ENVIRONMENTAL IMPACT ASSESSMENT OF URBAN LAKES ON GROUNDWATER REGIME IN HYDERABAD CITY

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ABSTRACT

Hyderabad metropolis is one of the fastest growing populations in India and has previously relied on surface water storages in lakes for urban water supply. Reported impacts on groundwater around Hyderabad urban agglomeration are varied and include: changes in land use from agriculture to residential/industrial, declining water tables, worsening water quality in lakes due to nutrient flows (urban sewage). One of the problems tackled under restoration of lakes program by Hyderabad Urban Development Authority is characterization of groundwater regime around lakes. Studies in three urban lakes watersheds, viz., Lakes in Northeast Musi basin, Durgamcheruvu and Mir-Alam- Tank have been carried out to monitor the groundwater contamination of nitrate, if any in the command areas. Bathymetric studies have helped find out the lake water storage. Lake water quality in terms of nutrients Total Phosphorous and Total Nitrogen have helped to compute Trophic Status Index. All the lakes under investigation are under hyper eutrophic condition.

The hydrological features of the lakes, associated hydrogeological aspects, importance groundwater conditions on water quality in the NE Musi basin has been investigated to establish interactions between lake water and groundwater system. The integrated geophysical and hydrogeological investigations have provided an insight of the complex nature of groundwater contamination in the basin. Groundwater occurs in shallow aquifers in granitic terrain, some limited in extent and some susceptible to impacts from urban development, industrialization as well as from natural processes in the area. Water balance has been evolved through groundwater flow modeling to compute interaction of the lake water with the groundwater regime. A tertiary treatment plant removes phosphates and associated wetland reduces the nitrates and treated sewerage enters the lake with less nutrient inputs. The lake water budget has helped to decide the capacity of sewage treatment Plant (STP) for tertiary treatment to be established on each lake in the watershed.

LAKES IN NE MUSI BASIN

Hyderabad Urban Development Authority under Green Hyderabad Program has plans to restore about 85 urban lakes in the Hyderabad. As a first step they have identified 5 lakes for assessing the groundwater lake water interaction for design of STPs. Among the 6 lakes in NE Musi basin around Hyderabad viz., Patelcheruvu, Peddacheruvu, Nallacheruvu, RK Puram Cheruvu, Nadimicheruvu (Safilguda) and Bandacheruvu lakes already an STP is functioning at Nadimicheruvu. The watershed covers an area of about 38 sq. km. (Fig. 1).

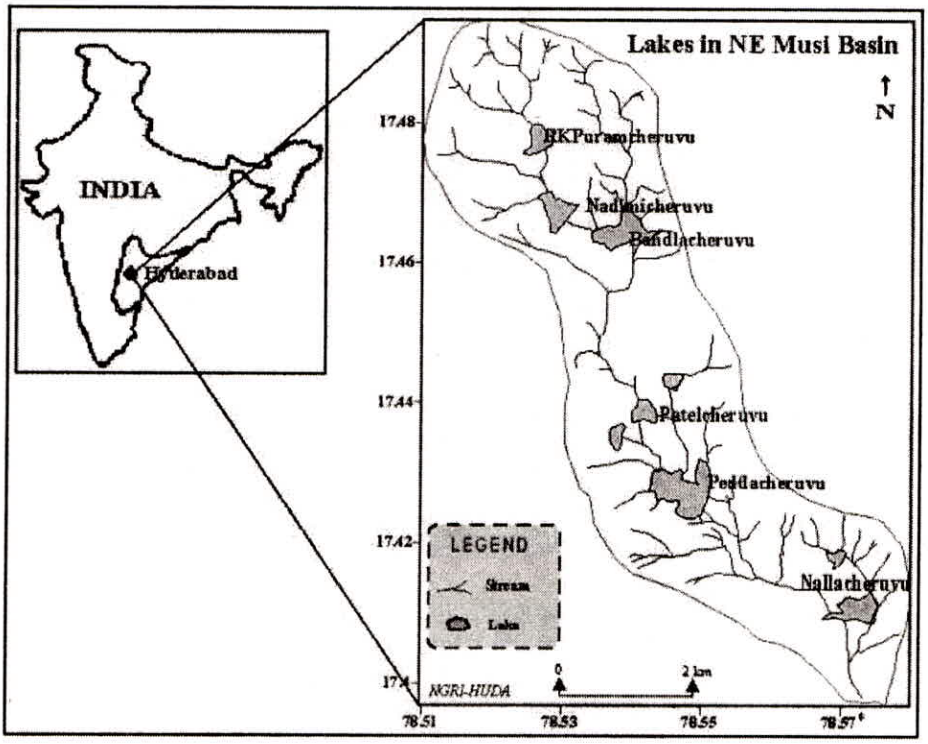

Fig. 1. Location map of Lakes in North East Musi Basin, Hyderabad

URBAN LAKE WATER RESTORATION METHODOLOGY

Among the parameters of interest for understanding lake water quality are Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Total Nitrogen (TN) and Total Phosphorous (TP). Periodical measurements of lake water are important to characterize the changing water quality with respect to inflows as a result of monsoon and non-monsoon period. The characterization helps to compute the status of lake in terms of nutrient load whether a lake is prestine (oligotrophic) or eutrophic. The nutrient parameters TN and TP are useful for computation of Trophic Status Index (TSI) and further the status decides which is the limiting parameter for eutrophic status in the lake (Carlson, 1977). The sediments also show adsorbing capacity of nutrients, which has to be estimated through monitoring of sediment samples for nutrient status. The sediment status decides the need for dredging of lake bed for removal of phosphates as the remediation of phosphate in lake environment is through only sediment disposal.

Further the a bathymetric survey of lake bottom surface will help computation of Lake Storage Capacity. Bimonthly monitoring of Inflow and outflow measurements on the inlet and outlet channels of lake helps compute the lake residence time, which is an important parameter for taking up lake cleaning operations. The residence time decides for clean up of a lake how

much time is needed. The measurement of evaporation loss from the lake surface determines the potential loss. In additional an important component in lake water budget is the groundwater component. The groundwater component plays a vital role, depending on the position of a lake in the watershed viz., recharge area or discharge area.

For understanding the lake water and groundwater interaction a groundwater flow model based on physical frame work, hydrogeological parameters, inflows/outflows into lakes, height of lake water column and groundwater withdrawal within the watershed has to be estimated. A groundwater balance has to be computed through the zone budget from the model after calibration (Gurunadha Rao et al, 2004). Further if likely contamination from the lake is expected a prognostic scenario depicting source loading in the lake water as well as other activities have to be incorporated in the mass transport model. The contamination of nitrates from the lake water in a watershed helps arresting spread of contamination. Lakes in NE Musi basin study has been illustrated to explain the need for a comprehensive study for lake restoration programs in the urban environment.

LAKES IN NE MUSI BASIN

The surface water quality measurements carried out in all the six lakes (Fig. 1) indicate the BOD concentration in surface water of six lakes is varying from 10 – 70 mg/l during October 2002 & 03 to 38 –169 mg/l during June of 2003 & 04. The maximum BOD has been found in Peddacheruvu and Nallacheruvu lakes and also reported in the earlier studies (APPCB, 2001). The minimum values have been found in Nadimicheruvu due to entry of treated wastewater entering the lake. The average COD concentration in the lakes varies from 140 – 450 mg/l during the study period (Fig. 2).

Nutrient load in terms of Total Nitrogen (TN) and Total Phosphorous (TP) has been estimated in the lake water as well as from the sediments. The TN concentration in lake water is found varying from 0.2 – 90 mg/l during the study period. The minimum TN values have been reported from Nadimicheruvu < 10 mg/l and maximum from Nallacheruvu. The TP concentration in lake water has been varying from 0.2 – 30 mg/l. The minimum value of TP has been reported from Nadimicheruvu and maximum value from Peddacheruvu. The sediments are also found adsorbing the TN and TP and their enrichment and depletion depends on the lake water conditions. There is cyclic behavior and enrichment during summer months and depletion during rainy season noticed during the study period. This cyclic behavior, particularly for TP can be controlled through dredging of lakebed sediments. TN & TP concentrations in sediments are found varying from 0.9 –136 mg/kg and 4.6 – 343 mg/kg depending the period of observation. Enrichment of TP and TN concentrations in sediments has been noticed during October month. Depletion in TN & TP concentrations in lakebed sediments has been reported during February (Gurunadharao et al, 2005).

Trophic Status Index (TSI) is a measure expressing the lake water quality based on nutrient inputs, based on TN and TP values (OECD 1982). The TSI index based on TN concentrations is varying from 33 – 121. The TSI index based on TP concentrations is varying from 81 –153. The TSI index implies that the lakes are mostly phosphate limited compared to the Nitrates. The conditions indicate that lakes are under hyper eutrophic condition and demands dredging of lake sediments for phosphate remediation.

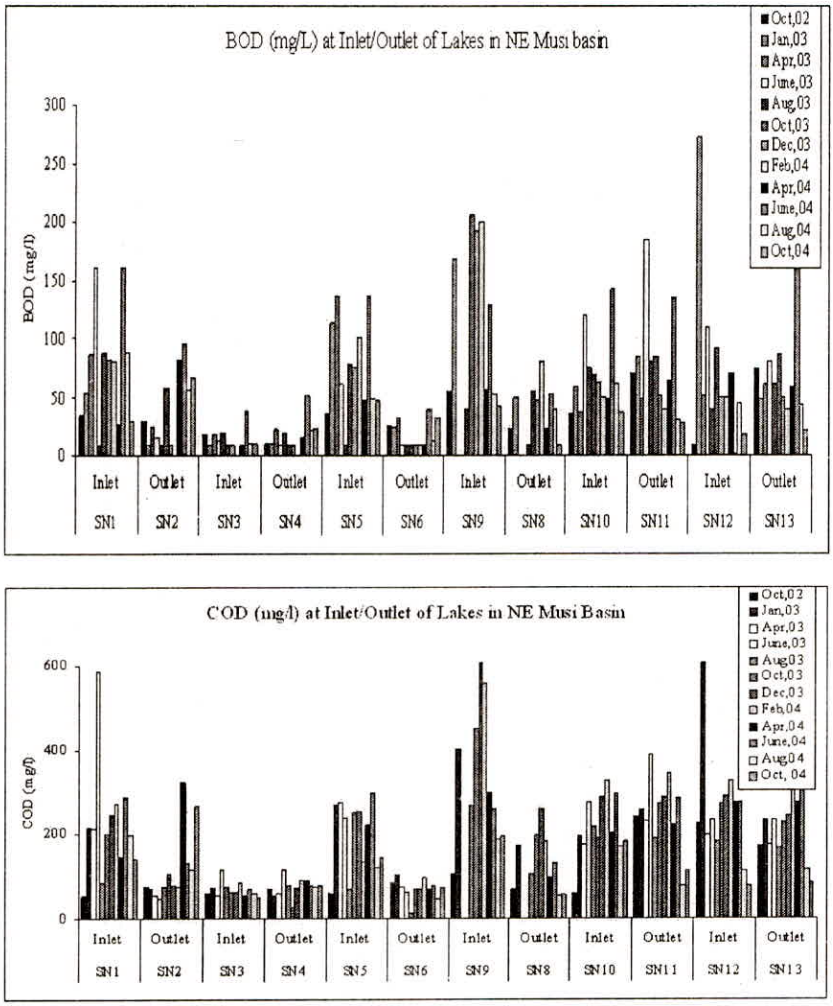

Fig. 2. BOD & COD (mg/l) in lakes of NE Musi Basin during Oct 2002- Oct 2004

LAKE WATER BUDGET

The storage capacity of lakes computed from the bathymetric survey carried out during June 2005 after rising the bunds indicate that Patelcheruvu can hold 115 Million Liters(ML) at FTL (Full Tank Level). The bathymetric survey carried out during 2003 indicated that Peddacheruvu could hold 368 ML and Nallacheruvu storage volume being 226 ML at respective FTL. The Patelcheruvu will have a residence time of 1.5 days, Peddacheruvu will have a residence time of 8.8 days and Nallacheruvu will have a residence time of 8.7 days. Thus these lake's residence times are found to be <10 days. A groundwater flow model has been constructed and groundwater balance computed using zone budget (McDonald & Harbough, 1988 and Nilson Guiger and Thomas Franz, 1996). The computed seepage losses

and suggested STPs capacity for tertiary treatment at individual lakes in the NE Musi Basin are shown in Figures 3 & 4 respectively.

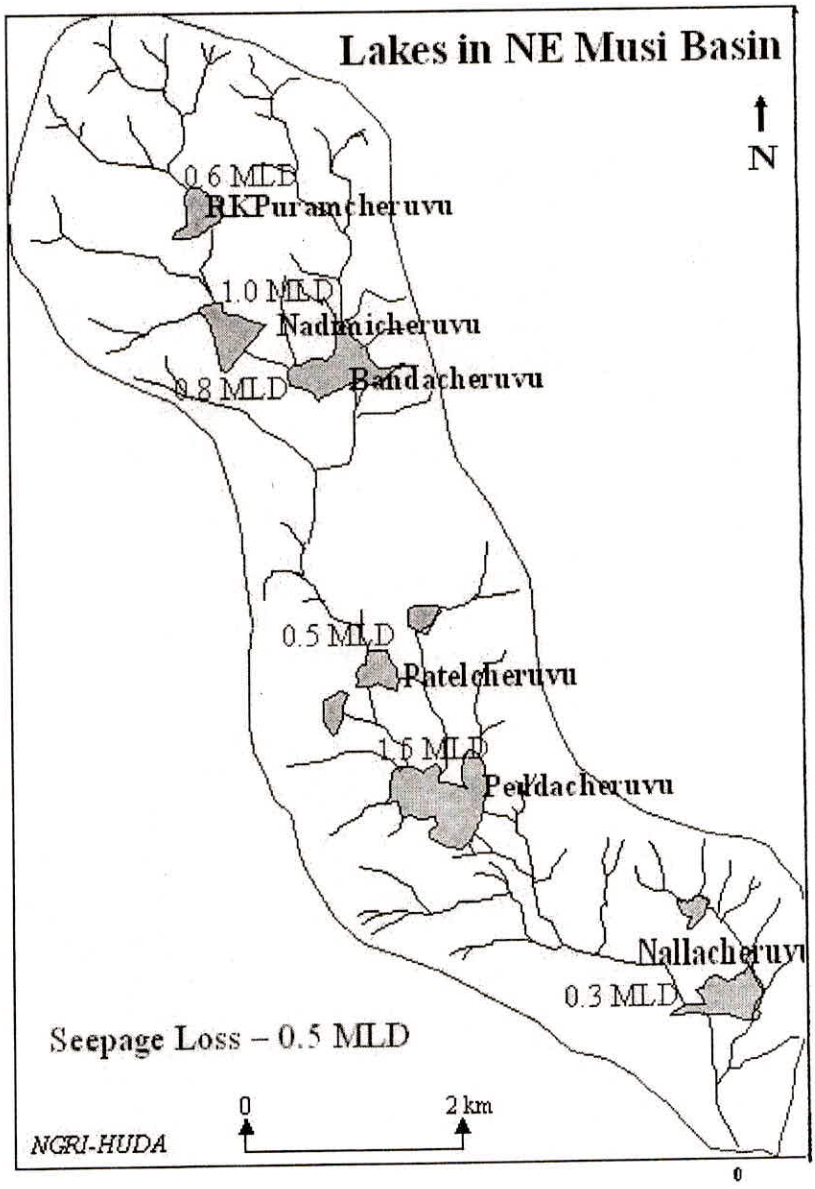

Fig. 3. Computed seepage loss from GW flow modeling: lakes in NE Musi Basin

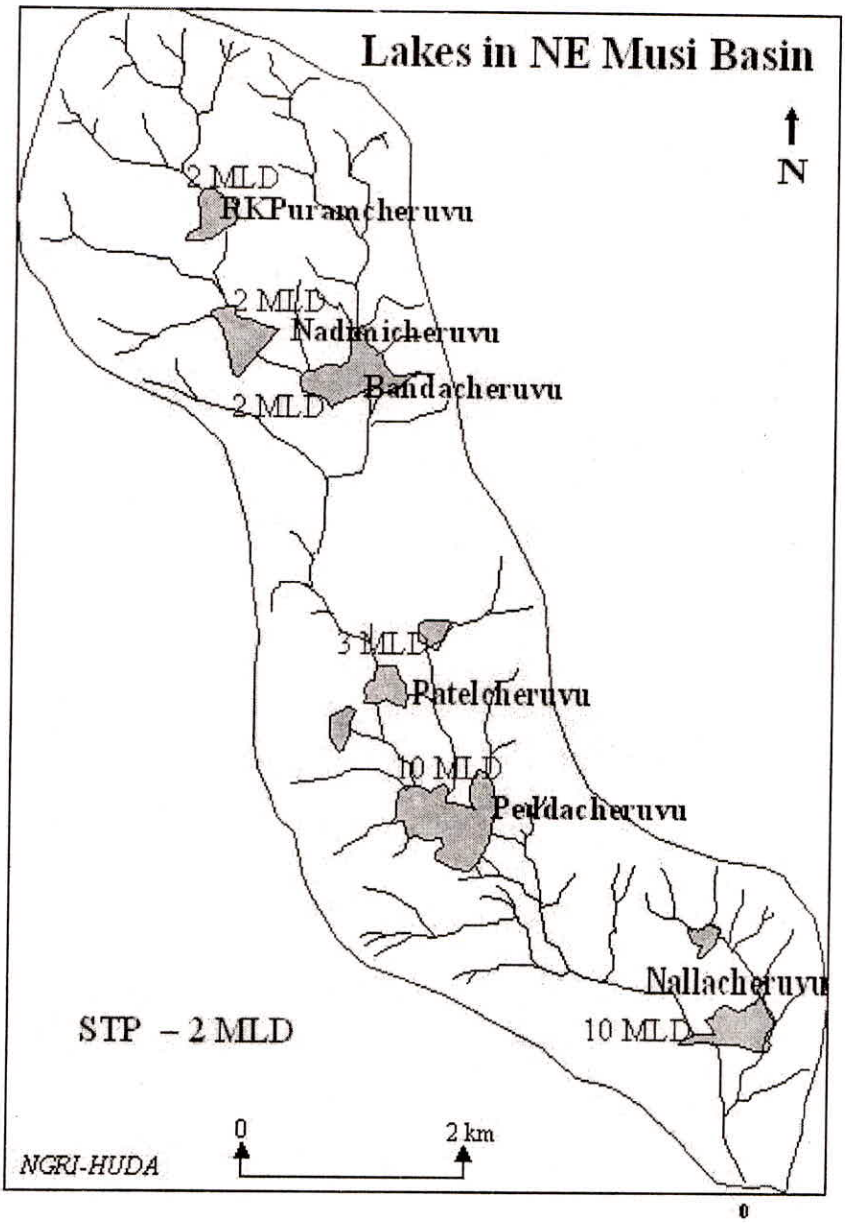

Fig. 4. Suggested Capcaity of STPs at individual Lakes in NE Musi Basin

Water budget has been computed with an average actual evaporation loss of 4.5 mm/d from lake water surface at full tank level of Patelcheruvu, Peddacheruvu and Nallacheruvu are 11 ha, 17ha and 17ha respectively. A groundwater flow model of the NE basin was constructed

to compute the zone budget of each lake in the watershed. A STP of 0.6 MLD capacity for tertiary treatment has been functioning on Nadimicheruvu. The lake surface area is about 10 ha and evaporation loss @ 4.5 mm/d from the lake water surface works out as 0.45 MLD. As the lake is situated in recharge area of the watershed it contributes about 1 MLD to the groundwater (Gurunadharao et al, 2005). Under lake restoration program it is envisaged to maintain FTL Nadimicheruvu, then it needs a supply of 1.5 MLD of treated wastewater. On a conservative basis with allowance for some outflow from the lake a STP of 2 MLD capacity is required. It is recommended to enhance capacity of the STP to 2 MLD at Nadimicheruvu based on lake water and groundwater interaction (Fig. 3).

The program envisaged by HUDA for establishment of STPs for tertiary treatment and a wetland for nitrate removal and dredging of lakebed for phosphorous removal is in line with the recommendations of the study. However, minor modifications in the capacity of STPs are needed in view of lake water interaction with groundwater playing a vital role in lake water budget and in addition to the surrounding urbanization. The surplus inflows to lakes above the STP capacity has to be diverted through separate surface runoff carrying channels bypassing the lakes.

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