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RAMGARH LAKE OF GORAKHPUR, INDIA

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ABSTRACT

Water is life for all the living organisms which is present on earth. Water is needed to ensure food security, feed livestock, and take up industrial production and to conserve the environment. Water scarcity involves water stress, water shortage or deficits, and water crisis. India is home to 18 percent of the global population but has only 4% of the global water resources and is one of the largest water users per unit of gross domestic product. This suggests that the way in which India manages its scarce water resources accounts for much of its water woes. Growth in urban population leads to additional water demand of 12,420 MLD in urban areas and is expected to grow at a rate of 4.2% per year till 2025. There is a vast gap between the demand and supply of water in urban areas of India. According to a study by the Centre for Science and Environment, 48% of urban water supply in India comes from ground water. Ground water exploitation for commercial and domestic use in most cities is leading to reduction in ground water level. The Asian Development Bank has forecast that by 2030, India will have a water deficit of 50%. Integrated holistic approach towards managing urban water supply is needed in India, which aligns with the UN's Sustainable Development Goals to be achieved by 2030 regarding availability and sustainable management of water and sanitation for all. Much of the water crisis in India is caused not by natural disasters, but rather because of severe mismanagement of water resources, poor governance, anthropogenic wastes and apathy about the magnitude of the crisis. The increased value of solid wastes and other hazardous waste in water systems such as rivers, ponds, lakes and canals also heavily pollute the water quality. This paper elucidates various measures for sustainable urban water management especially in Uttar Pradesh. Recycling and treating sewage water can also help us meet out the water scarcities in urban areas. Protection and conservation of Water bodies/ Ponds, recharging the ground water and the aquifers hold the key importance. The need of the hour is conservation of shrinking water bodies, wetlands and dying lakes. The case study of Ramgarh lake of Gorakhpur area has been mentioned in this paper which is the affected lungs of the city.

KEYWORDS: Urbanization, Integrated Water Resource Management, Ramgarh Lake.

INTRODUCTION

Water is a vital component of an ecosystem. It sustains life on earth. A community depends on water for its domestic, agriculture and industrial needs.[1] Availability of water has been the main reason for the development of varied civilizations near lakes and rivers. Both human population and water resources are distributed unevenly across the world. Around one- third of the world's population lives under physical water scarcity for the last couple of decades; it has become evident that due to a steadily increasing demand, freshwater scarcity is becoming a threat to sustainable development of human society. The Globe Economic Forum in its annual risk report lists; water crises the largest global risk in terms of its potential impact. The demand for water is growing thrice faster than the expansion of population and it is estimated that by 2025, the water scarcity will increase from 450 million to about 3,000 million people in the world.[2] The status of provision of water and sanitation has improved, albeit slowly, inadequate and poor quality of potable has not only resulted in additional sickness and death, but has increased health costs.[3] International Conference on Sustainable Development by the UN in 2015 has put Sustainable management of water in the coreframework of Millennium Development Goals (MDGs) and by 2030; it is goal to access the potable water for all. Water is important for socio-economic development and for sustaining the different ecosystems.The WHO/UNICEF Joint Monitoring Programme (JMP) is affiliated to UN-Water and was established in 1990and has provided regular estimates of progress towards the MDG targets, tracking changes over the 25 years to 2015. In 1990, global coverage of the utilization of improved water sources and sanitation facilities stood at 76 % and 54%, with respective MDG targets of 88 % and 77 %by 2017.[4] By 2025, 1.8 billion people are going to be living in regions or countries with absolute water scarcity. Given the transboundary nature of water (Fig.1), this will have grim implications for world peace and also equitable socio-economic development. With 263 trans-boundary river basins within the world, the potential for cooperation or conflict is tremendous.[5] 148 countries have territory within one or more transboundary river basins. Almost 450 agreements on international waters were signed between 1820-2007.[6]

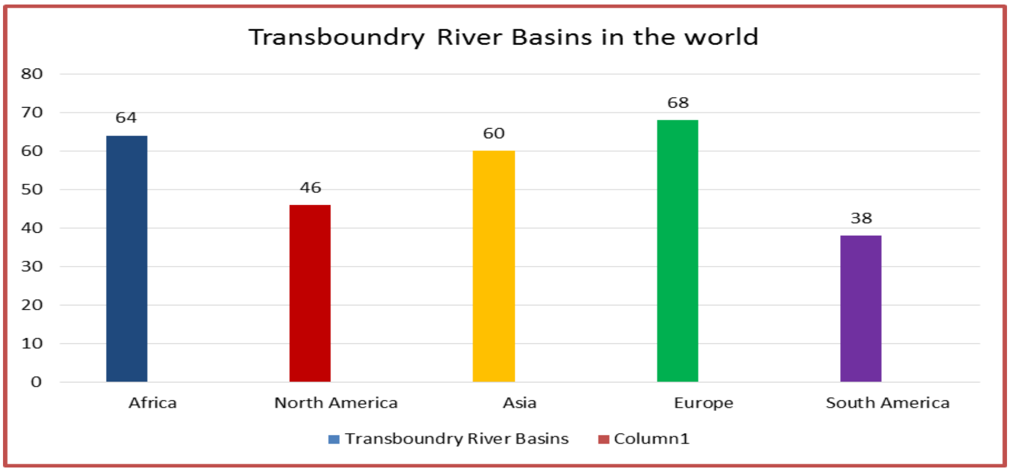


Figure 1. UN Water Report, 2014.

TYPES OF URBAN WATER SCARCITY

It is remarkable that 70–80% of all problems indeveloping countries are identified with water pollution, especially for children.The toxic pollutants released inwaste-waters can be harmful to aquatic organisms which also cause the regular waters to be unfit as consumable water sources.[7] There are two general type of water scarcity: physical and economic. Physical, or absolute, water scarcity is that the results of a region's demand outpacing the limited water resources found there. Around 1.2 billionpeople board areas of physical scarcity; many of those people board arid or semi-arid regions.[8] Two-third world population faces water scarcity, at least one month in a year. The quantity of individuals greatly affected by physical water scarcity would grow as populations increase and as weather patterns become more unpredictable and extreme.

Economic water scarcity is due to an absence of water infrastructure and also due to poor management of water resources where infrastructure is in place. The estimation of over 1.6 billion people faces economic water shortage.[8] In areas with economic water scarcity, there usually is sufficient water to satisfy human and environmental needs, but access is forbidden. Economic water scarcity might also result from unregulated water use for agriculture or industry, often at the expense of the ultimate population (Fig. 2). Finally, major inefficiencies in water use, usually because of the economic undervaluing of water asfinite natural resources, can contribute to water scarcity. Often, economic water scarcity arises from multiple factors together. Elimination of the wetlands and lakes that surrounds the towns, imply that the precipitation cannot charge the local aquifers. Nearly half the municipal water system is taken unsustainably from the aquifer system under the town.

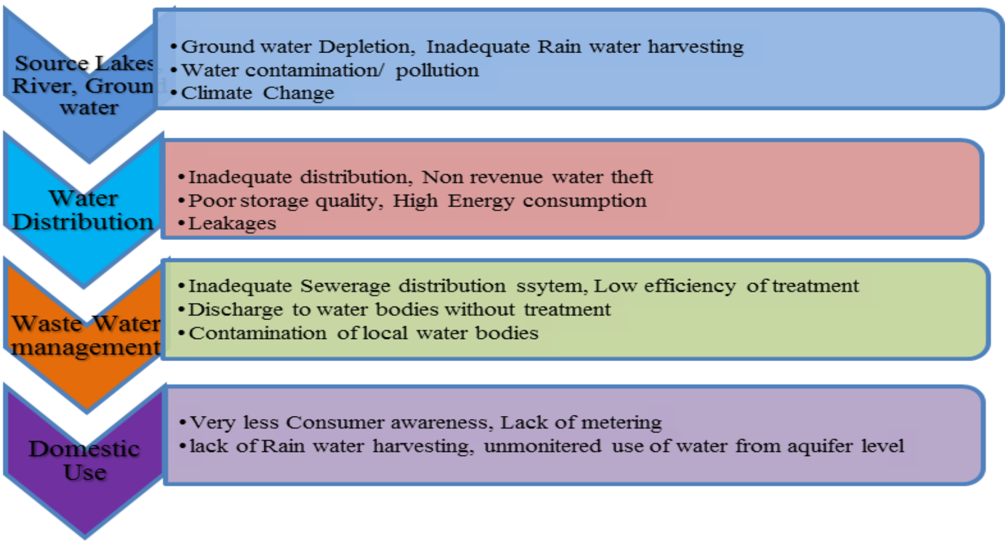
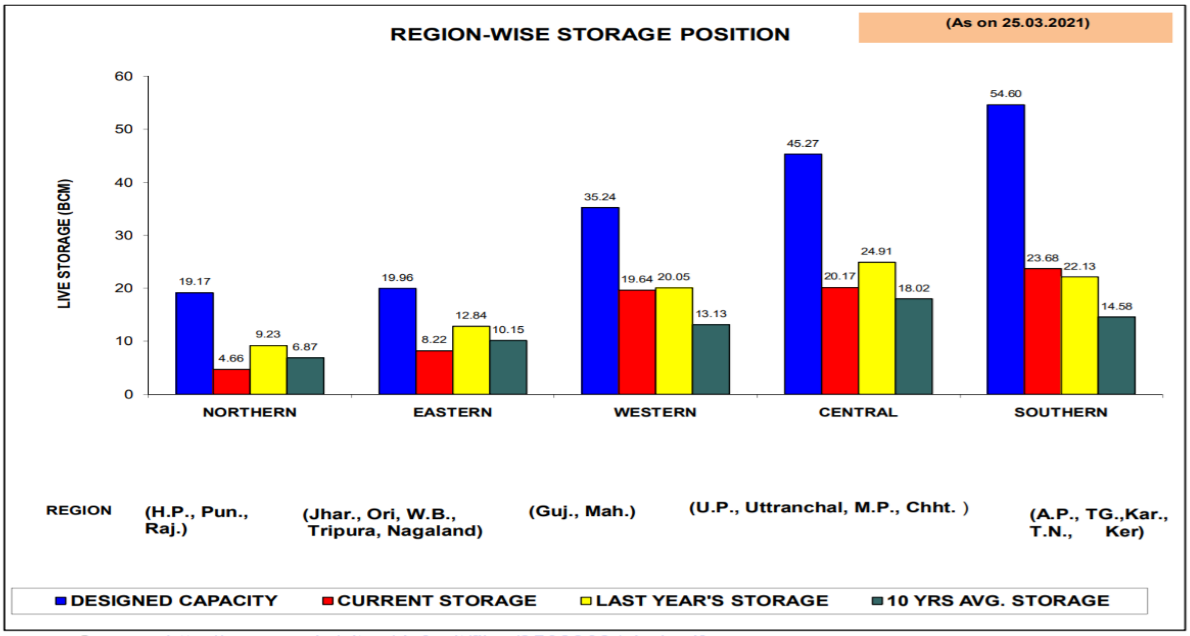


Figure 2: Water management in India.

In India receding water, greatly exceed the aquifer's renewal leveland some parts of the region sink up to 40 cm (16 inches) once a year. The non-availability of sufficient water is seen in specific month of the year or throughout the year in different Indian states. A shortage of drinking water starts creeping in from the months of March, reaching a peak during May and June (Fig. 3). Thereafter, availability of drinkable water improves gradually by July. Nearly, 71 per cent of the piped water users, about 89 per cent of the overall public tap users and about 68 per cent of the hand-pump users had insufficient potable during the month of May.[9]



Source: http://cwc.gov.in/sites/default/files/25032021-bul.pdf

Figure 3: Water Scarcity in different regions in India.

Phytoremediation of Waterbodies

Pollutants in water can be of inorganic and organic in nature. Table 1, lists the major sources of organic pollutants. The contaminants are not easy to destroy biologically but they can be transformed by decreasing their toxicity levels to a minimum.[10,11] The water quality is degraded due to increment, increase, industrialization, urbanization, over-consumption of natural water resources.[12,13] The whole aquatic ecosystems are disturbed by contaminated aquatic environment this leads to alternation and variation in life and survival of animals, plants and microorganisms. The detrimental changes majorly affect the species and finally the damage spreads to the community level of the aquatic ecosystem. Water contamination mainly occurs from agricultural fertilizers, industrial and household waste waters, acid rains, heavy metals (HMs), pesticides, oil and plenty of other inorganic and organic chemical compounds.[14] The various salts of nitrogen and phosphorus are responsible for changing an oligotrophic water system to Eutrophic one.[15] Among the various contaminants of water, various HMs like cadmium (Cd), lead (Pb), chromium (Cr), copper (Cu), zinc (Zn), nickel (Ni), vanadium (V), and selenium (Se) are common and chief pollutants. This can be a significant, dangerous and worldwide problem of pollution and still uncontrolled due to the shortage of knowledge, awareness, and absence of strict implementation of eco-friendly policies, legislations and financial resources.[16,17] World Health Organization have identified various HMs like Cd, Cr, Cu, Pb, Co, Hg, Ni, and Zn for special consideration for the standard of water.[18] The different sources of various heavy metals is listed in Table 2. Heavy metals are recognized because they are the major cause of skin diseases, asthma, cancer, dehydration, respiratory problems, cardiovascular and gastro-intestinal ailments in human. They also cause various severe ailments in aquatic fauna. Plasma membrane exposure to Cadmium (II) disturbs the cell's homeostasis and function involving induction in oxidative stress in animals and humans.[19] Chromium (VI) is a well-known carcinogen and its exposure to living organism causes various detrimental ailments, includingintense gastrointestinal irritation or ulceration and corrosion and lung cancer.[20] Cr is also very toxic to fishes, causing serious harm to its liver, gills and hematological problems.

According to UNEP, Phytoremediation is a efficient method to remove the contamination from soil, water, and air through the natural biological, chemical or physical activities and processes of the plants".Various aquatic and semiaquatic plants are known to remediate stressful contaminated conditions of water. Certain species of aquatic macrophytes have ability to cope with high concentration of various organic and inorganic pollutants present in water.[21] Phytoremediation of water takes place through the plants of members of family Cyperaceae, Potamogetonaceae, Ranunculaceae, Typhaceae, Haloragaceae, Hydrocharitaceae, Najadaceae, Juncaceae, Pontederiaceae, Zosterophyllaceae, Lemnaceae, etc. These plants are either emergent, submerged, or free floating.[22] Aquatic plants are extremely important componentsof an aquatic ecosystem for primary productivity and nutrient cycling. The notable environmental contaminants are inorganic and organic pollutants which can be phytoremediate in various ways.[23]

Table 1: Major sources of organic pollutants in water.[24]

Chemical in water	sources
Aliphatic and aromatichydrocarbons (includingbenzenes, phenols andpetroleum hydrocarbons)	Petrochemical industry wastes, Heavy/fine chemicals industry wastes, Industrial solvent wastes, Plastics, resins, synthetic fibres, rubbers and paints production, Coke oven and coal gasification plant effluents, Urban run-off, Disposal of oil and lubricating wastes
Polynuclear aromatic hydrocarbons (PAHs)	Urban run-off, Petrochemical industry wastes, Various high temperature pyrolytic processes, Bitumen production, Electrolytic aluminium smelting, Coal-tar coated distribution pipes
Halogenated aliphatic and aromatic hydrocarbons	Disinfection of water and waste water, Heavy/fine chemicals industry wastes, Industrial solvent wastes and dry-cleaning wastes, Plastics, resins, synthetic fibres, rubbers and paints production, Heat-transfer agents, Aerosol propellants, Fumigants
Organochlorine pesticides	Agricultural run-off, Domestic usage, Pesticide production, Carpet mothproofing, Timber treatment
Polychlorinated biphenyls	Capacitor and transformer manufacture, Disposal of hydraulic fluids and lubricants, Waste carbonless copy paper recycling, Heat transfer fluids, Investment casting industries PCB production
Phthalate esters	Plastics, resins, synthetic fibres, rubbers and paints production, Heavy/fine chemicals industry wastes, Synthetic polymer distribution pipes

Table 2: Different sources of Heavy Metals.[25]

Heavy Metals	Sources
As	Semiconductors, petroleum refining, wood preservatives, animal feed additives, coal power plants, herbicides, volcanoes and mining
Cd	Geogenic sources, anthropogenic activities such as metal smelting and refining, fossil fuel, application of phosphate fertilizers, sewage sludge
Cr	Electroplating industry, sludge, solid waste, tanneries
Cu	Electroplating industry, smelting and refining, mining, biosolids
Hg	Volcanic eruptions, forest fire, emissions from industries producing caustic soda, coal, peatand wood burning
Ni	Volcanic eruptions, land fill, forest fire, bubble bursting and gas exchange in ocean, weathering of soils and geological materials
Pb	Mining and smelting of metalliferous ores, burning of leaded gasoline, municipal sewage, industrial wastes enriched in Pb, paints
Zn	Electroplating industry, smelting and refining, mining, biosolid.

Pollutants (heavy metals)removal mechanism include phytoextraction, phytostabilzation, phytoaccumulation, phytofilteration (rhizofilteration/ blastofiltration) while for organic pollutants mechanism include phytodegradation, phytostimulation, phytotransformation, phytovolatilization, phytodetoxication, phytoassimilation, phytoevaporation for contaminated ecosystems[26] (Fig. 4). Phytoextraction and phytoaccumulation technique is based on hyper-accumulation, contaminant extraction andcapture by plant; phytofilteration is based on the use of plant roots (rhizofiltration) or seedlings (blastofiltration) toaccumulate, extract and capture contaminants; phytostabilization is based on complexation and/or contaminantdestruction; phytodegradation is based on contaminant destruction; phytovolatilization is based on volatilisation byleaves, contaminants extraction from media and release into air; phytoassimilation is based on contaminant transportand metabolism in plant chloroplast.[27] Phytoextraction is a improved potential method to remove various water contaminants effectively. During this process contaminants are absorbed in addition as hyper-accumulated into the various parts of plant.[28] The plants have great ability to consume and volatilizethe contaminants directly into the atmosphere through phytovolatization process. This process is cost effective in eliminating contaminants from soils, groundwater, residues, and sludge.[29] The plants metabolize the contaminants by some compounds produced within the plant tissues through Phytotransformation /Phytodegradation process.[30] Toxicity of Heavy Metals (HM)to plants causes Reactive Oxygen species (ROS) production, affecting physiological processes like photosynthesis, respiration and cell disintegration and even death of the plants.[11] Some plants have tolerant capacity toward HMs because presence of anthocyanins, thiols andantioxidants.[31] Some aquatic plants like duck-weeds have extraordinary efficiency to recover from high HMs exposure.[32]

Toxic effects of organic pollutants on the plant physiology and biochemistry are reported.[33] Around 400 metal hyper accumulating plant species are recognized.[34] In this regard, various species of aquatic plants such as *Lemna*, *Wolfia*, *Azolla*, *Spirodela*, *Wolfialla*, *Hydrilla*, *Eichhornia*, *Typha*, *Pistia*, *Crinum*, *Alternanthera*, *Phragmites and Crysopogon* have been tested to phyto-remediate by hyper-accumulating metals, metalloids and other contaminants. A large number of aquatic weeds of water such as *Eichhornia crassipes*, *Pistia stratiotes* L., *Lemna*, *Spirodela*, *Wolffia sp.*, *Wolfiella sp.*, *Typha sp.*, *Phragmites australis*, *Chrysopogonzizanioides* etc. are efficiently eliminate the contaminants from the water bodies.[36] The leaves androots of all these aquatic species arevery specific in structure which help in stabilization of plants and also nutrient absorption.[26] Due to coldtolerance property, duckweed can grow in all seasons, whereas, water hyacinth can survive only in summer. Duck-weed can also propagate over wide pH range. As compared to other aquatic plants, the biomass production of duckweed is rapid and its use in exploiting the phytoremediation process.[37] The duckweeds are basically taken from *Lemna* genus used in the field of phytoremediation and ecotoxicology.[38] Two aquatic species (*Lemnagibba* L. and *Lemna minor* L.) of Lemnaceae family are the mostly studied.[39] Also, two common duckweeds viz. *Lemna minor* and *Spirodela polyrrhiza* have been reported regarding the response of their growth, to be directly correlated with the aquatic environment.[40] *Wolffia globosa* has great tolerance towards Arsenic contamination. Evidence shows, it can accumulate 400 mg arsenic $kg^{-1}$of its dry weight and this Asian water meal also has ability to remove this HM quite efficiently.[11]

Eichhornia crassipes is an exotic invasive free-floating aquatic weed, which is proven to be very effective in the treatment of domestic and industrial waste water.[41] The plant is extremely tolerant and has a high capacity for, the uptake of HMs, including cadmium, chromium, cobalt, nickel, lead and mercury. Though it is a great invasive and opportunistic species, as uncontrolled growth of this weed can easily cover the entire lake or water body, depleting oxygen very fast but its efficiency in phytoremediation of metals can be exploited in controlled environment from polluted water.[42] The efficiency of water hyacinth regarding the removal of about 60–80% nitrogen[43] and about 69% of potassium from water has been reported.[44] Various environmental factors such as pH, temperature, radiation, and salinity influenced the expansion and physiological performance of the plant.[45]

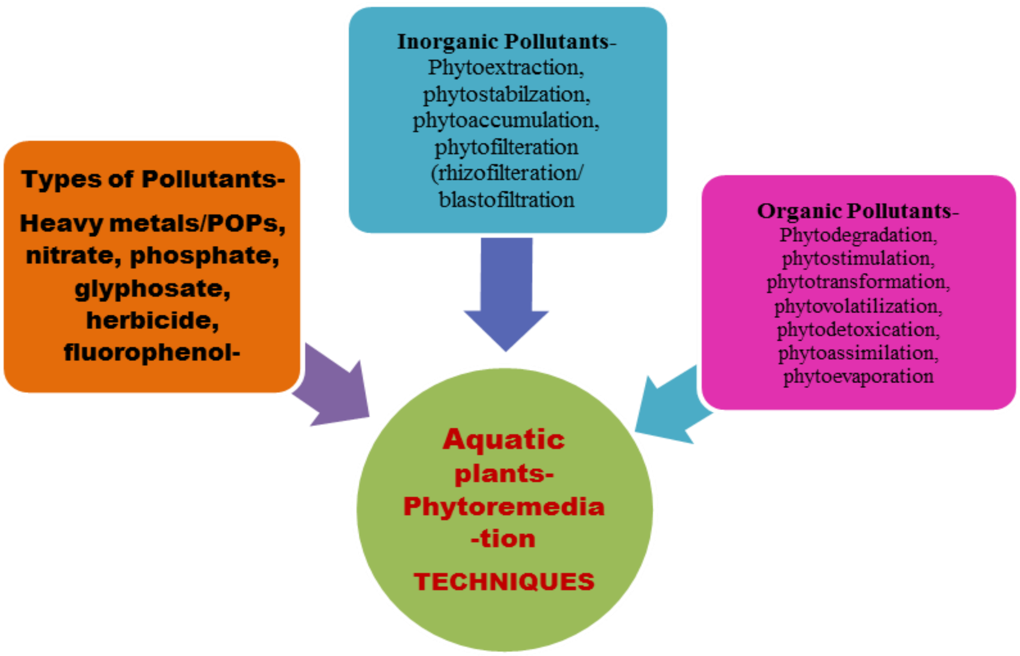


Figure 4: Phytoremediation Techniques for Organic and Heavy metals in Water.

CONSEVATION OF WATER BODIES

Water conservation needs policies and activities to maintain the hydrosphere for present and future need. Factors like global climate change has increased pressure on natural water resources especially in manufacturing and agricultural irrigation. Many countries have already implemented policies geared toward conservation, with much success (UEPA). The goals of conservation efforts include.

•Ensuring the provision of water for future generations where the withdrawal of freshwater from an ecosystem doesn't exceed its natural replacement rate.

•Energy conservation as water pumping, delivery and wastewater treatment facilities consume a big amount of energy. In some regions of the planet over 15% of total electricity consumption is dedicated to water management.

"Water Conservation Day" is celebrated every year on 22 March. A fundamental component to conservation strategy is communication and education for various water saving programs. Education, awareness and sensitivity from science to land managers, policy makers, farmers, and therefore the general public is another important strategy required in the responsiveness for conservation of water bodies.[46] There is need of methodology to reduce the consumption and recycling cost of water that are economically, socially, and environmentally costly.[47]

Urban sustainable water management needs to conserve the three major sources of water supply in nature; rivers, lakes and groundwater (Fig. 5). To preserve sources of water, managing lake catchments is essential along with *in situ* treatment of waterbodies. Conserving floodplains is vital to ensure a regular flow and quality of water to maintain healthy rivers. In addition, practices such as reforestation and building embankments are also beneficial.

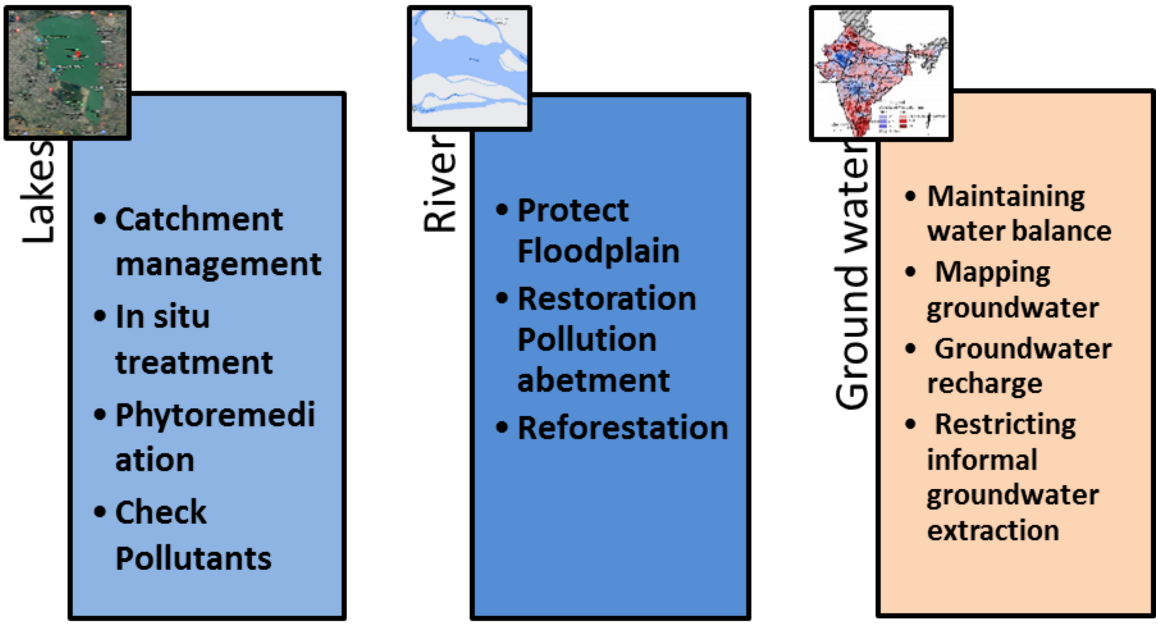


Figure 5: Conservation at Source of Water Supply to Urban Area. ***(Lake-Ramgarh Lake, Gorakhpur, River-Ghaghara, U.P, Ground water of India.***

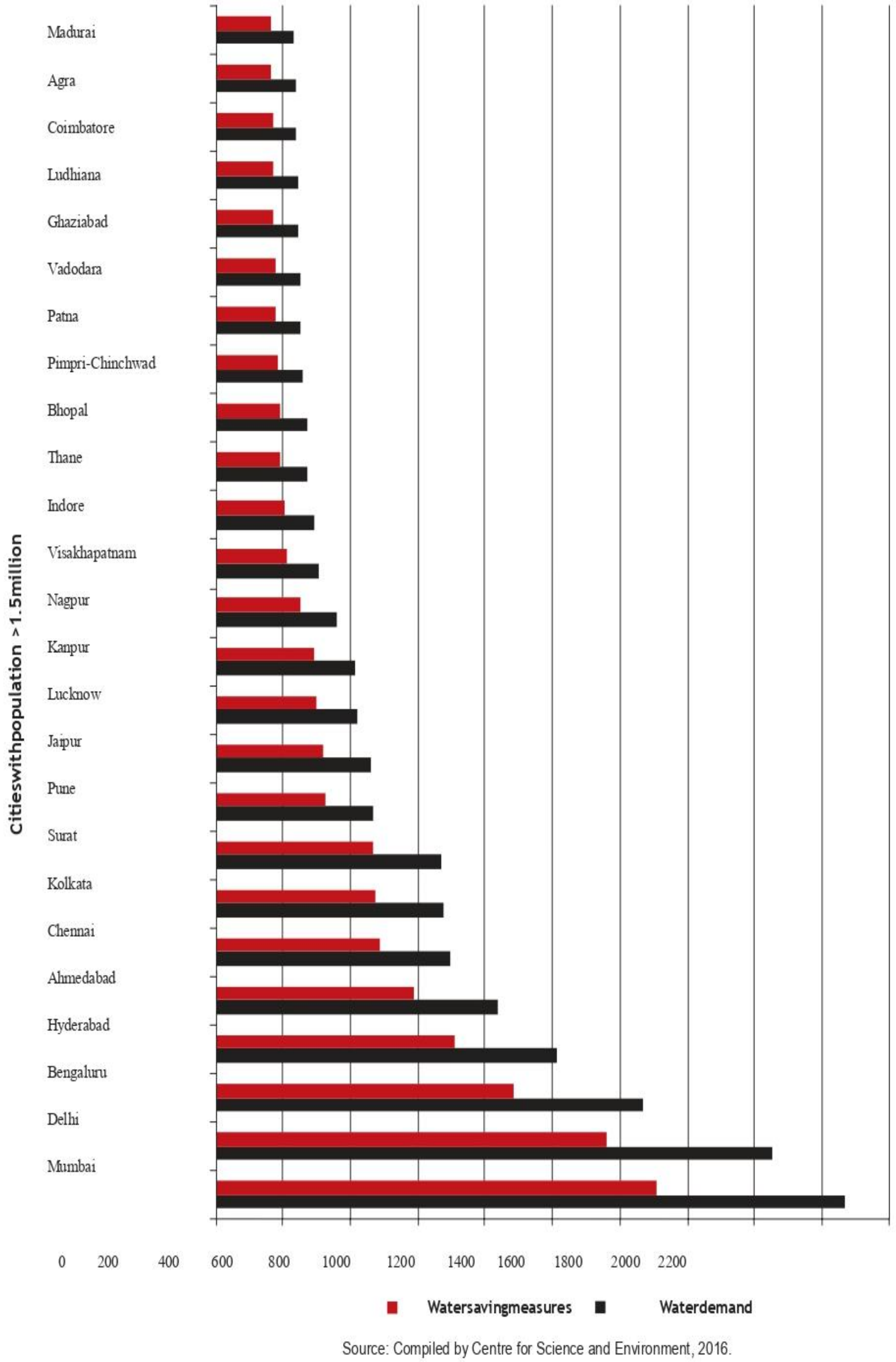


Figure 6: Potential for Water Saving in Urban Cities.

The Urban conservation strategy includes behavioral changes (Fig. 6). Urban Water Efficiency and Conservation is acomprehensive approach in which public participation is very necessary.Behavioural changes come under the blanket term of sustainable conservation, itincludes.

- Awareness Programs
- Social Acceptability
- Recycling/ Reuse of treated water
- Minimum leakage during conveyance
- Rain water harvesting at local level

NATIONAL RIVER CONSERVATION DIRECTORATE (NRCD)

It is a scheme under the Ministry of National Lake Conservation Plan (NLCP) and National River Conservation Plan (NRCP) by providing assistance to the State Governments. Plan of NRCP is.

- Interception and diversion work to capture the raw sewage flowing into the river through open drains and divert them for treatment.
- Setting up Sewage Treatment Plants for treating the diverted sewage.
- Construction of Low-Cost sanitation toilets to prevent open defecation on river banks.
- Construction of Electric Crematoria and Improved Wood Crematoria to conserve the use of wood and help in ensuring proper cremation of bodies brought to the burning Ghats.
- River Front Development works such as improvement of bathing Ghats.
- Afforestation and Public Awareness and Participation.

NATIONAL LAKE CONSERVATION PLAN (NLCP)

Government of India under National LakeConservation Plan (NLCP) approved programmes for conservation and management of polluted lakes in May 2001. The beneficiaries of the scheme are the State Governments, local bodiesand the local population.

Traditional urban-lake management approaches have often failed to save the Eutrophic lakes and the water quality. In order to conservethe natural integrity of these resources, a more holistic and aggregated approach is required in the code of conduct. (Fig. 7) Integrated urban lake basin management focuses not only on curative methods for lakerestoration but also envisions management at the catchment level.It helps in sustainably managing lakes and their catchment area througheffective improvement in governance by integrating institutional planning, policy, inclusive planning with stakeholders, technologies and also funding.[48]

Figure 7: Integrated lake basin management.[48]

THE CASE STUDY OF RAMGARH LAKE IN THE TERAI REGION OF EASTERN U.P.

Figure 8: Gorakhpur City, U.P, ISRO.

Figure 9: Map of Ramgarh Tal (Gorakhpur), Google Maps 2021.

GORAKHPUR CITY

Gorakhpur City, the headquarters of Gorakhpur District, is the second most vital town in Eastern Uttar Pradesh, after Varanasi. Meet a vicinity of 147 sq kms, it lies within the basin of the Rapti and Rohini rivers and the land is like of a bowl. It has rural villages and pre-urban habitats around it where agriculture is practiced.[49] Gorakhpur district is situated within the Terai region of the Nepal Himalayas. The district has numerous annual and perennial freshwater ponds and lakes of different dimensions.[50] Over time, due to human interferences, like dumping solid wastes, sewage water, rapid encroachment many of those have disappeared or are on the verge of doing so (Fig. 8). The famous Ramgarh

Lake is now spotlight to the study of receding water body due to several aspects.

RAMGARH LAKE

Ramgarh Lake (260 42' 30" N to 260 45' N and 830 24' 20" E to 830 25' 20" E) - an example of deteriorating lake because of several urban impacts an oversized, perennial, eutrophic lake, exists within the south-east a part of Gorakhpur city having luxuriant aquatic plants and animals (Fig. 9). Several macrophytes, planktons, aquatic fauna, aquatic fauna like *Eichhornia*, *Vallisnaria*, *Ceratophyllum*, *Pottamogeton* etc. are surface and submerged weeds. Among fishes, *Wallago attu*, *Murrel*, *Mystus seenghala* etc. are common while variety of insects like, *Nepa*, *Ranatra*, *Cybister*, etc. are present within the lake. Disposal of municipal solid wastes is deteriorating the water quality of lake and enriching eutrophication and siltation, that resulting contraction of the lake basin area. This encroachment was very huge due to the enormous greed of human being with shameful manner (Fig. 10).

Ramgarh lake project is being developed by the Gorakhpur Development Authority acquiring 486 ha area of the older lake between western dam along the lake and Padaleganj, Indra Nagar, Deoria bypass road. The project includes a Buddhist Complex, Research Center, Library, Deer Park, Five Star Hotel, Tourist Bungalow, Circuit House, Health Center, Water Sports Club, Planetarium, Aquarium, Children's Park, Shopping Center, Japanese Garden, etc. Thus, the beautification of the lake has continued to develop as a source of income through tourism.[51] Commercial use of Ramgarh Lake and the anthropogenic disturbances are mainly responsible for its eutrophication (Table-3.)

Table 3: Change in utilization status of Ramgarh Lake.[52]

Activities	Current status
Fishing	Incessantly Continue
Irrigation	Incessantly Continue
Vegetable Cropping	Upto 2005
Washing	Upto 1998
Recreational Activities	Incessantly Continue
Religious Activities	Incessantly Continue
Dumping Sites	Incessantly Continue
Cattle Bathing	Upto 2011
Drinking Purpose	Upto 1980
Traditional Boating	Upto 2004

Source: Field Survey (February 2017).

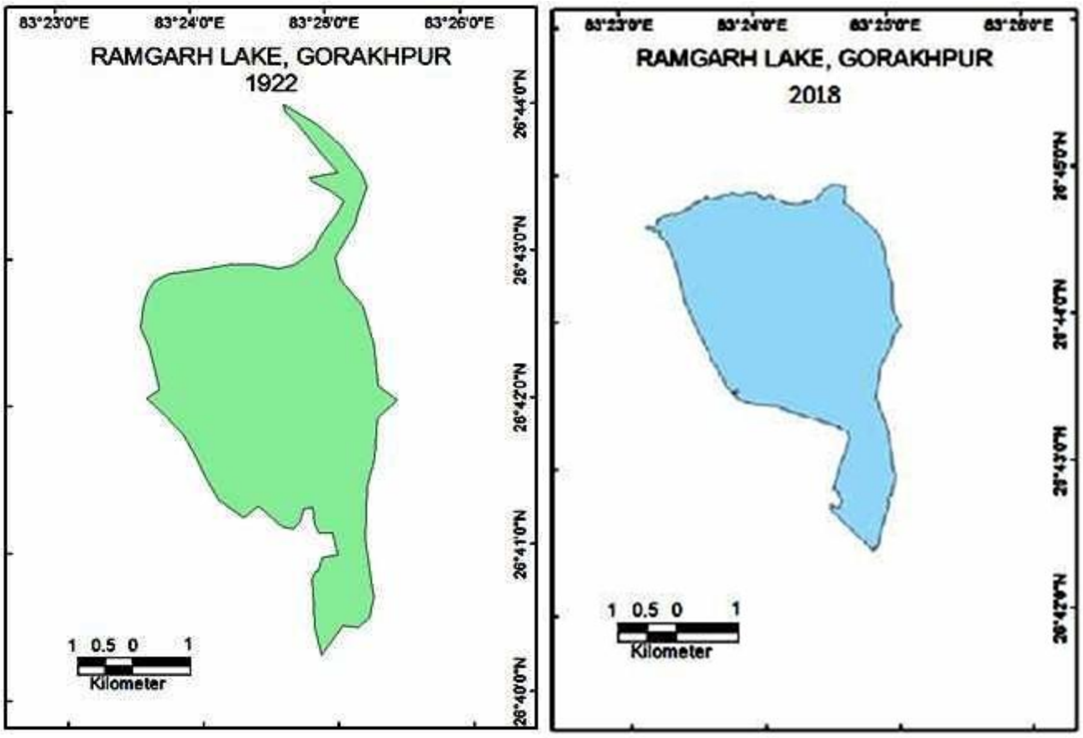


Figure 10: Reduction in area of Ramgarh Lake (1922 to 2018), Source:Top sheet NG44-8 (1922) and Google earth images (2018).

STATUS OF THE LAKE AND THE NEED FOR CONSERVATION

Traditionally, the lake was of immense value to the citizens of Gorakhpur. Over the time, all biological objects are affected with the slow death of lake. The watershed year seems to be 1980, after which the depletion of the lake really began. The population of villages like Ramgarh, Rampur, Singadia, Kuraghat, Bindutolia and Lakshmipur has increased because of urbanization. Many of those villages have encroached much portion on the lake. Different kind of pollution has also affected the potability of water.[49] In 80th decades, the low-lying marshlands were about 1635 acres but today there are hardly any such lands left. Flora and Fauna have shown steep decline. Human interference has affected the aquatic flora too. 79 percent of the floral species found in the lake in 1969 have disappeared. The density of another 4 percent has reduced. Water hyacinth is a big headache covering a large water surface area of Ramgarh Lake which is not a good for lake health. Submerged plants *like Hydrilla*, *Ceratophyllum*, *Najas* have disappeared totally. Floating plants like *Pistia* and *Salvinia* have gone too. In 1998, therewere about 28 varieties of fishes in Ramgarh lake which reduced to 18 in 2006 and 6 to 10 species were remained up to June 2018.[52]

A substantial amount of the effluents is discharged into the Ramgarh lake. Excess nutrients have led to eutrophication and prevent the penetration of sunlight into the waters. Many ofthose impacts are linked with the development of general infrastructure like roads, airportsand tourism facilities, including resorts, hotels, restaurants, shops and golf courses.

Negative impacts from tourism occur when the demands of the extent of people visiting the area is bigger than the environment's ability to address it, within the appropriate limits of change. The Uttar Pradesh Jal Nigam is working on a proposal given tothe state government for extension of the seweragesystem in the city. The Lake Conservation Department of Government of Indiais also implementing a project for cleaning and beautification of the lake. Ramgarh Lake is lifeline for Gorakhpur city as a source of ecological social, economical benefits. Urgent measures are required to stop the decline in catchment area and for restoring the water quality in the lake for conservation of the lungs of this growing suburban area.

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