Facilitating Rain Water Harvesting and Storm Water Management for Recharging Groundwater in Urban Areas - A Case of Bhopal Region

Favoriser la collecte et la gestion des eaux pluviales pour recharger les nappes phréatiques en site urbain – le cas de la région de Bhopal.

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RESUME
Notre article porte sur la situation actuelle de la rareté de l'eau et sa future demande en prenant la région de Bhopal comme exemple. Il présente les résultats de nos études au regard de l'étude des caractéristiques physiologiques et hydrologiques de la région et son modèle d'urbanisation qui est responsable de la perturbation du drainage naturel du quartier urbain et aussi des quartiers attenants dans la région concernée. En plus, comme un résultat de cet article, on a trouvé des zones potentielles d'eau (présenté sous forme de cartes), avec comme un but principal d'exploiter l'eau de pluie (qui est normalement rendu inutile dans la région urbaine comme l'eau pluviale) et d'aider à la recharge des eaux souterraines diminuées de la région concernée.

ABSTRACT
Our paper explores the present situation of water scarcity and demands for the future taking a case example of Bhopal region. It gives results of our studies regarding the study of physiographical and hydrological characteristics of the region and its pattern of urbanization that has led to disturbance in the natural drainage of the urban area and the adjoining region alike. Further we have worked out water potential zones (in the form of maps) as an outcome of the paper with a primary purpose to tap rain water (which usually goes waste from the urban areas within the case region as storm water) and help charge the depleting ground water resources of the region in question.

KEYWORDS
Groundwater recharge, rainwater harvesting, storm water management, urbanisation, water potential zones.
INTRODUCTION

India, as it depends on Monsoon for its rainfall, has a highly seasonal pattern of precipitation, with 50% of precipitation falling in just 15 days and over 90% of river flows in just four months.

Today in the 21st Century, India can still store only relatively small quantities of its fickle rainfall. India can store only about 30 days of rainfall, compared to 900 days in major river basins in arid areas of developed countries (India’s Water Economy, 2005).

The National Commission on Water of 1999 has shown that overall water balances are precarious; that crisis situations already exist in a number of basins and that by 2050 India demands will exceed all available sources of supply.

Also, India is currently in the early stages of a profound demographic, social and economic transition. The proportion of the population which is urban has doubled over the last thirty years (and is now about 30%); agriculture now accounts for only about 25% of GDP; and the economy has been growing at around 7% a year (India Year Book, 2006).

Urbanization has led to concretization of massive land. The paved pathways, roads and roofs all are impervious surfaces that do not allow the water to percolate into the ground and also lead to huge quantity of storm water to flow and go to waste. If this water is saved and treated it can cater to half the demand of the city. If this water is directed to the ground it can increase the water table and give plenty of water in the summer season. The other important factor is that lack of environmental considerations in city planning and construction has led to blocking of natural drainage system of the cities. This has particularly happened in our case example i.e. Bhopal Region in Madhya Pradesh State of the Central India.

1 ABOUT THE CASE FABRIC

1.1 About Bhopal City and the Problem

Bhopal is the capital city of Madhya Pradesh, the second largest state of India. The city is marked by chequered history and scenic beauty and has excellent connectivity with all parts of the country by road, rail and air.

History testifies that Bhopal "The City of Lakes" is situated on the site of an 11th century city, called Bhojpal, founded by Raja Bhoj.

Bhopal has been facing a fast rate of urban development and industrialization, over the last decade population growth was about per year 3.5% quite higher than the national average of 2%. This has brought about an adverse impact on the available precious water resource. Urban development is posing a serious problem to the planners and they find it difficult to arrange sustainable supply of good quality water for public health.

The topography of the area also does not encourage the planners. The Deccan Trap underlies almost 65% of the area of the city and Vindhyan sandstones occupy only 35% of the area. It being a hard rock terrain the site feasibility has to be assessed for construction of tube wells. In Deccan Trap basalts, aquifers are encountered at shallow depth (30 to 75 m.bgl) and in vindhyan sandstone depth ranges 100 to 150 m. bgl.

The water supply to Bhopal city is mainly from surface water from Upper Lake. A rapid spread of urbanisation of Bhopal city has lead to the increased water demand. 60 MGD of water is supplied by Municipal Corporation in organized sector (60% of the urban population). The residents are in desperation to meet their water needs and
they have drilled their own tube wells. This arbitrary drilling has also lead to the declining trend of water level. Now most of the residents struggle with dwindling yields of tube wells. The ground water management is called for to meet the domestic water requirements of the ever-increasing population of the Bhopal city.

Bhopal is fast developing city in all directions. Fringe areas are converting into a part of urban development at a faster pace rapidly. The study has been conducted on tehsil level, which covers Bhopal urban area and surrounding villages. So that proposals can be framed at the larger perspective urban level. Availability of data, at some level restricted to go in much deeper analysis.

1.2 Water Bodies of Bhopal

The identified study area for Bhopal has 16 major water bodies covering an area of 7019.49 hectares. These water bodies are being put to different uses such as water supply, irrigation, washing, recreation and fisheries etc. Water bodies are presently in different ecological status. Detailed information about these water bodies are presented in table -1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of water resource/water body</th>
<th>Water spread area (in hectares)</th>
<th>Ecological status</th>
<th>Present Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Upper lake</td>
<td>31.0</td>
<td>Mesotrophic</td>
<td>Water Supply, Recreation &amp; Fisheries</td>
</tr>
<tr>
<td>2</td>
<td>Lower lake</td>
<td>12.9</td>
<td>Advance stage of Eutrophic</td>
<td>Raw water supply &amp; recreation</td>
</tr>
<tr>
<td>3</td>
<td>Shahpoor lake (Third lake)</td>
<td>9.0</td>
<td>Advance stage of Eutrophic</td>
<td>Recreation and fisheries</td>
</tr>
<tr>
<td>4</td>
<td>Saranggau lake (top)</td>
<td>4.2</td>
<td>Advance stage of Eutrophic</td>
<td>Recreation</td>
</tr>
<tr>
<td>5</td>
<td>Mota Talab</td>
<td>1.89</td>
<td>Advance stage of Eutrophic</td>
<td>Washing and miscellaneous</td>
</tr>
<tr>
<td>6</td>
<td>Sukhna Hussain Talab</td>
<td>1.0</td>
<td>Bog lake</td>
<td>Abandoned</td>
</tr>
<tr>
<td>7</td>
<td>Mansi Hussain Chay Talab</td>
<td>1.2</td>
<td>Eutrophic</td>
<td>Fisheries</td>
</tr>
<tr>
<td>8</td>
<td>Lodhia Talab</td>
<td>1.5</td>
<td>Advance stage of Eutrophic</td>
<td>Fisheries</td>
</tr>
<tr>
<td>9</td>
<td>Kolar Dam</td>
<td>28.50</td>
<td>Mesotrophic</td>
<td>Water Supply, Recreation, Fisheries &amp; Irrigation</td>
</tr>
<tr>
<td>10</td>
<td>Kola Jot Dara</td>
<td>22.6</td>
<td>Mesotrophic</td>
<td>Irrigation</td>
</tr>
<tr>
<td>11</td>
<td>Halai Khecha Dara</td>
<td>11.3</td>
<td>Mesotrophic</td>
<td>Irrigation &amp; supply for Industrial area (Gowind pani)</td>
</tr>
<tr>
<td>12</td>
<td>Lahar Pur Reservoir</td>
<td>15.0</td>
<td>Advance stage of Eutrophic</td>
<td>Irrigation</td>
</tr>
<tr>
<td>13</td>
<td>Keva Dara</td>
<td>52.4</td>
<td>Mesotrophic</td>
<td>Irrigation</td>
</tr>
<tr>
<td>14</td>
<td>Chokli pani</td>
<td>12.3</td>
<td>Eutrophic</td>
<td>Recreation</td>
</tr>
<tr>
<td>15</td>
<td>Nandi Sari Tank</td>
<td>4.5</td>
<td>Mesotrophic</td>
<td>Recreation</td>
</tr>
<tr>
<td>16</td>
<td>Dhanokha Village pani</td>
<td>2.4</td>
<td>Mesotrophic</td>
<td>Potable water &amp; Recreation</td>
</tr>
</tbody>
</table>

Table -1 Water bodies of Bhopal - area, status and use
1.3 Present Status of Water Availability

It is an irony that even the "city of lakes" is no exception to water crisis in organized sector of the city Bhopal Municipal Corporation supplies 60 MGD of water, which is sufficient for entire city @ 160 lpcd. Still about 40% of the population is dependent on ground water, due to poor management.

Drawl of raw water is from:
- Upper lake – 29 to 30 MGD
- Kolar dam - 24 to 25 MGD
- Open well/Tube wells -5MGD

1.4 Future demand of water

The water supply schemes in Bhopal have been developed in different phases depending on the projected requirement from time to time. The three landmark decisions for augmenting the supply were:
- 1970's - Increase in upper lake capacity (local)
- 1980's - Kolar scheme —-32K.M. away from Bhopal
- 2005 - Narmada water scheme—-67.3K.M. Away from Bhopal

The future water demand projection depending on the population growth rates indicates that water demand in year 2031 for Bhopal city would increase to 118 MGD. The present identified schemes would not be able to meet such high demand; thus there is a need to look for alternative options such as:
- Development of possible resources within the area.
- Ground water recharge
- Conservation of existing water bodies

The projected demands for water in the city until the year 2031 have been worked out:

<table>
<thead>
<tr>
<th>Year</th>
<th>Population In lacs</th>
<th>Demand in MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>19.62</td>
<td>65.0</td>
</tr>
<tr>
<td>2021</td>
<td>26.49</td>
<td>87.5</td>
</tr>
<tr>
<td>2031</td>
<td>35.77</td>
<td>118</td>
</tr>
</tbody>
</table>

2 AIMS AND OBJECTIVES OF THE RESEARCH

The aim of the research exercise is to suggest water buffer (potential) zones where the underground water potential is high so that these areas are conserved for future.

The objectives include:
- To demarcate water recharge areas so that proper recharge mechanisms are established here Maps Prepared and used for Study and Analysis of details of the surface and ground water bodies. The GIS based maps prepared include:
  - Geological map
  - Geomorphologic Map (showing various drainage densities, relief areas, delineating the watersheds and assessing the quantity of water in the catchments)
  - Structural Map (Built Areas)
  - Land use and land capability map
  - Watershed from the Geomorphology Map
3 METHODOLOGY ADOPTED

The water resource assessment, availability and development play an important role in shaping the cities. The gap between supply and demand is increasing, seeing the fact the methodology adopted in the study area involves thematic map generation from Remote sensing data and their integration through GIS. The material used for purpose of study comprises of Survey of India Degree sheet on 1:250,000 scale namely 55E, and Topo sheet on 1:50,000 scale namely 55E/3,55E/4,55E/7,55E/8,55E/11,55E/12 and satellite data IRS-1C LIIS III BIL format 4 bands, band 2,3,4 and 5. Decision support system and ARC-INFO software were used for analysis purpose. Auxiliary data such as Rainfall, tube wells, hand pumps data metallurgical data from various departments like Public Health Engineering Department, Bhopal Municipal Corporation, Water Resources Department, Town And Country Planning Department, Geological Survey Of India and Central Ground Water Board is used.

Geological map, Geomorphological map, Structural map and Lineament maps are prepared (Fig. 1, 2 and 3). Using visual interpretation of satellite data followed by selective field checks. Drainage map is also prepared giving an idea of slope and drainage pattern. For integration all the maps are converted into digital format in GIS and final output map of Hydrogeomorphology is prepared, based on class and various combinations a final output map is generated. With various structures and other features are marked on it. Depending upon class, intervals and underlying Lithology the structures are proposed such as Nalla bund, stop dam, check dam, sub surface dykes, percolation tanks and recharge pits, that can be used by the planners while taking planning decisions.
4 FINDINGS AND RESULTS

Water resources have become the casualty of intensive urbanization. Pollution of water bodies, lakes, rivers and contamination of precious groundwater. The Bhopal city is no exception to this and over a period of time, grave situation has cropped in. The high nitrate concentration is due to disposal of untreated sewage through open and unlined drains / Nallas and indiscriminately dumping of solid wastes without considering Hydro geological situations.

The water level has gone down to 150 meters below ground level. The reason is not very far to seek. The main trouble is that we have been siphoning the water out and we have forgotten to give back what we have drawn by means of recharging the water sources.

A considerable portion of the ground is covered with relatively impermeable layers of various paving materials; infiltration and evaporation are almost nil and most precipitation runs off.

In fact we should store at least 90%, if not the full amount of water which nature give us. To fulfill the ever-increasing demand of water it is necessary to collect the water in water bodies and recharging the ground water sources. The main factors responsible for ground water resource development assessments are geology, geomorphology, lineaments and hydrology. Water potential zones are demarcated as high low and medium. Rain water harvesting and water resource action plan is also proposed and characteristics of suitable land fill sites have been discussed (Fig. 4).

The drainage system of an area gives important clues of the sub surface conditions, which helps in deciphering ground water condition of that area. Water divide zones are delineated with the help of drainage map because, the zones where no percolation of water takes place are not suited for ground water storage.

Rainwater harvesting is very important for urban development as the soil surface exposed to recharge gets drastically reduced and hence recharge gets diminished.
CONCLUSION

Water resources are extremely sensitive and once degraded would take hundreds and even thousand of years to revive. Urban planners will have to give priority to conserve, protect and economic use of water resources. Every planning should have the essence of being a “Water Resource Friendly”.

Study of geology, geomorphology, lineaments, hydrology and Preparation of water resource action plan with the help of remote sensing data and GIS application will give immense help to urban planners in preparation of master plan of any city, viz. location of recharge structures, land use, to tap surface run off and water potential zones. Solution of water is with in the development area itself.

It is expected that the study results if implemented would shape up the water scenario of Bhopal in an eco-friendly direction and scale down the overall exploitation thereby maintaining the equilibrium between the recharge and discharge.

LIST OF REFERENCES

Walton, Groundwater resource evaluation. McGraw-Hill series in water resources and environmental engineering