	2.3	0.10

Table 3a: Results of Water Quality Parameters, Chemical (dry season)

Sl. No.	Parameter (Average value)								
	DO mg/l	TH mg/l	Cl^- mg/l	F^- mg/l	NO_3^- mg/l	Na mg/l	K mg/l	Fe mg/l	As μg/l
1.	5.6	81	29.5	0.45	1.3	40	1	3.0	ND
2.	6.4	70	63.5	0.09	1.8	80	5	0.27	ND
3.	4.7	100	40.2	1.04	2.1	50	3	1.7	0.001
4.	6.7	160	50.7	2.77	1.6	20	2	2.5	ND
5.	7.2	110	70.4	1.65	2.8	40	2	1.7	ND
6.	5.5	120	40.9	1.08	2.8	30	4	4.0	0.002
7.	6.2	80	34.0	2.11	1.9	70	1	3.5	0.001
8.	6.9	210	46.7	0.11	5.4	25	1	1.6	0.001
9.	7.6	150	54.8	0.04	3.3	65	3	1.5	0.004
10.	7.7	120	32.1	1.98	3.8	50	2	2.6	0.001
11.	5.9	150	35.5	0.09	4.5	50	2	1.8	ND
12.	6.1	110	66.9	1.01	6.2	50	2	1.3	ND
13.	7.2	100	70.1	2.03	5.5	80	1	0.44	ND
14.	6.6	180	39.9	1.04	5.9	30	1	0.13	ND
15.	5.5	160	40.9	0.36	10.8	40	3	1.12	ND
16.	6.4	90	29.4	0.03	1.6	20	3	0.05	ND
17.	7.8	90	30.7	0.07	1.6	20	1	0.14	ND
18.	7.0	120	42.3	0.01	1.4	30	2	0.03	ND
19.	6.6	100	55.9	0.03	1.7	20	1	0.15	ND
20.	6.3	100	51.0	0.08	1.5	30	1	0.56	ND

TH: Total Hardness, ND: Not Detected.

Table 3b: Results of Water Quality Parameters, Chemical (wet season)

Sl. No.	Parameter (Average value)								
	DO mg/l	TH mg/l	Cl^- mg/l	F^- mg/l	NO_3^- mg/l	Na mg/l	K mg/l	Fe mg/l	As μg/l
1.	5.6	80	49.5	0.45	1.4	34	1	1.4	ND
2.	6.4	75	43.5	0.19	1.4	70	5	0.26	ND
3.	4.7	100	60.2	0.09	1.1	35	3	0.7	ND
4.	6.7	130	70.7	2.17	1.2	20	2	0.5	ND
5.	7.2	110	70.4	1.60	2.0	20	2	1.2	ND
6.	5.5	120	40.9	1.08	2.2	40	4	2.2	ND
7.	6.2	100	37.0	2.01	1.9	60	1	1.5	ND
8.	6.9	200	46.7	0.10	4.4	30	1	0.6	ND
9.	7.6	120	50.8	0.04	2.3	55	3	1.5	ND
10.	7.7	120	32.1	1.08	3.7	45	2	1.6	ND
11.	5.9	150	30.5	0.09	5.5	55	2	1.8	ND
12.	6.1	160	60.9	1.01	4.2	30	2	1.0	ND
13.	7.2	100	50.1	2.55	4.5	60	1	0.44	ND
14.	6.6	100	39.9	1.04	5.0	36	1	0.10	ND
15.	5.5	170	40.9	0.36	5.8	40	3	0.12	ND
16.	6.4	190	29.4	0.03	1.6	30	3	0.05	ND
17.	7.8	90	40.7	0.07	1.2	20	1	0.14	ND
18.	7.0	120	32.3	0.01	1.3	30	2	0.03	ND
19.	6.6	100	50.9	0.03	1.3	20	1	0.05	ND
20.	6.3	100	50.0	0.08	1.1	30	1	0.26	ND

TH: Total Hardness, ND: Not Detected

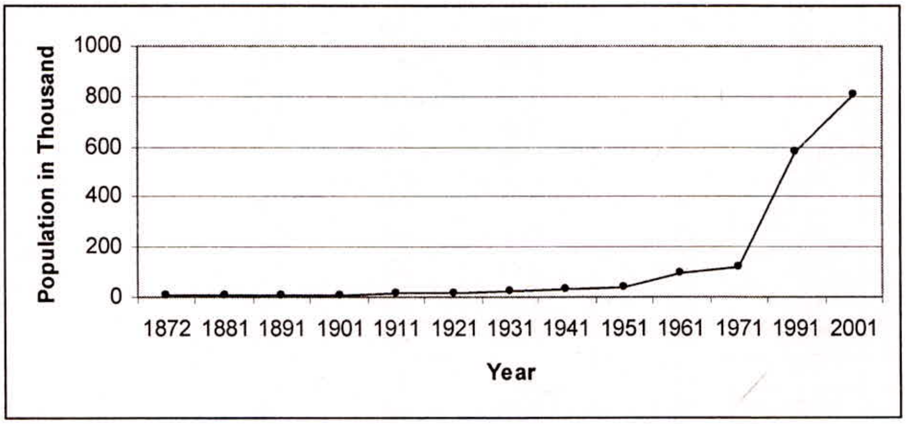

Fig. 2: Population trend of Guwahati city

The Guwahati Metropolitan Corporation covering an area 216.97 sq. km. spreads over sixty wards with a total population of 8,09,895 according to the 2001 census. However, in reality the present population may be above 14 lakhs. The trend of population growth in the city is shown in Figure 2. The main source of drinking water for the bulk of the inhabitants of the city is ground water, obtained from hand tubewell, deep tubewell and ringwell set up on their own for drinking and other domestic requirements. Although the Brahmaputra river flows along the northern boundary of the city, still the Guwahati Municipal Corporation (GMC), other statutory bodies and various government departments have failed to provide piped water to a large section of the city dwellers due to non existence of necessary infrastructure and resources.

The present demand of drinking water for the city is 119.98 MLD (Million Liters per Day) based on the 2001 census population of 8,09,895. Against this, 109.00 MLD are presently supplied for all types of use such as domestic, industrial, institutional etc. Thus, the present supply shows a deficit of about 11 MLD for a population based on the 2001 census. Given the present population of about 14 lakhs, the deficit increases several fold, which is an alarming problem for the present as well as the future generations. By 2021, the requirement of domestic water is expected to be about 302.5 MLD. Table 4 shows the present water supply position in the city.

Table 4: Piped Water Supply in Guwahati City

Water supply agency	*Surface water (MLD)*	*Ground water (MLD)*	*Total piped water (MLD)*
GMC(Guwahati Municipal Corporation)	72.20	7.80	80.00
PHED (Public Health and Engineering Department)	13.39	–	13.39
UWSSWB (Urban Water supply and Sewage Board)	12.6	–	12.6
N.F. Railway	3.45	.0068	3.46
Gauhati Refinery	.52	–	.52
Total	102.60	7.81	109.97

Source: Various water supply agencies (2002).

In Guwahati, the main source of drinking water is groundwater followed by surface water supplied as piped water by various agencies. Surface water and rainwater are also collected by a small section of population at individual household level. The household survey carried out in the course of this study reveals that out of the total households of the city, 59 percent households use groundwater installed by themselves, 25 percent use piped water supplied by various supply agencies viz. Guwahati Municipal Corporation, Public Health and Engineering Department, Urban Water Supply and Sewerage Board, NF Railway and Guwahati Refinery, 11 percent use both supplied and ground water, 3 percent use both groundwater and surface water and only 2 percent use both ground water and rain water (Figure 3).

Guwahati has one of the largest rivers of the world, the Brahmaputra, flowing along its northern boundary with an average daily mean flow of about 20,000 cumec at Pandu near Guwahati. It is unfortunate that this huge potential of the Brahmaputra has not yet been properly tapped for supplying the much needed domestic water for city dwellers. About 103 MLD water is supplied by different water supply agencies in the city. Apart from the Brahmaputra river, there are several streams that flow from the hills located in the city or its surrounding areas. But these streams are not properly tapped. Among them, some flow round the year, while others are seasonal. Some of the households use surface water from the streams located close to their houses. In the city, only 2 percent of the households use both groundwater as well as surface water The study further reveals that in the city out of the total population using surface water, 78 percent of the households use spring water followed by 20 percent using river water, mainly those who live near the river Brahmaputra and are in the low income group, and only 2 percent of households use pond water, during the scarcity period (Figure 4). Within the city area, there are some public ponds which are large perennial water bodies but these are not properly maintained. These include Dighalipukhuri, Silpukhuri, Nagputapukhuri, Jorpukhuri etc. The figure 6 shows the pattern of surface water use (source wise) in the city.

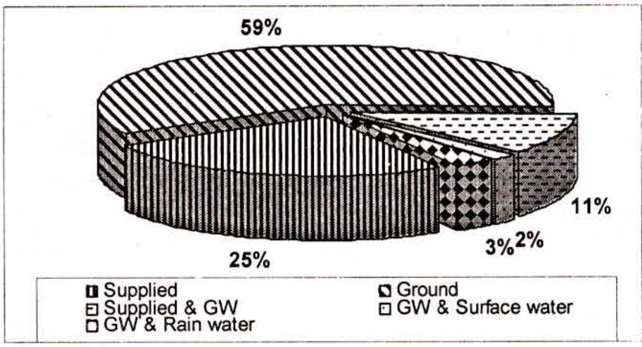

Fig. 3: Drinking water sources in Guwahati for individual households

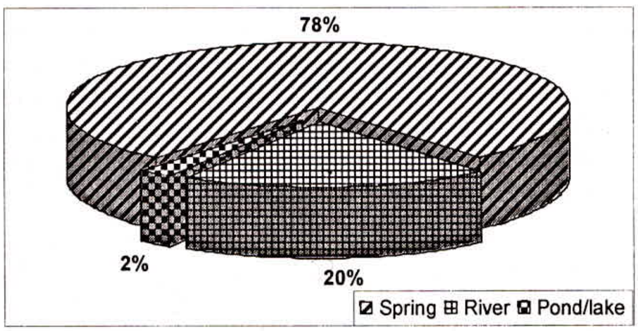

Fig. 4: Pattern of surface water use in Guwahati

Although there is considerable scope for harvesting of rainwater, including rooftop harvesting, in the city, the practice is almost non existent till today. However, a limited number of households store rain water in different types of vessels. These households represent only 6.7 percent of the total households. Of these, 92.5 percent use the water for washing, 2.5 percent for cooking and drinking and only 5 percent for gardening.

In recent years private agencies are getting involved in the domestic water supply business. The most important among these is the agency that supplies 'Brahmajal' directly from the Brahmaputra to the needy urban households using a fleet of small-size tanker trucks. These waters are claimed to be purified using an innovative, low-cost technology. On an average basis, the vendors supply 60,000 to 70,000 liters of 'Brahmajal' daily to the city dwellers.

Analysis of data and information collected in the course of the present study and observations done in the field have made it clear that drinking water supply is grossly inadequate and irregular in a large number of municipal wards of Guwahati city. The present schemes of urban water supply are in a dilapidated state with improperly designed, old and ill-maintained infrastructure, inefficient service facilities and poor regulatory mechanisms. Faced with a bourgeoning civic population and an expanding urban sprawl, the existing infrastructure for supplying drinking water to the city dwellers appears to be exceedingly overstressed, almost bursting at the seams. Overdependence on groundwater for meeting drinking water needs of a larger section of the city population constitutes a major problem for Guwahati where rapid depletion of water table due to overexploitation of groundwater in recent years with its attendant water quality and health-related consequences has become a cause of great public concern. The situation is rather paradoxical because, unlike many other urban centres in the country, the Guwahati city is located right on the bank of one of the world's largest rivers—the Brahmaputra which is a perennial source of abundant water resource. Besides, the city with its rolling topography marked by several hills and hillocks provides a good number of potential sites for locating large-size storage reservoirs to serve different parts of the city with networks of well-designed distribution system.

In order to assess the existing pattern of availability and use of domestic water, an effort is made in the present study to collect a set of household data related to the drinking water availability and use in the city. The study reveals that the city of Guwahati is presently served by piped water supply in limited quantity in specific areas. This facility neither covers the entire city nor fulfills the standard of per capita demand.

It is found that 60% of the surveyed households in the city have adequate water for domestic requirement whereas 40% of the households face inadequacy to varying extents (Figure 5). Out of this forty percent, around 20% faces inadequacy due to drying up of sources, 13.2% face erratic supply, 3.1% are not supplied by any agency and 3.7% face other problems like deterioration of water quality.

The average consumption of water in the Guwahati city is found to be around 481 litres per day per household in the summer, that is approximately 120 litres per head per day, which is lower than the WHO norms 135 litres per head per day, and 383 litres on average in the winter, that is approximately 95 liters per head per day (Figure 6). While implementing the urban water supply schemes for providing potable drinking water to the urban population, the Central Public Health and Environmental Engineering Organization (CPHEEO) follows the norm of 135 liters per capita per day. This calculation is done on the basis of household survey. For the sample survey, an average of 4 persons in a family was considered. As per CPHEEO norms the minimum need of water is 540 litres per day per household. The Figure 7 shows that households in only 6 wards of the city use more than 540 liters, which fulfills the CPHEEO norms. But in the winter only 4 wards fulfill these norms.

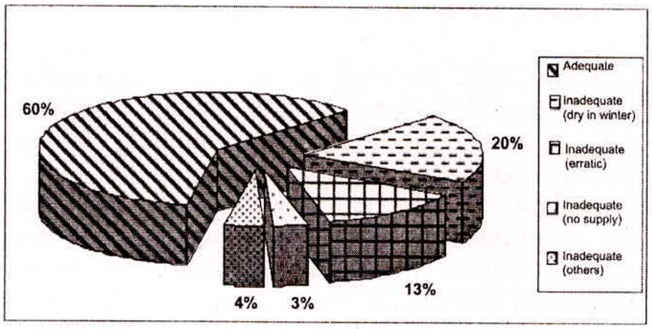

Fig. 5: Status of water adequacy in Guwahati city

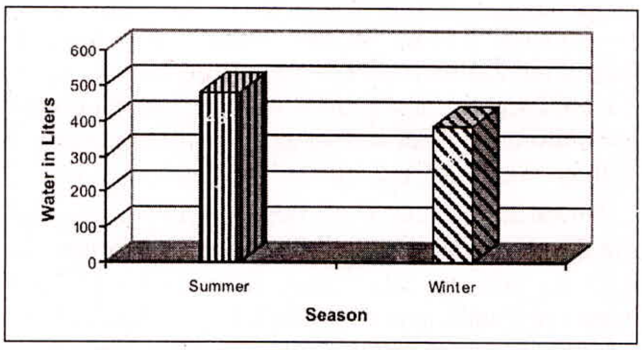

Fig. 6: Water use by households

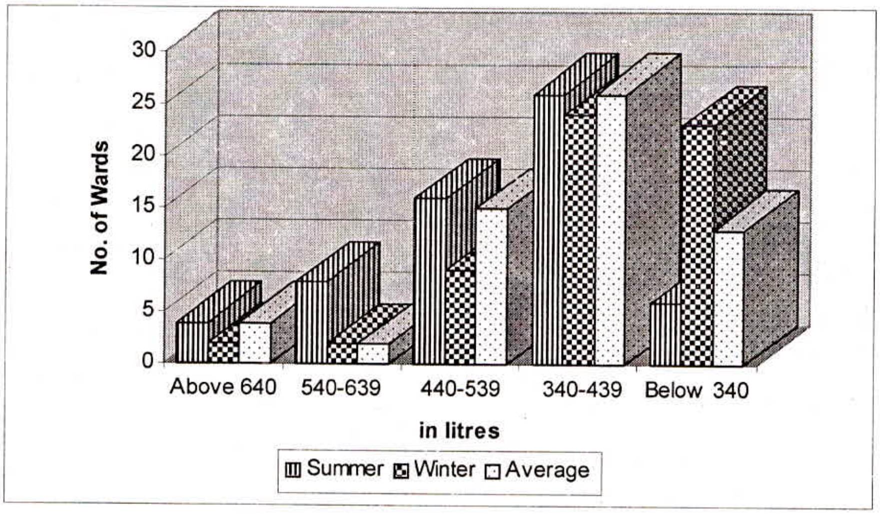

Fig. 7: Pattern of daily water use by households

PLAN FOR SUSTAINABLE MANAGEMENT

A long-term sustainable drinking water management strategy for Guwahati can be conceived centering around multiple, large-scale, centralized, modern technology based water supply schemes based on the Brahmaputra that will cater to the need of different service districts or blocks identified in the city. These schemes should be supplemented with time-tested, small scale, decentralized, location-specific practices of water conservation and harvesting such as ground-water recharge, injection wells, percolation tanks, rainwater (rooftop and land surface water) harvesting etc. Such decentralization of water management will provide the necessary framework for ordinary people to participate in the vital sector of water management, especially in case of those who are socio-economically disadvantaged and/or those living in geo-environmentally sensitive locations.

Considering the need for improvement in water supply and the future growth of population in the city, a long-term strategy with following broad features has been conceptualized. The objectives of the scheme will be: (i) to meet the required demand for potable water of a large projected population in different parts of the city on long-term basis, (ii) to provide safe and economical source of supply and (iii) to shift the emphasis to surface water (Brahmaputra river water) which is plentifully available all the year round.

Based on the surface topography and density of population of the city area, it has been proposed to divide the city into several service sectors (areas). As per a preliminary estimate, the tentative number of such sectors may be restricted to three, namely eastern, southern and western to be served by multiple storage reservoirs atop selected hills in different parts of the city area.

The eastern sector covers 28 nos. of wards, namely 14, 18, 19, 20, 21, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 45, 46, 47 and 48. The southern sector covers 19 nos. of wards, namely 15, 16, 17, 22, 23, 24, 44, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59 and 60. The western sector covers 13 nos. of wards, namely 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13. The surface water from river Brahmaputra will be used as raw water sources. Each of the sectors will have at least one intake arrangement for drawing raw water from river Brahmaputra using a floating barge. The raw water will be pumped to the treatment plant located in each of the sectors. For the northern sector there will be two treatment plants, while for the southern and western sectors there will be three in each sector. The areas (wards) to be covered by different service sectors are tentatively shown in Figure 8. All treatment plants should be set up on the basis of topography. After treating the water it will be pumped to service reservoirs which will be located on the top of different hillocks in each of the service sectors. The lay out and technical specifications of the mains will be decided keeping in view the ultimate demand conditions upto year 2050.

Distribution mains will be laid from different service reservoirs to the areas of water demand. Detailed technical parameters for the distribution pipe network and their alignments should be selected with the help of sophisticated modern technologies like computer simu-lation, remote sensing and GIS. Besides, there should be some small surface water treatment plants set up to fulfill the requirement of small localities where spring water is available, like Basistha, Matgharia hills etc.

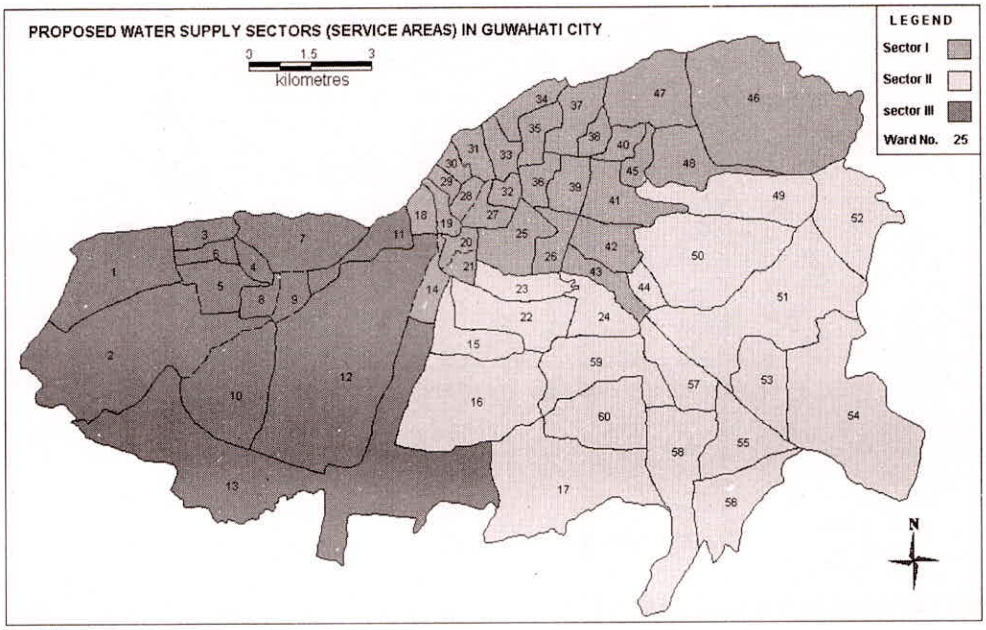

Fig. 8: Proposed water supply sectors (service areas) in Guwahati city

Proper monitoring, maintenance and management of the created infrastructure, introduction of effective regulatory mechanisms, necessary institutional arrangements and policy guidelines are some of the important factors that may ensure sustainability and efficacy of the proposed strategy.

CONCLUSIONS

The issues pertaining to sustainable use and supply of drinking water in the city emphasizing the need for proper utilization of the perennially abundant source provided by the Brahmaputra river that flows along the northern margin of the city, and the topographic advantage of the area with scattered hillocks that provide suitable locations for installing several large-size water supply reservoirs to serve different parts of the urban area have been discussed in the paper. Besides the modern, centralized type of large scale water management system based on the Brahmaputra, the study also suggests judicious use of time-tested, decentralized systems based on water harvesting and conservation through groundwater recharge, injection wells, percolation tanks and (beels), watershed management etc. The unprecedented growth of population in and around Guwahati city will continue to create water scarcity in near future. Therefore, a perspective planning for water supply, primarily from surface water, needs immediate attention. Moreover, in accordance with the potentiality of ground water in different parts of the GMC area, the planners should design the future water supply systems for public distribution as well as those at household levels.

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