ENVIRONMENTALLY COMPATIBLE GROUNDWATER MANAGEMENT IN URBAN AGGLOMERATION OF GANGA BASIN

D.K. CHADHA,
Central Ground Water Board, New Delhi

J.N. RAI and B.C. JOSHI,
Central Ground Water Board, Northern Region, Lucknow

Abstract *Accelerating water demand, limited and diminishing availability of surface water, fast declining trends of groundwater levels in unconfined zone and increasing pollution in surface water makes urban life environmentally unfit and unhealthy. Ganga basin which constitutes 26% of the total geographical area of the country possesses a population of 357 million, which is nearly 42% 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 groundwater resource in Ganga Basin is becoming scarce day by day, as a result of which, in the near future the availability of water for survival of humanity will be difficult. This will also affect the economic growth of the region. It is assumed that due to urbanization and industrialisation, the basin will transform into a highly polluted and deficit basin by 2050, if proper preventive and water conservation methods are not followed and adopted. The present paper deals with the various aspects of the impacts of urbanization on groundwater, i.e., lowering of water table, excess runoff, surface water and groundwater pollution in major cities of Ganga Basin. For environmentally compatible and sustainable groundwater development, the management measures specific to the area have been discussed. The legislative measures are also suggested for suitable development of groundwater and conserving surface water in urban micro-watersheds to prevent and control the environmental deterioration.*

INTRODUCTION

The term, human settlement, is essentially an innate usage which is applicable to a city, town, village or even a single hutment in the remotest place. Each settlement has a basic organization with its own social, economic and a cultural setup. It has some basic requirements i.e. food, water, housing and sanitation. It is difficult to manage all these in their entirety particularly in large metropolitan cities. The system breaks, and thing become scarce, scanty and dear by their sheer weight. Water in general, particularly in urban areas, is indeed becoming one of the most vulnerable and scarce resource. 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 Mardel 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, sewage 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 (Fig. 1). The drainage area of the basin lying in India is 861,452 sq.km., which is 26% of the total geographical area of the country.

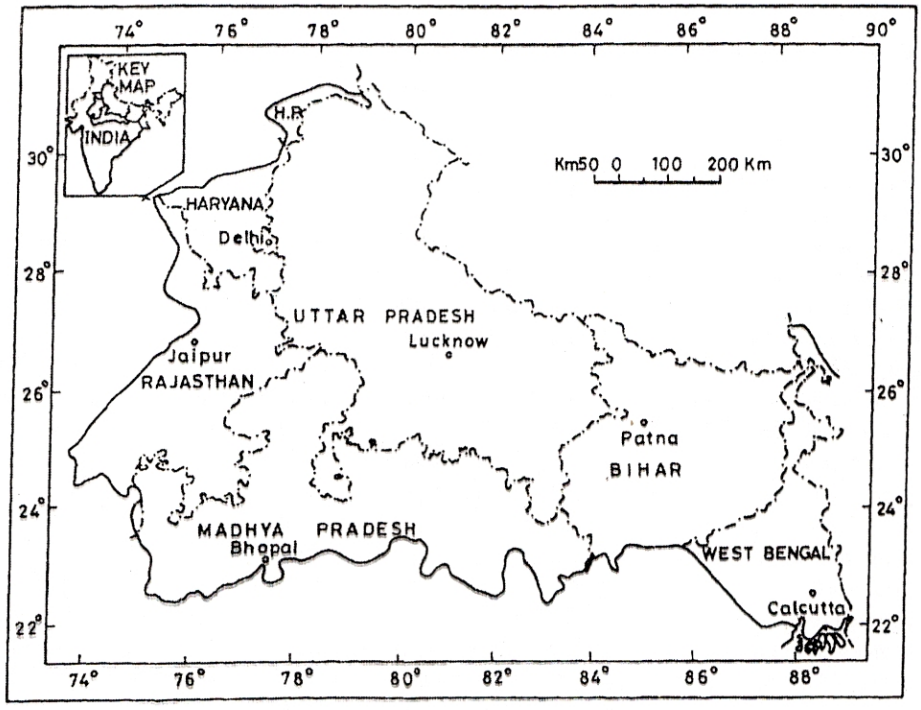

Fig. 1 States falling in the Ganga Basin

The total population of the basin is 357 million, which is nearly 42% of the country'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 lakhs. The population 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 pose severe environmental problems and call for scientific and planned management of surface water and groundwater.

URBANIZATION AND GROUNDWATER

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 old days 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 urbanization and industrialisation in the basin will lead to transform it in to highly polluted and deficit basin by 2050.

IMPACT ON GROUNDWATER

It is observed that the hydrological setup of Metropolitan centres is modified and they are now quite different from normal and natural conditions, quantitatively and qualitatively (Rai, 1999). The water table is lowered in general. The surface runoff has increased due to increase in impervious strata and infiltration decreases accordingly. The enhanced anthropogenic activities and increasing population have deteriorating impact on groundwater regime, which are summarised below.

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 increases, water supply demand begins to rise and thus the withdrawal of groundwater 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 groundwater. 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

State	Capital city	Period	Range of lowering (m)
Bihar	Patna	1975-1976	No appreciable change
NCT*	New Delhi	1962-1995	10-15
Madhya Pradesh	Bhopal	1956-1998	3-4
Rajasthan	Jaipur	1988-1977	8-10
Uttar Pradesh	Lucknow	1979-1999	10-11
West Bengal	calcutta	1958-1997	5-8

* NCT: National Capital Territory

Further, in Kolkata City it is observed that due to large scale withdrawal of groundwater from the confined aquifers in central and southern parts, a groundwater trough has been formed in the piezometric surface. It was reported to be at 9 m 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 (Fig. 2).

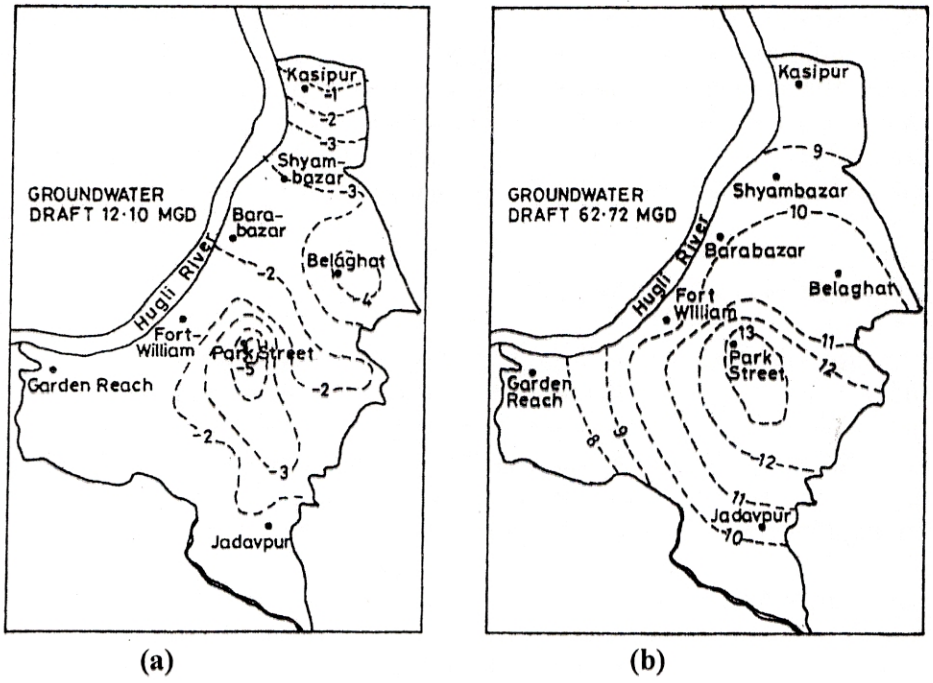

Fig. 2 Decline in piezometric surface in Calcutta metropolitan area
(a) 1958 premonsoon (b) 1998 premonsoon

Retardation in Groundwater Recharge

The reduction in groundwater 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 increases, the extent of pervious area decreases. Consequently, the amount of infiltration and recharge to groundwater is reduced. The status of population density in capital cities of various states in Ganga Basin are given in Table 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	Kolkata	43,90,078	187.33	23,435

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

Increased Surface Runoff

The increased built-up area reduces infiltration and increases surface runoff 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 in poor recharge.

Generally, it is found in the urban area that neither the National Housing norms nor the State Housing norms are 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 groundwater. Even, the old storage tanks and ponds are being filled to construct multi-storeyed buildings, which deteriorate the natural hydrological regime of the area and ultimately the eco-system.

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 Kolkata, Yamuna between Delhi and Etawah, Chambal down-streams of Nagda to Kota, Sone near Amlai and Dalmianagar and Gomti in Lucknow, are 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 for the propagation of animal life. Similar conditions are also met with groundwater, 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 groundwater is highly polluted. The concentration of heavy metals like Pb, Cd, Cr, and Fe is found beyond permissible limits over 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 centres, groundwater is polluted due to bacteriological contamination. The Nitrate pollution is very high in the groundwater 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 effects of DDT, Aldrin, Dieldrin, Dioxin, Chlorinated Organic compounds and Methylnitrosomanis (infants) disease due to Nitrate and Nitrate toxins.

Salinity Ingress

This phenomenon is observed in most of the cities and towns of Haryana, Rajasthan, National Capital Territory of Delhi and in western part of Uttar Pradesh.

In the cities like Agra, Mathura, NOIDA and Ghaziabad, groundwater deteriorates in quality on excessive pumping. It is observed that due to over pumping of fresh groundwater, there is ingress of brackish and saline water from other aquifers of bad quality, and thus the quality of water deteriorates. Similarly, deterioration of groundwater quality is reported in some parts of Kolkata due to over drafting. It is more pronounced in the deltaic region in South 24 Parganas.

MANAGEMENT OF GROUNDWATER IN URBAN CENTRES

To ensure sustainable and optimum development of groundwater 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 urbanization and industrialisation the per capita land and water availability is declining very fast. The groundwater 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 groundwater in urban centres, the following steps are essential for efficient groundwater management and sustainable development.

Balanced Urbanization

Since, urbanization is intercombed with development and industrialization, this cannot be stopped, even after considering its bad impact on water resources. In this context, it is essential to have balanced patterns of urbanization, i.e., to develop satellite towns and 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 groundwater 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 National Housing Policy (Ministry of Urban Development, 1992) and procedure governing land acquisition in urban areas is a 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 itself for formulation of master plan policy, by legal and regulatory measures.

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

and Kolkata, 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 river, canals, water ways, aquifers, in each city, under the technical guidance of Central Water Commission, 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 of developing extra drainage from city area to remove ponded rain water.

Construction of Tubewells

Tubewells drilled to large depths 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., groundwater is found brackish even at shallow depth (less than 60 m bgl). The development of groundwater 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.

Shallow Tubewells in Flood Plains

It is observed in the flood plains of Yamuna river that construction of shallow tubewells (30 to 40 m) have solved the water scarcity problem during summer; the dewatered aquifer in these flood plain, get 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 plains of rivers Gomti and Ganga, respectively. However, in case of Kolkata along Hoogli, there is every possibility of quality problem and salinity hazards.

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. Therefore, it should be made necessary for all government and 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 drains off from their land as surface runoff. Such water ponding will recharge the aquifer and restore the water table.

(b) In the low lying areas, along the main roads, which are generally flooded and waterlogged, the water can be utilised and diverted into infiltration well/recharge well through a settling pond/ditch. It is observed that in the twin city of Hyderabad- Secundrabad, a 10 m wide road top of 1 km length with 20 mm average rainfall, could collect and store 5450 cu.m. rain water for artificial recharge.

(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 groundwater 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 groundwater recharge. It will ensure the sustainable groundwater development.

Construction of Percolation Tanks With Bunds

The artificial recharge can also 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 and IIT complex in New Delhi, by such artificial recharge methods.

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 NCT New Delhi, Gomti river at Lucknow and Ganga river at Patna, Hoogli at Kolkata are under severe pressure from pollution in their catchment. The rivers are highly

polluted, since most of the urban drainage and waste are 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' (Fig. 3) in and around Kashi (Choudhari, 1990), though it is situated on the banks of river Ganga.

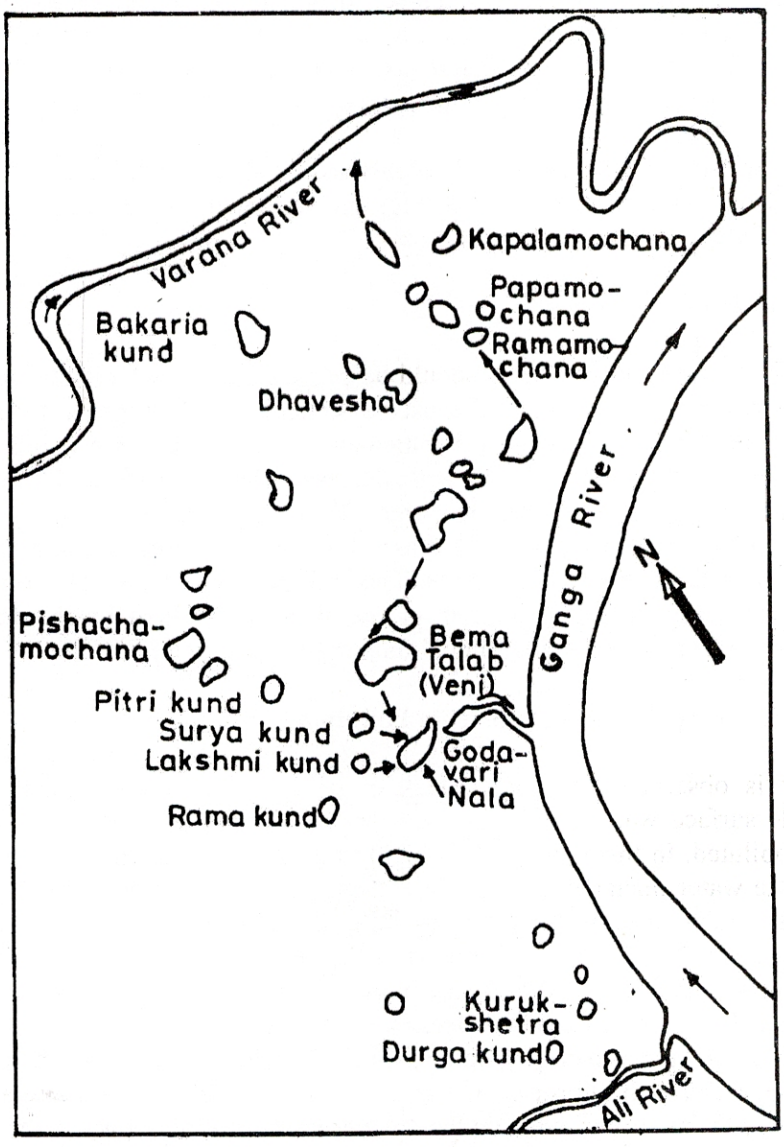

Fig. 3 The ponds and lakes of Kashi (Prinsep, 1822)

These 'Kunds' have not only served the purpose of domestic utilization but scientifically acted as water harvesting structures. They have not only recharged 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', 'Bada Talab' 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, a number of 'Kunds'/Talabs in Varanasi, Lucknow and Patna at present are covered by huge multi-storeyed buildings. There are some structures left in dilapidated condition which 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.

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 subsurface infiltration and consequently the groundwater recharge. The water catchment area should be developed in such a way so as to make it soil erosion free and solution free by putting more land under afforestation. This will minimise the surface runoff and in turn recharge the phreatic aquifer in the watershed. Such catchments can be developed in capital cities like Bhopal, Jaipur and New Delhi (NCT).

Protection of Water Resources from Pollution

It is observed that due to lack of proper waste water management, the available surface water and groundwater in urban and industrial areas are 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 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 Zinc, which deteriorate the quality of groundwater and create health hazards for urban population. Such localities should be demarcated as problematic and such industries, which are really polluting groundwater and surface water, should be served with notice 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.

Wastewater Management

It is highly essential to take up 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 centres.

CONCLUSION

It is observed in almost all the major cities of the basin that the impact of urbanization on groundwater is reflected in form of lowering of water tables, excess runoff due to paved and cemented area, pollution of surface water and groundwater due to 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 a very significant role in the development 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, and storm water drainage. Such facilities must be provided in slum areas through planned development to control the environmental problems. If it could be achieved, there will be significant improvement in water management system without any adverse impact.

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