LAKE WATER BUDGET OF MIR-ALAM-TANK, HYDERABAD CITY

K. Mahesh Kumar, V.V.S. Gurunadha Rao, S. Sankaran, B.A. Prakash and P. Yadaiah
Environmental Hydrology Group
National Geophysical Research Institute, Hyderabad – 500 007

ABSTRACT

Lake water budget study in Mir-Alam Tank has covered hydrological, geohydrological, geophysical and water quality analyses, lake water quality, trophic status, groundwater flow and mass transport modeling studies in the Mir Alam Tank Watershed. The granitic watershed covers about 18.5 sq. km. The Mir-Alam- Lake is formed on a third order stream. Surface water flow direction is from South to North. Bathymetric survey had been carried out during May 2003 indicated that between the islands 1 and 2 (range lines 10 to 17) in the lake, a submerged weir i.e. masonry retaining wall of about 0.6 m below the present water level on both sides of the island was noticed, which indicate that there may be an old anicut prior to formation of Mir-Alam tank. The water level noticed during May 2003 is +515.375 m with water spread area of 1.3806 M .sq.m. The volume of water estimated from capacity curve at the water level (RL 516.53 m) is 6.09576 MCM. Mir-Alam tank has a volume has been computed as 7.42516 MCM at the FTL + 517.4 m. Maximum depth of 9.6 m has been noticed in the tank (+506.775 m (amsl)) during May 2003. If one assumes a total outflow of 25 MLD from the Mir Alam Tank, the residence time of lake-water would be 300 days(< year). The lake has lost about 700 ML capacity during last two decades due to encroachments. Flow measurements on inlet channels have shown an average total inflow of 8 MLD with maximum total inflow observed being 13 MLD.

Lake water samples have been collected at 14 locations in the Mir Alam Tank and analyzed for major cations and anionic concentrations, trace element concentrations to assess their presence if any, in lake water. Pesticide residue analyses of lake water have been carried out during January 2004 for assessing persistence of organo-chlorine pesticide residues. Persistence of Endosulfan and metabolites of DDT suggest that a substantial agricultural runoff seems to be entering the lake. Trophic status index has been computed from Total nitrogen and total phosphorous concentrations indicate the hyper eutrophic condition. Katedan IDA established two decades back is catering to the industrial needs of textiles, metallic industries and battery manufacturing in the Mir Alam Watershed. The IDA is situated in the recharge area of watershed and whatever effluent outflows from IDA may travel down the flow path and likely to contaminate groundwater in the watershed. Thus trace element analyses of groundwater samples indicated that except one or two places the concentration of Arsenic, Nickel was found slightly in elevated concentrations. The lake water budget has been computed through groundwater modeling of the watershed. Considering growing urbanization during near future, an STP of 10 MLD has been suggested for tertiary treatment of influent streams entering the lake.

INTRODUCTION

Hyderabad Urban Development Authority (HUDA) under green Hyderabad program has taken up the restoration of urban lakes and Mir Alam Tank is the included for lake restoration program. The assessment of groundwater and surface interaction of Mir-Alam Tank has covered hydrological, geohydrological, geophysical and water quality analyses, lake water quality, trophic status, groundwater flow and mass transport modeling studies in the Mir Alam Tank Watershed. The granitic watershed covers about 18.5 sq. km. The Mir-Alam- Lake is formed on a third order stream. Surface water flow direction is from South to North (Fig. 1).

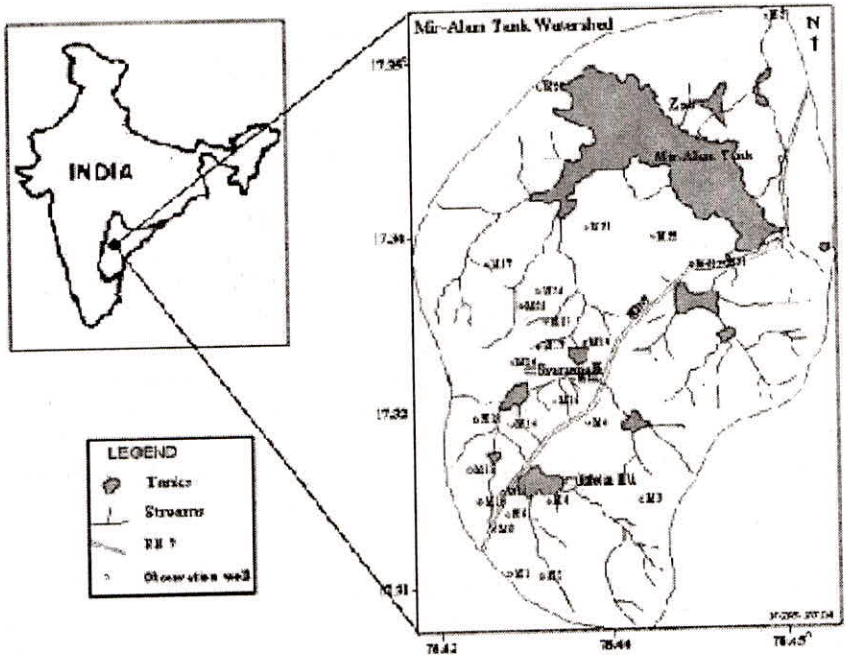


Fig. 1. Map showing location of Mir-Alam Tank watershed

HYDROGEOLOGICAL AND GEOPHYSICAL INVESTIGATIONS

Grey granites constitute large part of the area and are made up of quartz and feldspar as major minerals with flacks have biotitic and hornblende as accessory minerals. Pegmatite veins, which are having characteristic feature of granite, have been identified in some localities near Mir Alam tank.. Alluvium is deposited by stream action along the stream course starting from Katedan to Mir-Alam tank. Alluvium thickness varies from 5-10 m comprising of massive to coarse-grained sand and gravel with little amount of silt and clay. VES soundings have been carried out at 22 locations in the watershed for deciphering aquifer geometry. In general lithologic sections show topsoil followed by weathered rock, fractured rock underlain by bedrock. Weathered zone thickness varied from 5 - 15 m and the fracture zone has maximum thickness of 35 m. Depth to basement varied from 35- 50 m bgl (GWD, 2000).

Groundwater occurs under phreatic conditions in the shallow weathered zone and under semi confined to confined conditions in the fractured and sheared zones at deeper levels. In general weathered zone thickness is limited to 10-15 m. The groundwater level measurements on 33 observation wells have indicated that average depth to water is about 9.5 m bgl in the watershed. Depth to water level has been < 4 m bgl in the valley parts along stream channel. Groundwater fluctuations are influenced by local pumping conditions. Groundwater level contours show a predominant groundwater flow direction towards the Mir Alam tank. Average annual rainfall in the watershed is 700 mm and 14 years average annual evaporation is 2440 mm (IMD).

GROUNDWATER QUALITY

Groundwater pH is ranging from 7.2 – 8.4. Total Dissolved Solids (TDS) concentrations in groundwater have shown elevated TDS between Katedan IDA to Mir Alam Tank and slightly lower concentrations below the Mir Alam Tank. TDS concentrations of groundwater in the Katedan IDA are ranging from 416 – 4058 mg/l with an average of 1640 mg/l. TDS concentration is reported to be < 1090 mg/l in 25% of samples, between 1090 – 1490 mg/l in 25% samples and 25% of samples range 1490 –1970 mg/l. The rest 25% samples exceed TDS of 1970 mg/l. This may be attributable to industrial pollution from Katedan IDA entering the groundwater regime in the upstream. Chloride concentration > 300 mg/l, sulfates > 270 mg/l and nitrate as nitrate > 50 mg/l are found in 60% of samples. Fluoride concentration in groundwater is very high and ranges from 1 – 5.4 mg/l with an average of 2.7 mg/l (Hem, 1985).

Katedan IDA established two decades back is catering to the industrial needs of textiles, metallic industries and battery manufacturing in the Watershed. The IDA is situated in the recharge area of watershed and whatever effluent outflows from IDA may travel down the flow path and likely to contaminate groundwater in the watershed.

LAKE WATER QUALITY

Lake water samples have been collected at 14 locations in the Mir Alam Tank and analyzed for major cations and anionic concentrations, trace element concentrations to assess their presence if any, in lake water. Pesticide residue analyses of lake water have been carried out during January 2004 for assessing persistence of organo-chlorine pesticide residues. Persistence of Endosulfan and metabolites of DDT suggest that a substantial agricultural runoff seems to be entering the lake. The pH value of lake water is varying from 7.5 –8.4 with an average of 8.2. TDS concentration in lake water as well as inlet channels is varying from 717 – 1331 mg/l with an average concentration of 1100 mg/l. TDS concentration of pre-monsoon has been found in the range of 327 – 1224 mg/l with an average of 1090 mg/l. Post monsoon monitoring during October 2003 has shown TDS values of 337 – 2189 mg/l with an average concentration of 1073 mg/l. Chlorides, sulphates, sodium ions dominate TDS (APPCB, 2001).

The nitrate as nitrate concentration in surface water has been found to be in the range of 4.5 – 45 mg/l. Average nitrate concentration scenario seems to be very much elevated as regards nutrient input present in lake water. This requires further consideration for implementing lake restoration programs. Similarly nitrate concentration during pre-monsoon (June 2003) has

been in the range of 9 – 30 mg/l. Post monsoon sampling during October 2003 has reported nitrate concentration values of 5 –35 mg/l. Fluoride concentrations in lake water ranged between 0.9 - 4.0 mg/l with an average of 2.7 mg/l. During post monsoon (October 2003) surface water samples have showed lower levels of 0.3 - 1.5 mg/l.

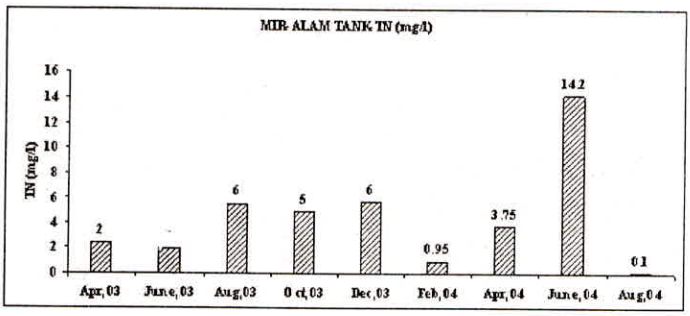
Bimonthly sampling of lake water has been analyzed for assessment of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Nitrogen (TN) and Total Phosphorus (TP). Also 6 sediment samples have been collected at a depth of about 2 m for estimation of adsorbed TN and TP. Average DO in lake water varied from minimum of 2.1 mg/l during October 2003 to 6.9 mg/l during August 2004. The BOD values of lake water are varying from 19 – 35 mg/l with a BOD of 199 mg/l in the inlet channel near Hasan nagar boating point. Maximum BOD has been registered in the center of lake. Chemical oxygen demand of surface water has varied from 43 – 85 mg/l with highest COD at boating point in the east. COD levels have been found elevated > 200 mg/l in the inlet channels.

Average TP in lake water has been found to be > 9 mg/l up to June 2003 and thereafter reported has reduced to <5 mg/l. There seems to be no enhancement in TP values during last one year. However maximum values have been found during summer months may be attributable to remobilization of phosphorous from lakebed sediments during anoxic conditions (Fig. 2). Soluble Reactive Phosphate, which is readily available for algal blooms constitutes to be about 40% of TP. Lakebed sediments have TP concentration of 7 - 10 g/kg. Trophic Status Index (TSI) based on TP values is ranging from 114 –122 (Carlson, 1977 & OECD, 1982). The lakes are under hyper Eutrophic condition, which is imperative for removal of phosphorous from lakebed sediment.

Average TN concentration in lake water has been found to vary from 2 –14.2 mg/l. Maximum TN values have been observed during June 2004, which is about 5 times that of minimum value. Due to drought conditions, lake has not received good surface runoff and thereby resulted in low TN values of 5-6 mg/l (Fig. 2). Within the lake, average TN concentration was maximum > 5.3 mg/l near Setwin Colony and minimum < 2.7 mg/l at Ed Ghar. The TN concentration in sediment has been found varying from 1500 – 4000 mg/kg. In a cyclic fashion TN again started increasing through June to August 2004. Average TSI(TN) values for Mir Alam Tank water are varying 60-90, which seems to be slightly lower than TSI(TP) (Carlson, 1977 & OECD, 1982).

LAKE WATER BUDGET

Bathymetric survey had been carried out during May 2003 and the water level of lake was +515.375 m (amsl) with water spread area of 1.3806 M.sq.m. The volume of water estimated from capacity curve at the water level (RL 516.53 m) is 6.09576 MCM. Mir-Alam tank has a volume has been computed as 7.42516 MCM at the FTL + 517.4 m. Maximum depth of 9.6 m has been noticed in the tank (+506.775 m (amsl)) during May 2003. If one assumes a total outflow of 25 MLD from the lake, the residence time of lake-water would be 300 days(< year). The lake has lost about 700 ML capacity during last two decades due to encroachments. Flow measurements on inlet channels have shown an average total inflow of 8 MLD with maximum total inflow observed being 13 MLD (Gurunadharao et al, 2004).



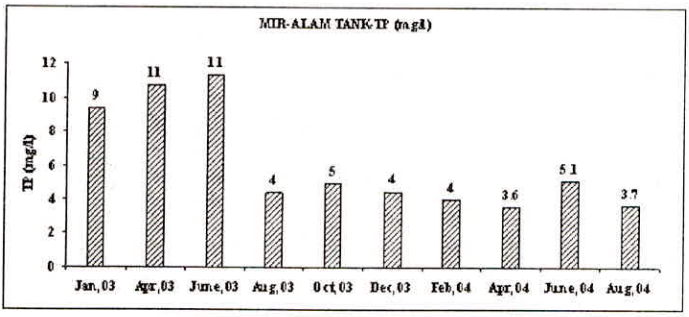


Fig.2 Total Nitrogen (TN) and Total Phosphrous (TP) in Mir – Alam Tank during January 2003 – August 2004

GROUNDWATER MODELING

Assessment of interaction between Mir Alam Tank and groundwater regime was computed through a zone budget of groundwater balance (McDonald and Harbaugh, 1988). The computed groundwater levels for June 2003 in the watershed are shown in Figure 3 (Nilson Guiger and Thomas Franz, 1996). Two zones have been demarcated in the model viz., Zone I outside Mir Alam Tank and Zone II Mir Alam Tank itself. Mir Alam Tank contributes about 2 MLD towards seepage to the groundwater regime. An average rainfall of about 700 mm is being received directly on the lake surface. Annual Evaporation of 2400 mm occurs in Hyderabad. Net loss from the lake water surface through evaporation works about 1700 mm/yr (2400 –700). Considering the lake surface of about 140 ha with an average evaporation rate of about 4.5 mm/day during a drought year, the lake would lose about 6.3 MLD through evaporation. For maintaining Full tank Level (FTL) of the lake, there should be a balance between total inflows and outflows in the lake. It is recommended to establish a STP > 8.3 MLD. On a conservative estimate taking into consideration some outflow (1 MLD) from lake through Zoo Park, HUDA may establish an STP of 10 MLD at Mir Alam Tank (Gurunadharao et al 2004). Presently average total inflow to Mir Alam tank is about 7 MLD and rest of 3 MLD influent sewage has to be gathered at the inlet of STP for treatment.

Groundwater flow model has computed groundwater velocity of < 15 m/yr. This implies that contaminants from sources may migrate with low velocity. Further a mass transport model has been shown that the contaminant migration pattern for the present and predicted for next 20 years considering hydrodynamic dispersion. The model prediction of contaminant plume shape clearly shows that contaminants from the Katedan IDA does not reach the Mir Alam tank, which indirectly is saving the lake water free from groundwater contamination. Further the irrigation wells in the watershed are acting as sinks for groundwater contaminants and thereby arresting its migration towards the lake.

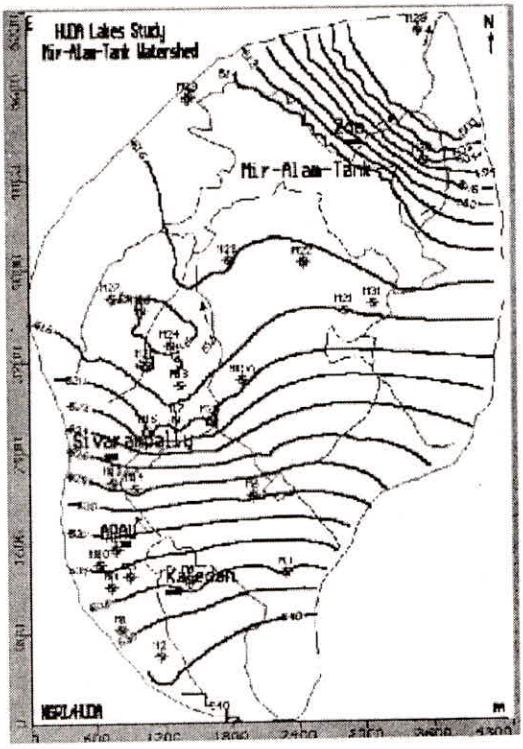


Fig. 3. Computed water level in m (amsl) in Mir-Alam-Tank watershed June 2003

CONCLUSIONS

The trophic status index of the Mir Alam Tank indicate that it has reached hyper eutrophic state and warrants immediate necessary actions to be initiated for lake restoration. Groundwater lake water interaction has been determined through the groundwater flow model study has helped in arriving at the lake water budget. Mir Alam Catchment area is mainly agricultural land (~80%) and considering further urbanization during near future, the STP capacity could be enhanced to 15 MLD for diverting increased sewage flows for treatment before entering the lake. Thus the HUDA envisaged plan of establishing a STP of 10 MLD is sufficient for meeting the daily requirement of the lake water budget. The STP shall be a

Tertiary treatment plant for treating the Phosphates and Nitrates in the influent streams entering the lake. Removal of Total phosphorous from sediment could be possible only through dredging, which is an appropriate remedial measure.

ACKNOWLEDGEMENTS

We are grateful to Dr. V.P. Dimri, Director, NGRI for the encouragement and allowing to present the paper. We wish to thank HUDA for sponsoring the project to NGRI and help by the Officials of HUDA during field investigations.

REFERENCES

APPCB, (2001), A project Report on Protection, Development and Conservation of Lakes in Hyderabad Metropolitan Area for HUDA. pp.279.

Carlson, R.E. (1977), A Trophic State Index for Lakes. Limnol. And Oceanog. 22(2): 361-369.

GWD, (2000), Groundwater conditions in twin cities of Hyderabad and Secunderabad. Groundwater Department Government of A.P, April 2000.

Gurunadha Rao, VVS, Sankaran, S., Prakash, BA, Chandrasekhar, SVN, Mahesh Kumar , K and Yadaiah, P, (2004), Lake Water Budget of Mir-Alam-Tank and Groundwater & Surface Water Quality in the Mir-Alam-Tank Watershed: HUDA Lakes Study. Tech NGRI-GW-2004-445, pp 35.

Hem, J.D., (1985), Study and interpretation of the chemical characteristics of natural water US GS Water Supply Paper 2254, 263 pp.

McDonald, J.M. and Harbaugh, A.W., (1988), A modular three-dimensional finite-difference groundwater flow model. Techniques of Water resources Investigations of the U.S. Geological Survey Book.6, pp. 586.

Nilson Guiger and Thomas Franz, (1996), Visual MODFLOW: Users Guide. Waterloo Hydrogeologic, Waterloo, Ontario, Canada.

OECD (1982), Eutrophication of water, Monitoring, assessment and control. Final Report. OECD Cooperative Program on Monitoring of Inland Waters (Eutrophication Control). Environmental Directorate, OECD, Paris.