

Research and development for the management of groundwater

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The session on Research and Development for the management of Groundwater included 24 papers covering numerical models of groundwater flow and mass transport using various techniques. Application of versatile software like MODFLOW, SUTRA and MT3D models and also some analytical models for solving site specific problems are presented. Topics on isotope hydrology, revitalization of wells, artificial recharge and their future prospects in hydrological assessment were also covered. Need for development of numerical techniques as well as site specific groundwater flow and mass transport models for management of groundwater resources is stressed.

Delineation of groundwater table zones in the Tarai belt of North - West Uttar Pradesh using remotely sensed data and their relationship with soils by H.C. Sharma, Ambrish Kumar and Vinod Kumar have found that groundwater table remained shallow in heavy textured soils due to poor profile drainage as compared to the light textured soils. Four soil type and groundwater table associations were identified though visual interpretation of colors (tone)/texture of IRS-LISS II FCC of bands 2,3 and 4 imageries on 1:50000 scale for the pre-monsoon period for identification of soil types.

Unsteady seepage from a canal by GC Misra and D.N Bhargava used analytical solution for unsteady seepage from a canal and pointed out that linear relationship for shallow water table condition overestimates seepage from canal. The linear relationship is applicable only for deep water table condition. The computations showed that seepage losses per unit area is higher for smaller width canals.

Stream-aquifer inter flow estimation -evaluation of common algorithms by Deepak Kashyap and Ahmad Al Abbar computed inter flow between stream and aquifer in the two dimensional steady state numerical model. Comparison of numerical results from the model showed that use of water table observation seems to be inadequate for reliable estimation of stream- aquifer inter-flow and suggested necessity of monitoring the piezometric head by a network of piezometers for accurate estimation of inter flow.

A two dimensional groundwater flow model for spring by AK Bhar and GC Mishra developed a two dimensional flow model by using Hantush basic solution for the rise of

piezometric surface due to recharge from a rectangular area. Using random jump technique and the spring flow model, the transmissivity, storativity and recharge were estimated from the spring flow data of Kirkgoz spring in Turkey. Estimates reveal that about 6.36% of recharge appears as spring flow.

Groundwater pollution potential assessment through drastic indices methodology- A case study for Bangalore North Taluk (Bangalore Urban district) by Nataraju, and others present that the urban runoff is highly polluted with domestic and industrial wastes that can have serious consequences for the groundwater sources. Seven parameters used in DRASTIC approach and indices were calculated for assessing the vulnerability for groundwater pollution in the area. Suggested that vulnerability assessment can be improved by incorporating additional parameters such as infiltration capacity, land use and actual pollution load.

Analysis of Arsenic contaminated groundwater domain in Nadia district, West Bengal by Mujamdar, Ghosh and Chakravarthy simulated as a ten layer model using a flow and mass transport simulation approach through visual MODFLOW and MT3D software. Mass transport analysis indicates an in-situ source of Arsenic. Possibility of Arsenic removal through design of wells for withdrawing Arsenic free groundwater was studied through analysis of well capture zones. Suggested need for geo-chemical analysis which would help in ascertaining influence of clay lenses on transport of Arsenic.

Characterization of groundwater resource and estimation of aquifer parameters in basaltic terrain, Eastern part of Amaravati district, Maharashtra by Khadri and Deshmukh presented results of hydrogeomorphological, geochemical, geophysical and remote sensing and pumping tests in Deccan Plateau. Suggested the integrated approach has helped in deciphering zones of highly fractured, jointed and vesicular basalt zones as suitable sites for groundwater exploration and there is good scope for increasing irrigation potential by improving the yield of the wells through artificial recharge.

Revitalization of tube wells yielding saline water in Delhi - A Case study by Sushil Gupta presented a study in Delhi area about the presence of brackish to saline water at shallow depths limiting the groundwater availability and up-coning of fresh-saline water interface due to heavy pumping. A safe discharge has been worked out to arrest up-coning of fresh-brackish water interface in wells by sealing at the bottom three meters by cement slurry. The experiment has proved revitalization of otherwise yielding highly saline water well.

Saltwater intrusion process in a layered coastal aquifer system using SUTRA software by Mathew K. Jose applied to a coastal aquifer with varied boundary conditions as well as aquifer parameters to assess their sensitivity of different parameters. Analysis indicates the extent and intensity of salt water intrusion in the aquifer system depends on aquifer/aquitard permeability, influx at the boundaries and dispersivity of the medium. Suggested that a flow barrier in the coastal aquifer system can prevent the advancement of intrusion of saltwater at depth.

Conjunctive use of canals aquifers and management of rainwater by R. Subbaiah and NK Tyagi applied a linear programming technique in the command area of Western Yamuna canals in Haryana to solve the problem of alkalinity and reclaim the land. The rainfall surplus has been managed through a) storage in rice fields b) storage in fallow alkaline land c) storage in lined and unlined ponds and runoff diversion for artificial recharge through tube wells. The model suggests that about 80% runoff from rainwater could be managed to store economically in rice fields. Utilization of managed rainwater in conjunction with irrigation waters increased the income of the farmers in the project area.

Evolution of Water with subsurface drainage for variable recharge and constant ET by Surjeeth Singh and S.K. Singh showed that shallow groundwater table is affected by the recharge in the presence of drainage and also helps for design of subsurface drains and management of crop practices. Boussinesq equation has been solved mathematically to infer the effects of variation of recharge and ET on the evolution of water table.

A characteristic study of dispersion parameters for solute transport in groundwater by B. Chakravarthy and N.C. Ghosh compared analytical solutions of one dimensional and two dimensional transport problem. Close to source, advection dominates whereas away from it dispersion phenomena dominates and also studied the effect of transverse dispersivity with distance from the source and found that combined effect of longitudinal and transverse dispersivity reduces the concentration as compared to longitudinal dispersivity.

Drain spacing computation in sloping lands-- an Analytical approach by A. Upadhyaya and H.S. Chauhan attempted to reduce the water-logging and salinity problems and used the Baumann's method for solution of Boussinesq equation for both constant or depth dependent evapotranspiration for evolution of water table. Effect of slope of impermeable barrier, various rates of evapotranspiration and values of reduction factor on falling water table and drain spacing has been illustrated with a numerical example.

Analysis of numerical dispersion in finite difference approximation of solute transport equation by Anupma Sharma, NC Ghosh Manohar Arora and Digamber singh analyze the mathematical quantification of numerical dispersion originating from the truncation of Taylor's series. Numerical dispersion is found to depend on space and time discretisation scheme. Numerical simulations illustrate that for zero value of numerical dispersion obtained in centered in distance and centered in time difference equation. The mixed Lagrangian Eulerian techniques are an found attractive over Finite difference and Finite element methods for minimization of numerical dispersion.

Estimation of subsurface components of the water balance of lake Nainital (Kuamun Himalaya) using Environmental isotopes by P. Nachiappan, B. Kumar and others computed the sub-surface outflow from the lake by indirect means and used in water balance equation to estimate the sub-surface inflow. The findings have been verified by environmental chloride method through computation of mass balance. The study indicates that Groundwater contributes about 50% of total annual inflow to the lake. The sub-surface outflow is about 55% of total outflow from the lake. Water retention time as computed by isotopic mass balance, chloride mass balance and conventional water balance method is 1.93yr, 1.77y and 1.92 y respectively for Nainital lake. Hydrogeological investigations

indicate that the Sukhtal lake appears to be a major recharge source for Nainital lake and any activity in Sukhtal lake may affect it.

Isotope Hydrology - Present status and future prospects in India by Bishm Kumar and SM Seth provides a review of the isotope hydrological studies carried out in India in past four decades. An effort has been made to focus various important studies that can be carried in the country to understand various problems that may come up in future. Suggested that the important task is to develop a data base for environmental isotope studies. Need for monitoring isotopic concentration of natural concentration 5-6 stations for monitoring environmental isotopic composition in precipitation and groundwater stressed.

Identification of aquifer recharge sources and zones in parts of Ganga-Yamuna Doab, Uttar Pradesh, India using environmental isotopes by M. Someswararao, B.Kumar, P.Nachiappan and Jagmohan used Tritium tracer for recharge estimation. The study reveals that rainfall has actively recharged the local aquifers in Sharanpur district where the aquifer thickness could extend up to 100 m depth. The unconfined aquifer in Hardwar district could not get recharged from the rainfall due to deep seated aquifers. They have also delineated the sand bars developed in the paleo-channels act as a local recharge zone in the plains, while the Bhabhar and Siwalik Hills (above 400 m (amsl)) act as regional recharge zones. The areas close to major rivers viz. Ganga and Yamuna act as discharge zones for regional groundwater flow system. Further geochemical studies are suggested to protect these identified recharge zones.

Planning conjunctive use for controlling water table in a canal command area by S.K. Viswakarma, Kale and Tiwari studied a multipurpose irrigation project on river Narmada at Bargi in Madhya Pradesh to suggest preventive measures to control rising trend of water table in the canal command area. Linear programming technique was adopted to allocate the existing resources and appropriate quantity of groundwater that can be pumped was worked out month-wise to arrest the rise in water table. It has been observed that the current supply of canal water does not fulfill the water requirement of allocated crop plan particularly in peak demand periods, may be supplemented by groundwater withdrawal.

Characteristic equations for estimation of unsaturated hydraulic conductivity - a case study by Vevekanad Singh and B. Soni and SL Srivastava analyzed the role played by the unsaturated hydraulic conductivity in the design of subsurface drainage systems The study was carried out in Narsingpur district. The soil moisture characteristic has been determined based on the data of moisture content and corresponding suction head for all the soils. The unsaturated hydraulic conductivity function has been derived from the Brooks and Corey relationship by non-linear regression analysis. The unsaturated hydraulic conductivity for clay, silty clay, clay loam, silty loam and silty clay loam have been determined.

Optimum lining of distribution network for effective reduction in groundwater withdrawal in a distributary canal command by Vinod Kumar, HC Sharma and Shiv Kumar estimated the water losses in the form of seepage through bed and banks of irrigation canal network and found three main reason for poor distribution efficiency in a canal

command resulting in waterlogging conditions. Different lining alternatives, involving partial or full lining of the distributary, minors and water courses was studied and cost economics worked out for Bulandshar distributary of Upper Ganga Canal. The availability of canal water at field level can be increased by 50 % in the optimal lining condition. This will result in about 7% reduction in groundwater withdrawals for supplemental irrigation in the command. Lining of the canals down to 5 ha command seems to be best option.

Increasing groundwater recharge through integrated approach in black soil region by DH Ranade, LK Jain assessed impact of soil and water conservation structures on groundwater regime in Hingonia-Pipliyatapha watershed in Madhya Pradesh through construction of two water harvesting tanks and construction of field bunds in 250 hectares. About 44% increase in availability of water in wells has been reported in the rabi cropped area.

Estimation of rainfall recharge in a coastal through inverse groundwater modeling by JV Tyagi and Sudhir Kumar estimated recharge due to rainfall in central delta areas of Godavari, Mahanadi and Krishna has been estimated as 13 -17 %, 12 -13% and 16-19% respectively by groundwater balance approach. An inverse modeling approach has been used by defining recharge zones in the MODINV model for central Godavari delta. The recharge coefficient has worked out to be 17%.

Numerical Simulation of saltwater intrusion into east coastal basin of Indian Subcontinent due to anthropogenic effects by A. Ghosh Bobba highlights the important role of subsurface water contamination models in planning, management, and regulation with a focus on generic and site specific contamination of subsurface water systems. A case study of central Godavari delta has been presented and suggested some remedial measures to arrest the ingress of sea water in the coastal aquifer from the Bay of Bengal.

Estimates of outflux of groundwater along the perimeter of a coastal aquifer by Manta Devi Nowbuth, Hemlata Koolwant, Farook Mawlabaccus discusses a case study of Mauritius about water stress problems during droughts. The aquifers are unconfined and coastal aquifers and over exploitation of the groundwater resources may result in sea water intrusion. Outflow towards the sea has been computed and the results indicate that it is possible to either capture or retain the groundwater presently being lost to the sea. Location of high loss rates is indicative of locations of preferential pathways, characteristic of basaltic aquifers. It is suggested to increase the yield of the wells to arrest the outflow to sea. Low outflow zones are vulnerable for sea water intrusion, and hence it would not be advisable to exploit groundwater further in these areas.

The session is interesting as it has covered the gamut of groundwater management alternatives and application of modeling techniques and their limitations. More and more upcoming groundwater problems in the country will be addressed with the knowledge and experience gained from the above studies. Immediate need faced by all the groundwater hydrologists the lacunae in the data. We hope the lot of data will be pouring from the Central Government aided hydrology project.