ENVIRONMENTALLY COMPATIBLE GROUND WATER MANAGEMENT IN URBAN AGGLOMERATION OF GANGA BASIN

Dr. D.K. Chadha, *Chairman*[1]
Dr. J.N.Rai, *Scientist-'D'*[2] and Dr. B.C. Joshi, *Asstt. Hydrogeologist*[2]
[1]Central Ground Water Board, New Delhi
[2]Central Ground Water Board, Northern Region, Lucknow

ABSTRACT

Accelerating water demand, limited and diminishing availability of surface water, fast declining trends of ground water levels in unconfined zone and increasing pollution in surface water makes urban life environmentally unfit and unhealthy. Ganga basin which constitutes the 26 percent of the total geographical area of the country possesses 357 million population, which is nearly 42 percent of the total population of the country. Besides surface water, the total availability of groundwater for Industrial and Domestic uses in the basin is about 20390 MCM / year. However, the ground water resource in Ganga Basin is becoming scanty and scarce day by day as a result, in the near future the availability of water for survival of humanity will be difficult and dear. This will also affect the economic growth of the region. It is assumed that due to urbanization and industrialisation, basin will transform into highly polluted and a deficit basin by 2050, if proper preventive and water conservation methods are not followed and adopted.

The present paper deals the various aspects of the impacts of urbanization on Ground Water, i.e., lowering of water table, excess runoff, surface water and ground water pollution in Capital cities and other major cities of Ganga Basin. For environmentally compatible and sustainable ground water development, the management measures specific to the area have been discussed. The legislative measures are also suggested for suitable development of ground water and conserving surface water in urban micro-watersheds to prevent and control the environmental deterioration.

1.0 INTRODUCTION

Human settlement is essentially an innate usage which is applicable to a city, town, village or even a single hutment at remotest place. Each settlement has a basic organization with its own social, economic and a cultural setup. It has some basic requirement's i.e.food, water, housing and sanitation. It is difficult to manage all these things in their entirety particularly in large metropolitan cities. The system breaks, and things become scarce, scanty and dear by their sheer weight. Water in general, particularly in urban areas, is indeed becoming one of the most vulnerable things to scarcity.

The need to accelerate the provision of safe drinking water in various settlements has been stressed time and again. The Drinking Water Mission was made operative to meet the ever increasing demands in rural sector under Rural Water Supply Programme.In fact, it was initiated in India even before the Mar del Plata Conference and the UN Declaration in 1980. It was further strengthened through the setting up of National Drinking Water Mission in 1986 for Rural Water Supply and it is still continuing as Rajeev Gandhi Drinking Water Mission which include, provisions of drinking water, sanitation, water disposal etc. which is directly related to the quality of environment that would evolve in a particular city.

The Ganga Basin lies in the states of Bihar, Delhi, Madhya Pradesh, Haryana, Himachal Pradesh, Uttar Pradesh and West Bengal(PL-I). The drainage area of the basin lying in India is 861452 sq.km. which is 26 percent of the total geographical area of the country.

The total population of the basin is 357 million, which is nearly 42 percent of the county's population with population density of 414 person/sq.km supported by about 110 urban centres with population more than 1 lakh and eight cities which possess population more than 10 lacks.

The populations of the cities have increased considerably and accordingly the water demand has also gone up. The urban centres have crowded suburbs, unplanned settlements and slums, which create and pose several severe environmental problems and call for scientific and planned management of surface water and ground water.

2.0 URBANIZATION AND GROUND WATER

Almost all the cities in Indian history, originated and developed on the banks of rivers and other water bodies. It is true that in the olden day's problem of water supply was not so complex and acute, as it is being faced today. The problem of water pollution was unknown during those days and the pure water was available in plenty. But in modern time, with phenomenal growth of population and increasing requirements, the water regime has deteriorated in quality and quantity, especially in the urban centres. It is assumed that urbanisation and industrialisation in the basin will lead to transform it in to highly polluted and deficit basin by 2050.

3. 0 IMPACT ON GROUND WATER

It is observed that the hydrogeological setup of Metropolitan centres is modified and they are now quite different from normal and natural conditions, quantitatively and qualitatively (Rai, J.N. 1999). The water table is lowered in general. The surface run off is increased due to increase in impervious

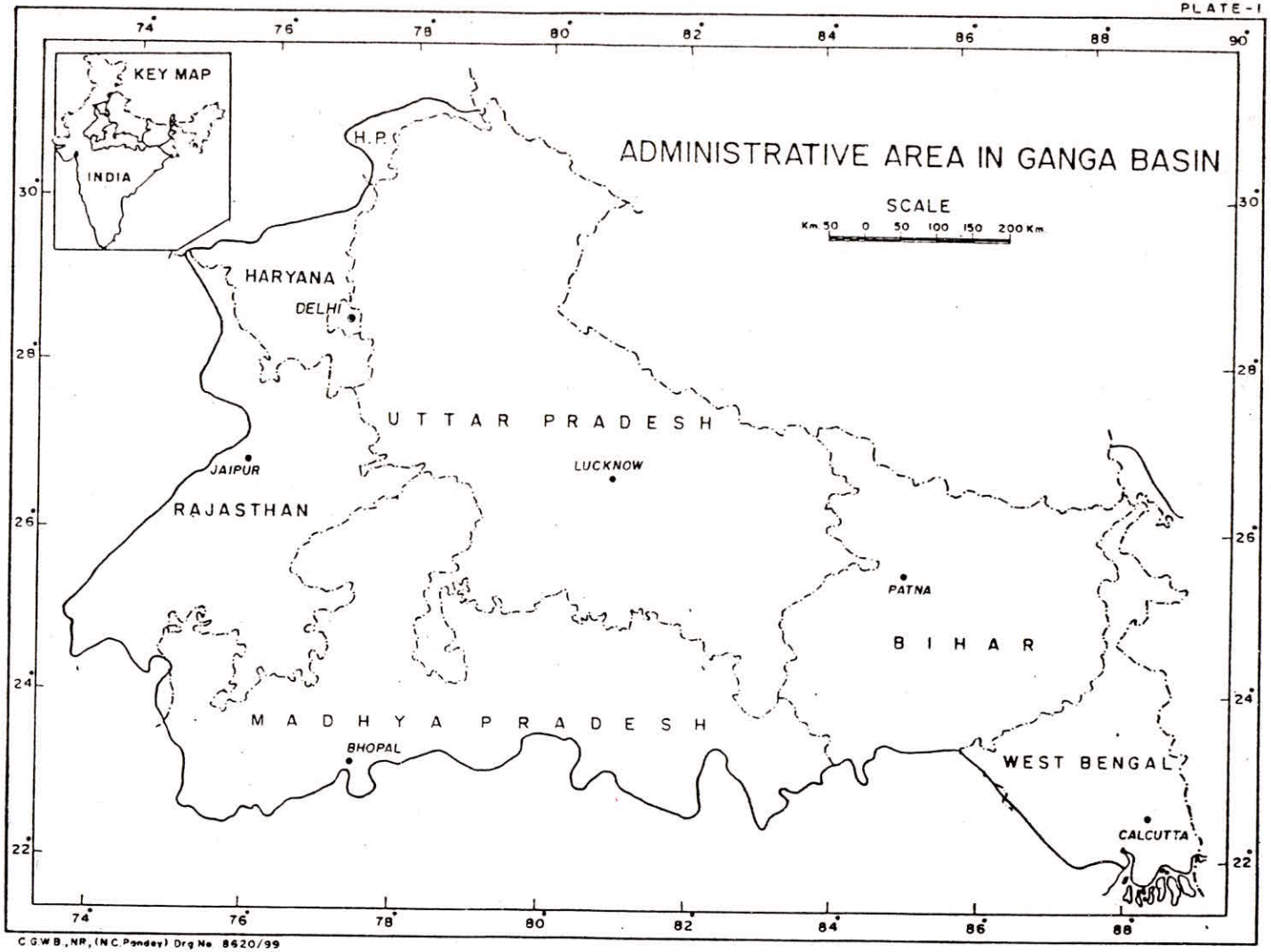


PLATE-I
ADMINISTRATIVE AREA IN GANGA BASIN
KEY MAP
INDIA
SCALE
Km 50 0 50 100 150 200 Km
H.P.
HARYANA
DELHI
UTTAR PRADESH
JAIPUR
LUCKNOW
RAJASTHAN
PATNA
BIHAR
MADHYA PRADESH
BHOPAL
WEST BENGAL
CALCUTTA
74° 76° 78° 80° 82° 84° 86° 88° 90°
30° 28° 26° 24° 22°
C.G.W.B., NR, (N.C. Pandey) Drg No 8620/99

strata and infiltration decreases accordingly. The enhanced anthropogenic activities and increasing population have deteriorating impact on ground water regime, which are summarised as follows.

3.1 Lowering of Water Table

The important aspects of urbanization, which mostly influence hydrogeological processes, are the increase in population density and increase in building density. As the population of city area increases, water supply demand begins to rise and thus the withdrawal of ground water also increases, causing lowering of water tables. It is observed that in almost all capital cities of Ganga Basin, a cone of depression has been created in water level due to excessive withdrawal of ground water. In most of the metropolitan cities water table lies below 10 m bgl. and more, e.g. in New Delhi where the water level in the City block area has been recorded at a depth of 20 to 25 m bgl, is deeper than the surrounding areas. Similar conditions have been recorded in other capital cities of the basin (Table-1).

Table 1 : Lowering of Water Table in Capital Cities

Sl.No.	State	Capital City	Period	Range of Lowering (in m)
1.	Bihar	Patna	1975-1976	No appreciable change
2.	N.C.T.	New Delhi	1962-1995	10-15
3.	Madhya Pradesh	Bhopal	1956-1998	3 - 4
4.	Rajasthan	Jaipur	1988-1997	8 -10
5.	Uttar Pradesh	Lucknow	1979-1999	10-11
6.	West Bengal	Calcutta	1958-1997	5 - 8

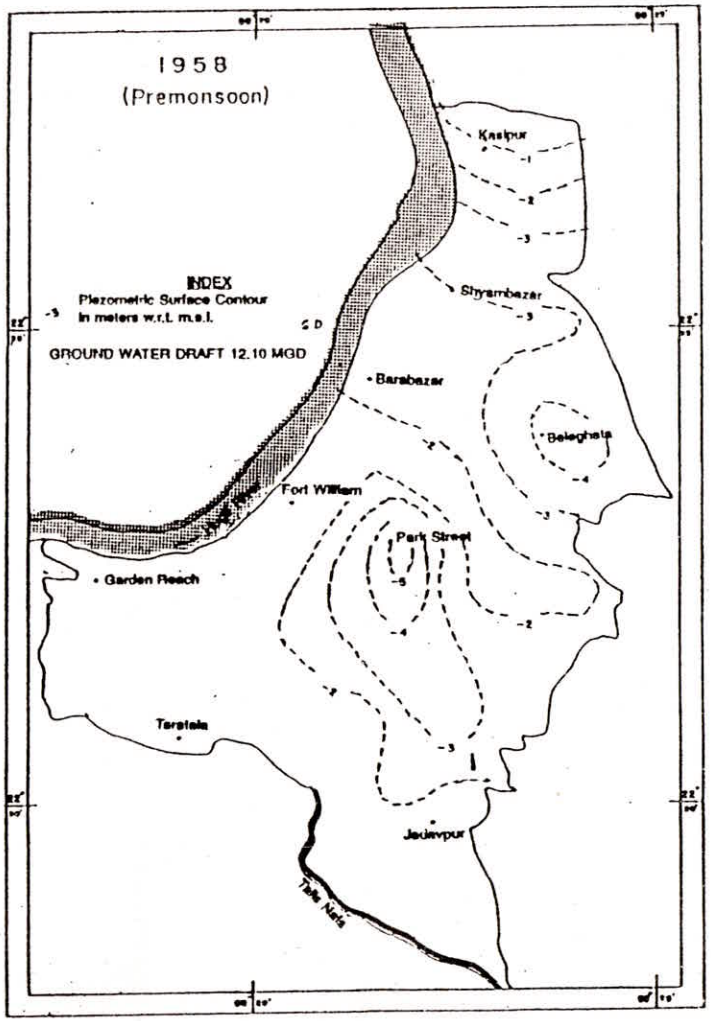
Further, in Calcutta City it is observed that due to large scale withdrawal of ground water from the confined aquifers in central and south Calcutta, a ground water trough has been formed in the piezometric surface. It was reported to be at 9 metre below MSL, approximately over an area of 60 sq. km in pre-monsoon of 1989, and extended to 125 sq.km in pre-monsoon of 1998 (Plate-2).

3.2 Retardation in Ground Water Recharge

The in ground water storage and quantity are adversely linked with the increase in building density. The building density increases proportionately with population density. As the built-up area rises, the extent of pervious area decreases consequently, the amount of infiltration and recharge to ground water is reduced. The status of population density in capital cities of various states of Ganga Basin are given in Table-2.

DECLINE IN PIEZOMETRIC SURFACE IN CALCUTTA METROPOLITION AREA

PLATE-2



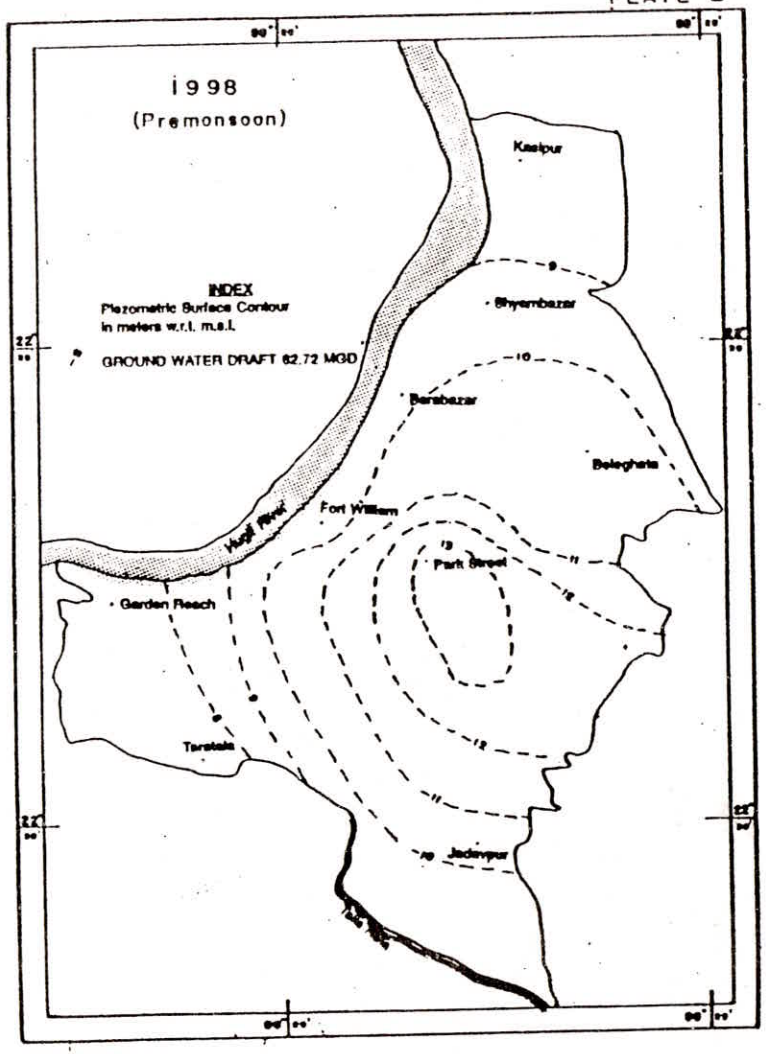


Table 2 : Status of Population Density in the Capital cities in Ganga Basin.

State	Capital City	Population	Area (sq.km)	Population Density (No. Per sq. Km)
Bihar	Patna	13,76,000	125	11,008
N.C.T.	New Delhi	93,70,000	496	18,891
Madhya Pradesh	Bhopal	10,63,622	296	3,593
Rajasthan	Jaipur	18,40,000	181.4	10,143
Uttar Pradesh	Lucknow	21,90,000	168	13,036
West Bengal	Calcutta	43,90,078	187.33	23,435

It is observed from Table-2 that in Calcutta and New Delhi where population density is highest have high built-up density. The amount of recharge to ground water is expected to be least in these cities.

3.3 Increased Surface Run-off

The increased built-up area reduces infiltration and increases surface run-off from the urban agglomeration. Thus the other change caused by urbanization, is the introduction of storm sewers, where a large volume of runoff is discharged within a short time interval giving rise to the problem of floods in drainage lines and finally to the rivers. The storm runoff results to poor recharge.

Generally, it is found in the urban area that neither the National Housing norms nor the State Housing norms being followed strictly, where at least 40% of land should be kept open for various environmental reasons. The utility and implication of open land in courtyard of a house or in the city area are not understood and entire land and plots are either covered or cemented. This certainly restricts the recharge to ground water. Even, the old storage tanks and ponds are being filled to construct multi-storied buildings, which necessarily deteriorates the natural hydrological regime of the area and finally the eco-system.

3.4 Quality Deterioration

With the increase in effluents from urban and industrial areas, the water quality deteriorates in and around cities. For example, the Ganga in Kanpur, Varanasi and Calcutta, Yamuna between Delhi and Etawah, Chambal down-streams of Nagda to Kota, Sone near Amlai and Dalmianagar and Gomti in Lucknow, is highly polluted. The hot effluents from Thermal Power Plants, mining activities in Dhanbad and Asansol belt are also adding to the pollution of streams and reservoirs in the region. The water in some stretches of these rivers is not suitable for drinking, bathing and even propagation of animal life. Similar conditions are also met with ground water, the quality of which is deteriorating day by day due to unplanned and non-scientific disposal of urban and industrial effluents.

The recent surveys in NCT Delhi have indicated that ground water is highly polluted. The concentration of heavy metals like Pb, Cd, Cr, and Fe is found beyond permissible limits over the large areas. Similar conditions also exist in other cities like Lucknow, Kanpur, Varanasi and Agra in U.P., besides other industrial and major cities of the states falling in the basin. It is also observed that in most of the hand pumps and wells of the urban centers, ground water is polluted due to bacteriological contamination. The Nitrate pollution is very high in the ground water of south-west parts of NCT Delhi, particularly in Najafgarh and Kanjhawala blocks. The Okhala-Kalindi Kunj area also contains high Nitrate concentration. The utilisation of such polluted water creates several health hazards such as abdominal pain, disorder of intestine, blindness, still birth due to Poly-chlorinated Byphenyls toxin, damage to lever, bone, brain due to Vinyle chloride and Benzene, carcinogenic effects due to DDT, Aldrin, Dieldrin, Dioxin, Chlorinated Organic compounds and Methylnitrosomanis (infants) disease due to Nitrate and Nitrite toxins.

3.5 Salinity Ingress

This phenomenon is observed in most of the cities and towns of Haryana, Rajasthan, National Capital Territory of Delhi and in the western part of Uttar Pradesh. In the cities like Agra, Mathura, NOIDA and Ghaziabad, ground water deteriorates in quality on excessive pumping. It is observed that due to over pumping of fresh ground water, there is ingress of brackish and saline water from other aquifers of bad quality, and thus the quality of water deterrorates. Similarly, deterioration of ground water quality is reported in some parts of Calcutta (CMC area) due to over drafting. It is more pronounced in deltaic region in South 24 Parganas.

4.0 MANAGEMENT OF GROUND WATER IN URBAN CENTRES

To ensure sustainable and optimum development of ground water in varied hydrogeological conditions, detailed and systematic hydrogeological surveys are essential. This should be based on priority focal points, essential for all the urban settlements. It is observed that due to increased urbanisation and industrialisation the per capita land and water availability is declining very fast. The ground water and surface water is being polluted due to faulty sewerage system and unscientific industrial waste disposal. In view of these deteriorating conditions of surface water and ground water around urban centres, the following steps are essential for efficient ground water management and sustainable development.

4.1 Balanced Urbanization

Since, urbanization is intercombed with development and industrialization, this cannot be stopped even considering its bad impact on water resources. In this context, it is essential to have balance patterns of urbanization, i.e., to develop satellite towns, decentralization of Government Offices in order to reduce the pressure on the large cities. It is also necessary to control unregulated peripheral development around major cities, i.e., construction of buildings particularly on agricultural land,

which is the source of grain, water and ground water recharge. It should be made necessary to review, citywise surveys of various public agencies for the use of land ownership and to formulate basic plans for efficient utilization of land for proper development of big cities. Suitable amendment in the laws of Indian Housing Policy, 1992 and procedure governing land acquisition in urban areas is must so as to facilitate the rain water harvesting and recharge. To ensure speedy action in reorientation of master plans on these lines, laws may be revised for Land acquisition in major cities. The concerned departments, must stress for this in the beginning for formulation of master plan policy, by legal and regulatory measures.

4.2 Watershed Management

(a) The catchment areas of surface water should be demarcated and must be left undisturbed in the master plan of the urban areas. Municipal Corporations must demarcate such catchment areas as restricted zones with a provision for reservoir. It may be planned in the capital cities like Bhopal, New Delhi and Jaipur where hilly terrains are available. However, in case of Lucknow, Patna & Calcutta, which are situated in plain lands, the abandoned channels, Ox-bow lakes, old Brick-kilns, ravines and excavations can be converted into recharge areas and water storage tanks instead of garbage dumping ground.

(b) Urban Development Authority, Town Planning Department or local bodies with specialized persons should be vested to control and regulate all water bodies, including rivers, canals, water ways, aquifers, in each city, under the technical guidance of C.W.C., Central Ground Water Board and State Ground Water Departments. It is necessary to provide structures for surface water percolation along the roads, pavements and other open spaces, to prevent water flooding and excess runoff from the area, consequently to improve the recharge prospect. Conservation of rain water should be considered on priority, instead to develop extra drainage from city area to remove ponded rain water.

4.3 Construction of Tubewells

Tubewells down to depth of 750 m are constructed in the entire basin as well as in the metropolitan cities. However, in the cities like Jaipur, Delhi and in the cities of western U.P., ground water is found brackish even at shallow depth (less than 60 m.bgl). The development of ground water in such places should be done very cautiously. The selection of well sites must be made with the help of remote sensing and geophysical surveys, so that fresh water aquifers can be delineated in the beginning itself.

To meet the growing demand of water supply, construction of Tubewells in urban areas should be done at safer localities, where the area is free from urban and industrial pollution and where there is no water table decline. In view of this, there is ample scope for construction of tubewells in and around cities like Patna, New Delhi and Lucknow.

4.4 Shallow Tubewells in Flood Plains

It is observed in the flood plains of Yamuna river that construction of shallow tubewells (30 to 40m)have solve the scarcity of water during summer, the dewatered aquifer in these flood plain, got naturally recharged during the monsoon and the depleted water level attains normal level. Similar structure can be constructed in Lucknow and Patna in the flood plain of rivers Gomti and Ganga respectively. However, in case of Calcutta along Hoogli, there is every possibility of quality problem and salinity hazards.

4.5 Rain Water Harvesting

(a) Utilization of roof top water is the cheapest method of rain water harvesting. It is observed in Hyderabad city that 10.90 MCM of rainwater could be collected by 20 mm of rainfall/ day from a 100 sq.m roof top (P. Babu Rao et.al.1998) Therefore, it should be made necessary for all Govt. buildings, Corporate buildings to take necessary measures for rain water harvesting structures. The individual and community participation should be encouraged by offering subsidies, rebates etc. Rain water harvesting should be made mandatory for Airports, Railways, Roadways of all Capital cities in the basin to meet their water demand. They must store and pond unutilised rain water, which moves from their land as surface runoff. Such water ponding will recharge the aquifer and restore the water table.

(b) The low lying areas, along the main roads, which are generally water flooded and water logged. This water can be utilised and diverted into infiltration well/ recharge well through a settling pond/ditch. It is observed in Hyderabad- Secundrabad twin city that 10 m wide road top of 1 km length with 20 mm average rainfall, 5450 Cu.m rain water could be collected and stored for artificial recharge (P.Babu Rao et.al.,1998).

(c) In initial stages of town planning, areas and localities should be identified where rain water can be stored. The local town development authorities, HUDCO etc. must give proper emphasis to this point. It should be made rather necessary and legal with each colony and Town development plans.

(d) If desired by local authorities of Town Planning Department, the Central Water Commission and Central Ground Water Board can provide the technical advice on demarcation of catchment area, low lying area in the city, where non-paved area is increasingly getting limited by urban development. This programme should be taken under integrated and coordinated development of surface water and ground water with their conjunctive use under National Water Policy (1987).

(e) The rain water harvesting methods suggested as above to collect and store runoff water from roof top of buildings, roads, parks, play grounds, airports etc. in low lying areas, and then

to pits and trenches for artificial recharge, will reduce the surface runoff and increase the ground water recharge. It will ensure the sustainable ground water development.

4.6 Construction of Percolation Tanks With Bunds

The artificial recharge could be done by constructing Check- weirs, Check- dams and Bunds in the undulating topography existing in suburbs of cities like Bhopal, Jaipur and New Delhi (NCT). The low lying area of a field, in highly sloping ground, can be converted into a percolation tank to arrest the surface runoff from the area. Recharging of aquifers should be done by Injection wells in the down slope of such Bunds and percolation tanks. Highly successful and promising results have been obtained in Jawaharlal Nehru University (J.N.U.) and I.I.T. complex in the National Capital Territory New Delhi, by such artificial recharge methods (Sikka, V.M. et.al., 1998).

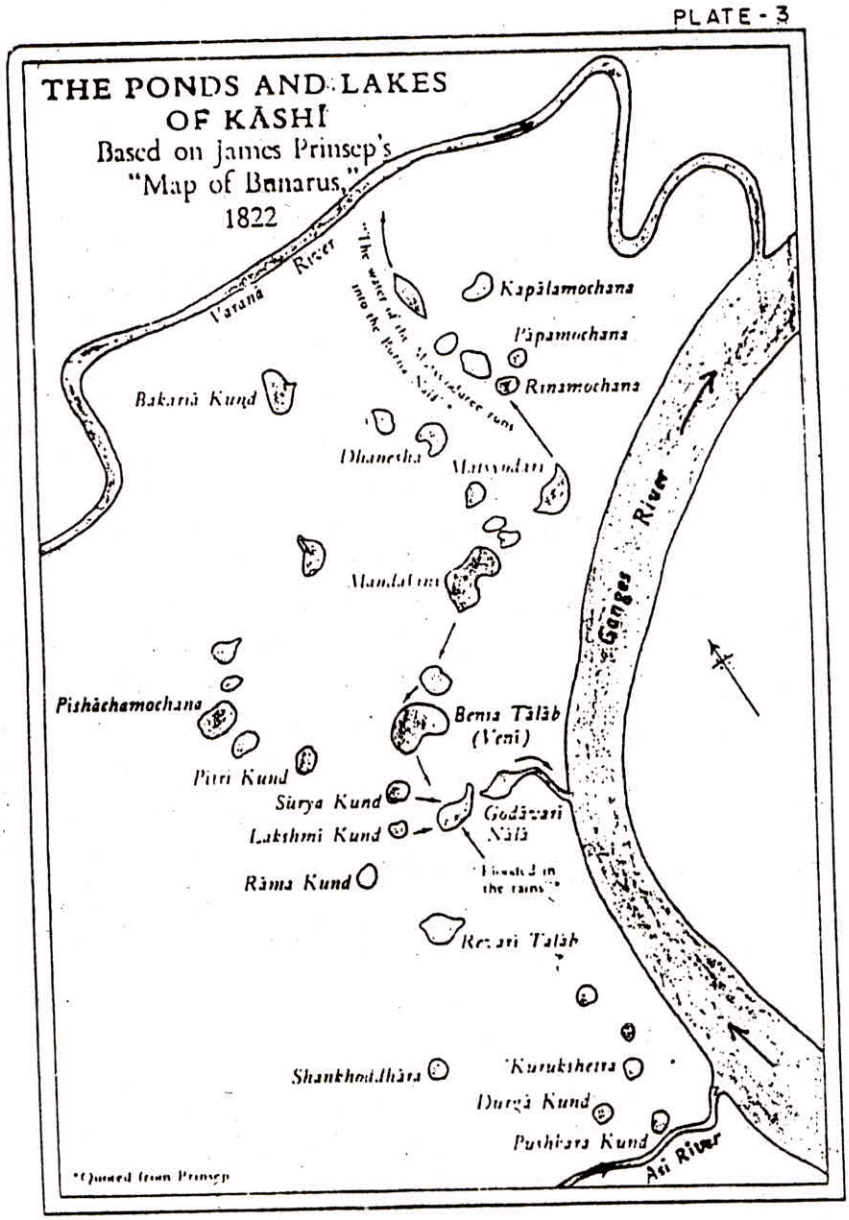
4.7 Maintenance and Rejuvenation of Existing Structures

(a) It is observed that surface water bodies like 'Talab' 'Ponds', Tanks, 'Kunds' in urban centres i.e. in Bhopal and Jaipur city, Yamuna river in national capital Territory New Delhi, Gomti river at Lucknow and Ganga river at Patna, Hoogli at Calcutta are under severe pressure from pollution in their catchment. The old traditional systems of water harvesting and their utilization are in a dilapidated condition. The rivers are highly polluted, since most of the urban drainage and waste being poured into them. It requires proper attention to control this.

(b) It is important to go for water harvesting structures in all urban centres where population is one Lakh and more. But, at the same time, it is also equally essential to protect and revive the old traditional systems of water harvesting in the form of ponds, tanks etc. Varanasi, the oldest city and the seat of urban civilization in India, was possessing about 84 'Kundas' (Plate-3) in and around 'Kashi' (Choudhari,G.C. 1990), though it was situated on the bank of river Ganga. These 'Kunds' have not only serve the purpose of domestic utilization but scientifically acted as water harvesting structures. They have not only recharge the aquifer system but have solved the problem of water logging during monsoon. The existence of 'Kunds' of Varanasi, the central canal of Delhi passing through the hearts/centres of the city, 'Chota Talab', 'BadaTalab' of Bhopal city not only indicate the old Indian traditions of water harvesting, but they constitute the rich heritage, which are almost in dying stage. Now, there is no existence of any canal in New Delhi as the entire system is covered by roads and buildings. At places where ever it exists, it is being used as garbage dumping ground. Similarly, number of 'Kunds'/Talabs in Varanasi, Lucknow & Patna at present are covered by huge multi-storied buildings. There are some such structures left in dilapidated condition and continue to play an important hydrological role in the local environment.

Under the circumstances, it is highly essential to protect and revive the full potential of remaining such structures in the main urban centres and their surroundings.

PLATE - 3


THE PONDS AND LAKES
OF KĀSHĪ
Based on James Prinsep's
"Map of Banarus,"
1822
Varuna River
Kapālamochana
Pāpamochana
Rinamochana
Bakariā Kund
Dhaneshā
Mandalam
Ganga River
Pishāchamochana
Benia Tālāb
(Veni)
Pitri Kund
Sūrya Kund
Lakshmi Kund
Godāvari
Nālā
Rāma Kund
Shankhodhāra
Kurukshetra
Durgā Kund
Pushkara Kund
Asi River

4.8 Afforestation Programme

The water catchment area should be demarcated in each city as stated earlier and deforestation should be and must be stopped which is generally a common practice to accommodate the urban settlements. The deforestation in the catchment, may cause heavy runoff, and will decrease the sub-surface infiltration and consequently the ground water recharge. The water catchment area should be developed in a way to make it soil erosion free and solution free by putting more land under afforestation. This will minimise the surface run-off and in turn recharge the phreatic aquifer in the watershed. Such catchments can be developed in capital cities like Bhopal, Jaipur and New Delhi (N.C.T.).

4.9 Protection of Water Resource from Pollution

It is observed that due to lack of proper water management the available surface water and ground water in urban and industrial areas getting highly polluted. In this context, it is highly essential that urban water management and waste water management practices should go side by side. The sewage water and industrial waste water of these cities must be treated before they meet natural drainage lines. It is reported from most of the urban centres that untreated effluents released through unlined drains, are very rich in heavy metals like Chromium, Cadmium, Iron and Zink, which deteriorate the quality of ground water and create health hazards for urban population. Such localities, should be demarcated problematic and such Industries, which are really polluting ground water and surface water, should be served with notices for necessary precautionary measures under subsection (3) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986) by Central Ground Water Authority with information to Central Pollution Control Board for further needful action.

4.10 Wastewater Management

It is must and highly essential to takeup urban waste water management along with urban water management. The best use of waste water could be done only by its purification, i.e., by removal of its contaminants and recycling the resource for gardening and farming. An appropriate minimum tariff should be fixed for treated waste water to encourage its use. This will not only serve the purpose of additional water supply, but also stop the pollution of water resources including tanks and rivers at urban centers.

5.0 CONCLUSION

It is observed in almost all the major cities of the basin that the impact of urbanization on ground water is reflected in lowering of water tables, excess runoff due to paved and cemented area, pollution of surface water and ground water due to sewer, sewerage and industrial wastes. Further, the increase in urban population and industrial intensity deteriorates the urban environment day by day. Under the circumstances the necessary management practices suggested are balanced

urbanization, watershed management, rain water harvesting including rooftop rain water harvesting, construction of percolation tanks, bunds and construction of shallow tubewells in flood plains and maintenance and rejuvenation of existing tube wells for eco-friendly development of urban centres.

Generally, the suburbs and slums grow around major cities in the watersheds. Though, the slum dwellers play very significant role in the developmental processes of the urban area, they still lack basic amenities like paved lanes, community bathrooms and latrines and create environmental problems related with drinking water, sewage, sewerage, storm water drainage and pollution. Such facilities must be provided in slum areas through planned and proper development to control the environmental problems. If it could achieve, there will be significant improvement in water management system without any adverse impact.

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