Bio-data

Name : **Dr. Shivendra Nath Rai**

Present Designation : Hon. Visiting Fellow

Date of birth : June 30, 1952

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Indian Institute of Technology Roorkee
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Fields of spécialisations : Geophysics
Groundwater modelling, exploration and management
hydrogeology
.

Qualifications (Name of University, Year of passing, and Field of specialization)

University	**Degree**	**Year of passing**	**Division**	**Subjects**
B.H.U., Varanasi	B.Sc.	1973	First	Maths, Physics, Geology
B.H.U., Varanasi	M.Sc	1975	First	Geophysics
B.H.U., Varanasi	Ph.D.	1986		Geophysics

Brief career progression in chronologically

Sl.No.	From	To	Name of Organization	Position held
1	Jan. 1976	April 1976	B.H.U., Varanasi	J.R.F.
2	May 1976	Jan. 1977	CSIR-National Geophysical Research Institt	J.R.F.
3	Jan. 1977	Jan. 1981	---do--	S.S.A.
4	Feb. 1981	Jan. 1986	---do--	Scientist 'B'
5.	Feb. 1986	Jan. 1989	---do--	Scientist 'C'
6	Feb. 1989	Jan 1994	---do---	Scientist 'E1'
7	Feb. 1994	Jan. 1999	---do--	Scientist 'E2'
8	Feb. 1999	Jan. 2005	---do--	Scientist 'F'
9	Feb. 2005	June 2014	---do--	Chief Scientist
10	July 2014	continue	Indian Institute of Technology, Roorkee	Honorary Visiting Fellow

Awards and Honours

- National Geosciences Award (formerly National Mineral Award) for 2007
- National Hydrology Award of IAH for 1993.
- National prize from the Kendriya Sachiwalay Hindi Parishad, New Delhi, 2003-04.
- President : Indian Chapter of International Association of Hydrogeologists (2012-13)
- President : Indo-German Nachkontakt Association, Hyderabad (2008-2010)
- Vice President : International Association of Hydrogeologists (IAH) (2004-08, 08-12)
- DAAD Fellow : at Univ. of Hannover, Germany, Sept. 1982 –Dec., 1984
- Fellow : A.P. Academy of Sciences (2010)

- Fellow : Indian Geophysical Union (2004)
- Fellow : Indian Association of Hydrologists (1997)
- Life Member : Association of Exploration Geophysicists
- Member : International Association of Hydrological Sciences (IAHS)
- Life Member : Association of Hydrologists of India (AHI) (2010)
- Associate Editor **:** Hydrogeology Journal (2008-March 2011)
- Member : Executive Committee of IAH (2013-2014)

Foreign assignments

- Visiting Scientist at the Federal Institute for Geosciences and Natural Resources (BGR), Hanover, Germany, Feb.-March, 1994 under DAAD invitation Program.
- Attended Inter Academy Panel (IAP) meeting on international issues related to "The Global Importance of Groundwater in the 21st Century " as INSA representative, Alicante, Spain, January, 23-27, 2006.

Attended IAH Council meeting in the following IAH congresses in my capacity of it's Vice-President.

- 34th IAH Congress at Beijing, China, Oct., 9-13, 2006.
- 35th IAH Congress at Lisbon, Portugal, Sept., 17-12, 2007.
- 36th IAH Congress at Toyama, Japan, 26 October-1st November, 2008.
- 38th IAH Congress at Krakow, Poland, September 12-17, 2010.
- Pretoria, South Africa, September 18, 2011
- 39th IAH Congress at Niagara Falls, Canada, September 17-21, 2012

Member of the International Scientific Committee of:

- 34th IAH Congress at Beijing, China, Oct., 9-13, 2006.
- 35th IAH Congress at Lisbon, Portugal, Sept., 17-12, 2007.
- 36th IAH Congress at Toyama, Japan, 26 October-1st November, 2008.
- International Seminar on "Efficient ground water resources management – the challenge of quantity and quality for a sustainable future". Bangkok, Thailand, Feb. 16-20, 2009.
- 38th IAH Congress at Krakow, Poland, September 12-17, 2010.
- Intl conference on "Groundwater in fractured rock", Prague, Czech Republic, 21-24 May, 2012.

HRD services and other Academic assignments

- Project Leader since 1995, supervised 6 In-house and 3 sponsored projects
- Nodal Officer of CSIR Network project on "Sustainable development and management of water resources in different problematic areas (2007-12).
- Course Director for the DST sponsored V SERC School on Advanced Geophysical Fluid Dynamics at Hyderabad, June 15-July 7, 1999.
- Convener of a workshop on" Geological Fluid Mechanics", Hyderabad, June 26-27, 1999.
- Convener of the National Seminar on "Geo-Scientific achievements and their societal utility", April 25, 2003, NGRI, Hyderabad.
- Course Director for the Training course on 'Role of Mathematical Modeling in Groundwater Resources Management' sponsored by DST, New Delhi, Dec. 13-23, 2004
- Convener of an international seminar on "Natural Hazards-Disaster Mitigation", , Hyderabad, Sept. 23-24, 2005
- Convener of a session on "Water Science" of the **94th Indian Science Congress** held during Jan. 3-7, 2007 at Chidambaram, Tamil Nadu.

- Convener of a national seminar (in Hindi) on 'Water Management', 23-24 Feb. 2007, Hyderabad.
- **Convener** of the Joint Intl. Convention (JIC) of 8th Scientific Assembly of **International Association of Hydrological Sciences (IAHS**) and 37th Congress of **International Association of Hydrogeologists (IAH**), and **Chairman** of the Scientific Committee of the IAH Congress, Hyderabad, India, Sept. 6-12, 2009.
- Advisor, Selection Committee of the Union Public Service Commission (UPSC), New Delhi, 25-29 the October, 2010.
- Member of the Expert Panel on groundwater constituted by Central Ground Water Board, New Delhi for evaluation R& D Projects on ground water.
- Supervised dissertation work for the partial fulfillment of the award of B. Tech. in Civil Engg for 5 students of Vidya Vikas Institute of Technology, JNTU Hyderabad during June- July 2011.
- Member of the Working Group of National Institute of Hydrology, 2012-13.

Chaired sessions in the following national/international seminars:

- National seminar on "Groundwater resources assessment and management-perspective for the 21st Century" held at B.H.U., Varanasi, during July 23-24, 1998.
- National seminar on "Environment-III" held at NCL, Pune during December 10-12, 1996.
- Workshop on " Present status of groundwater and future vision", CGWB, Southern Region, Hyderabad, March 3, 2000.
- Seminar on "Geology and natural environment of the lesser Himalaya: Present status and strategy for the next two decades", Kumaun University, Nainital, March 23-25, 2001.
- National Agricultural Technology Project Workshop on Groundwater Skimming and Recharging Technologies, Aug. 2001, Guntur, A. P.
- 2nd Intl. groundwater Conference(IGC 2006) on 'Groundwater for Sustainable Development: Problems, Prospective and Challenging', New Delhi, Feb. 1-4., 2006
- 34th IAH Congress, Beijing, October, 9-13,2006
- International Conference on "Hydrology and Watershed Management, Hyderabad, December 5-8, 2006.
- International Groundwater Conference on "Groundwater Dynamics & Global Change, held at Jaipur, Rajsthan, March 19-22, 2008.
- 36th IAH Congress at Toyama, Japan, 26 Oct.-1st November, 2008.
- 3rd international conference on "Hydrology and Watershed Management" with a focal theme on "Climate Change-Water, Food and Environmental Security", JNTU, Hyderabad, 3-6 Feb., 2010.
- International conference on "Sustainable water resources management and technologies", NEERI, Nagpur, 19-21 Jan., 2011
- International conference on "Geophysical Sciences-Energy, climate change and evolution of human society". Banaras Hindu Univ., 21-23 Dec. 2010.
- National conference on "Geosciences and water Resources for Sustainable development". Andhra Univ., 11-12 February, 2011.
- Workshop on "Augmentation and protection of groundwater resources", organized by CGWB at NGRI on 24 Feb. 2011.
- National seminar on hydrology with a special colloquium on " Management of Rural Water Resources", at Dr. B.R. Ambedkar University, Etcherla, Srikakulam District, A.P., 15-17 July, 2011.
- National seminar on hydrology with special colloquium on "Geomatics in Water Resources", at Gandhigram Rural Institute (DU), Dindigul district, 11-12 December, 2012

- Fifth International Groundwater Conference (IGWC-12) with theme "The assessment and Management of Groundwater Resources in Hard rock System with Special reference to Basaltic Terrain". Dr. Rafiq Zakaria Campus, Aurangabad, 18-21 December, 2012.
- Intl. conf. on 'Advances in Water Resources Development and management ", Punjab University, Chandigarh, October 23-27, 2013.
- Workshop on "Challenges and perspectives in conservation of water in urban areas". CGWB, Southern region, Hyderabad, 20th March.

Patent:

Method of Predicting the Dynamic Behavior of Water Table in an Anisotropic Unconfined Aquifer Having General Time Varying Recharge Rate From Multiple Rectangular Recharge Basins".

Inventors: Dr. A. Manglik and Dr. S.N. Rai

United States Patent no. : **US 8,140,309 B2** , date March, 20, 2012

Publications:

(i) **Ph. D. Thesis**

Rai, S.N., 1986. Mathematical modelling of transient flow in unconfined aquifers. BHU, Varanasi.

(ii) Books (edited) (6):

1. **Rai, S.N.,** Ramana, D.V. and Manglik, A. (Eds.), 2002. Dynamics of the Earth's Fluid Systems, A.A. Balkema, Netherland, pp.291.
2. **Rai, S.N.,** 2004 (Ed.). Role of mathematical modeling in groundwater resources management, DST Publication, pp. 448.
3. Thangarajan, M., **Rai, S.N.** and Singh, V.S. (Eds.), 2002. Sustainable Development and Management of Groundwater Resources in Semi-Arid Region with Special Reference to Hard Rocks, Pre-Conference Proceedings of the International Groundwater Conference(IGC-2002), Oxford &IBH Publishing Co. Pvt. Ltd., New Delhi, pp. 586.
4. Thangarajan, M., **Rai, S.N.** and Singh, V.S. (Eds.), 2002. Sustainable Development and Management of Groundwater Resources in Semi-Arid Region with Special Reference to Hard Rocks (Selected papers), Post- Conference Proceedings of the International Groundwater Conference (IGC-2002), A.A. Balkema, Netherland, pp.243. (Part-I)
5. Sinha, A.K., **Rai, S.N.** and Anoop Kumar, (Eds.), 2008. Hydrogeology and Groundwater Modeling. P.P. Printers, Jaipur, pp 359.
6. Thangarajan, M., Singh, V.S. and **Rai, S.N.** (Eds.), 2003. Sustainable Development and Management of Groundwater Resources in Semi-Arid Region with Special Reference to Hard Rocks, Post Conference Proceedings of the International Groundwater Conference (IGC-2002), pp.280. (Part-II)

(iii) Research papers (69):

1. Manglik, A. and **Rai, S.N.,** 2015. Modeling water table fluctuations in anisotropic unconfined aquifer due to time varying recharge from multiple heterogeneous basins and pumping from multiple wells. Water Resources Management, vol. 29, 1019- 1030 **IF 2.463**

2. Dewashish Kumar, **Rai, S.N.** Thiagarajan, S.N. and Ratnakumari, Y., 2014. Evaluation of heterogeneous aquifers in hard rocks from resistivity sounding data: a case study from Kalmeshwar taluk of Nagpur district, India. Current Science, 107(7). 1137-1145 **IF 0.897**

3. **Rai, S.N.,** Thiagarajan, S., Dewashish Kumar, Dubey, K.M., Rai, P.K., Ramchandran, A. and Nithya, B., 2013. Electrical Resistivity Tomography for groundwater exploration in a granitic terrain-a case study from NGRI campus. Current Science, 105(10), 1410-1418 **IF 0.897**

4. **Rai, S.N.,** Thiagarajan, S. and Dewashish Kumar, 2013. Groundwater exploration in basaltic terrains-Problem and prospects. Jour. of Groundwater Research, vol. 2/2, Dec., 31-42.
5. Rai, S.N., 2013. Groundwater exploration and management in context of India. In proceedings of national seminar on “Earth sciences for the society”. 74-79
6. Manglik, A., **Rai, S.N**.and Singh V.S., 2013. A generalized predictive model of water table fluctuations in anisotropic aquifer due to intermittently applied time varying recharge from multiple basins. Water Resour. Manag. 27, 25-36. **IF 2.463**
7. **Rai, S**.N., Thiagarajan, S., Ratnakumari, Y., Anand Rao, V. and Manglik , A. 2013. Delineation of aquifers in basaltic hard rock terrain. J. Earth System Sciences. 122(1), 29-41. **IF 0.941**
8. **Rai, S**.N., Thiagarajan, S., Ratnakumari, Y and Kumar, D. 2012. Exploring Deccan traps for groundwater in parts of Kalmeshwar taluk, Nagpur district, India, Journal of Applied Hydrolgy, XXV (3&4), 85-94.
9. **Rai, S.N**. and Manglik, A., 2012. An analytical solution of Boussinesq equation to predict water table fluctuation due to time varying recharge and withdrawal from multiple basins, well and leakage sites. Water Resour. Manag., 26, 243-252. **IF 2.463**
10. Ratnakumari, Y**., Rai, S.N**., Thiagarajan, S. and Dewashish Kumar, 2012. 2-D Electrical Resistivity Imaging for delineation of deeper aquifers in part of Chandrabhaga river basin. Current Science, 102(1), 61-69. **IF 0.897**
11. **Rai, S.N**., Thiagarajan, S. and Ratnakumari, Y., 2011. Exploration for ground water in the basaltic Deccan trap terrain in Katol taluk, Nagpur district, India. Current Science, 101(9), 1198-1204. **IF 0.897**
12. Kumar, D, Thiagarajan, S. and **Rai, S.N.,** 2011. Deciphering geothermal resources in Deccan traps region using Electrical Resistivity Tomography technique. J. Geol. Soc. India, 78, 541-548 **IF 0.396**
13. **Rai, S.N.** and Manglik, A. 2010. Modelling of water table fluctuation in the presence of canal seepage and pumping. Proc. of 38th IAH Congress , 1911-1915.
14. Bobba, A.G., Rao B.V., **Rai, S.N.** and Sarala, C., 2010. Mathematical model of nuclear waste solute transport through fracture porous matrix system. In: proc. of 3rd intl. conf. on “Hydrology and watershed management” (ed. B. Venkateswara Rao), vol. I, 663-669.
15. **Rai, S.N**., 2009. Development versus sustainable development of ground water resources in Indian context. Proc. of the international conference on ‘Water, Environment, Energy and Society (WEES) (Eds. S.K. Jain et al.,) Allied Publ. Pvt. Ltd., 401-416.
16. **Rai, S.N.,** 2009. Plate tectonic induced climate change and it’s impact on habitation. In: Proc. of National conf. on “Climate change and impact on life style” (Eds. S.N. Rai and Mala Rao), 16-20.
17. Rai, S.N. and Ratnakumari, Y., 2008. Groundwater resources – from exploration to management. In: Five decades of geophysics in India (Eds. B. Singh and V.P. Dimri), GSI Memoir, 68, 357-380
18. **Rai, S.N**., Thiagarajn, S. and Ratnakumari, Y., 2008.Water pollution and health hazard. Proc. of the national seminar on “Food nutrition-societal importance” (Eds. S.N. Rai and A.P.Singh) , 36-45.
19. **Rai, S.N**. and Thiagarajan, S., 2007. 2-D crustal thermal structure along Thuadara-Sindad DSS profile across Narmada-Son Lineament, Central India. J. Earth System Science, 116, 347-355. **IF 0.941**

20. **Rai, S.N**., 2007. Management and governance strategies for sustainable development of ground water resources. In: Water, Environment and Agriculture- Present Problems and Future Challenges", Proc. of IGC-2007 , Coimbatore, Feb. 7-10, TS7-20
21. **Rai, S.N**. and Thiagarajan, S., 2006. Crustal thermal structure of central India across the Narmada-Son Lineament (NSL), J. Asian Earth Sci., 28, 363-371. **IF 2.215**
22. **Rai, S.N.,** Manglik, A.,and Singh, V.S., 2006. Water table fluctuation owing to time-varying recharge, pumping and leakage, J. Hydrol., 324, 350-358. **IF 2.514**
23. **Rai, S.N**., 2006. Groundwater development and management scenarios in India. In: Proc. of the International symposium on "Groundwater sustainability" (Stephen Ragone et al. Eds.), NGWA Press, U.S.A., 41-46.
24. **Rai, S.N.,** 2006. Management and governance of ground water resources. Proceeding of national symposium on "Water Resources Management for Sustainable Development ". Bhubneshwar, 126-128.
25. Manglik, A., **Rai, S.N**. and Singh, V.S., 2004. Modeling of aquifer response to time varying recharge and pumping from multiple basins and wells. J. Hydrol., 292, 23-29. **IF 2.514**
26. Ramana, D.V., Thiagarajan, S. and **Rai, S.N**., 2003. Crustal thermal structure of the Godavari graben and coastal basin. Curr. Sci., 84(8), 1116-1122. **IF 0.897**
27. **Rai, S.N.,** Thiagarajan, S. and Ramana, D.V., 2003. Seismically constrained 2-D thermal model of Central India along Hirapur – Mandla Deep Seismic Sounding profile across the Narmada Son Lineament. Curr. Sci., 85(2), 208-213. **IF 0.897**
28. **Rai, S.N.,** 2003. Groundwater pollution in India - an overview: In: Groundwater pollution (Eds. V.P. Singh and R.N. Yadava), Allied Publ. Pvt. Ltd., 419-436.
29. **Rai, S.N**., 2002. Modeling of groundwater flow in Schoneiche waste disposal site, Germany. In: Sustainable development and management of groundwater resources in semi-arid region with special reference to hard rocks (Eds. M. Thangarajan, S.N. Rai & V.S. Singh), Oxford and IBH Publ. Co., 465-470.
30. Srivastava, K. and **Rai, S.N**., 2002. Stochastic modeling of groundwater flow in heterogeneous aquifer. In: Sustainable development and management of groundwater resources in semi-arid region with special reference to hard rocks (Eds. M. Thangarajan, S.N. Rai & V.S. Singh), Oxford and IBH Publ. Co., 471-475.
31. Thiagrajan, S., Ramana, D.V. and **Rai, S.N.,** 2001. Seismically constrained two-dimensional crustal thermal structure of the Cambay basin. J. Earth System Science (formerly Proceeding of Indian Academy of Sciences (EPS)), 110, 1-8. **IF 0.941**
32. **Rai, S.N**., Ramana, D.V., Thiagarajan, S. and Manglik, A., 2001. Modeling of groundwater mound formation due to transient recharge, Hydrological Processes, 15(8), 1507-1514. **IF 2.068**
33. Srivastava, K., **Rai, S.N**., and Singh, R.N., 2001. Modelling of water table fluctuation in a sloping aquifer with random hydraulic conductivity, Environmental Earth Sciences (formerly Environmental Geology), 41, 520-524. **IF 1.070**
34. **Rai, S.N.** and Manglik, A., 2001. Modelling of water table fluctuations due to time-varying recharge from canal seepage. In: New approaches characterizing groundwater flow, K-P. Seiler and S. Wohnlich (eds.), Balkema Pub., The Netherlands, p.775-778.
35. Manglik, A. and **Rai, S.N**., 2000. Modelling of water table fluctuations in response to time varying recharage and withdrawal, Water Resour. Manag. 14 (5), 14(5), 339-347. **IF 2.463**
36. **Rai, S.N**. and Manglik, A., 2000. Water table variation due to time varying recharge and withdrawal. In: Groundwater – past achievements and future challenges (Eds. Oliver Silio Et al.), A.A. Balkema Pub., 259-262.
37. **Rai, S.N.** and Manglik, A., 1999. Modelling of water table variation in response to time varying recharge from multiple basins using the linearised Boussinesq equation, J. Hydrology, 220, 141-148. **IF 2.514**

38. **Rai, S.N**. and Singh, R.N., 1998. Evolution of water table in a finite aquifer due to transient recharge from two parallel strip basin. Water Resour. Manag., 12(3), 199-208. **IF 2.463**

39. **Rai, S.N**., Ramana, D.V. and Singh, R.N., 1998. On prediction of groundwater mound formation in response to transient recharge from a circular basin.Water Resour. Manag., 12(4), 271-284.**IF 2.463**

40. Manglik, A. and **Rai, S.N**., 1998. Two-dimensional modelling of water table fluctuation due to time-varying recharge from rectangular basin, Water Resour. Manag., 12(6), 467-475. **IF 2.463**

41. Srivastava, K**., Rai, S.N**., and Singh, R.N., 1998, Analysis of water table fluctuations in a finite aquifer due to transient random recharge from a strip basin, Hydrology J.,21(4),67-74

42. Manglik, A., **Rai, S.N**. and Singh, R.N., 1997. Response of an unconfined aquifer induced by time varying recharge from a rectangular basin. Water Resour. Manag., 11(3), 185-196. **IF 2.463**

43. **Rai, S.N**. and Srivastava, K., 1997. Modelling of water table fluctuations in response to transient random recharge, J. Geophys., 18, 125-129.

44. **Rai, S.N.,** 1997, Analytical solution of a ditch drainage problem using an integral balance method, Hydrology J., 20(1-4), 30-34.

45. **Rai, S.N**., Ramana, D.V. and Manglik, A., 1997. Modelling of water table fluctuation in a finite aquifer system in response to transient recharge. Proc. Intl. Seminar on Emerging Trends in Hydrology (Eds. D.C. Singhal et al), Sept. 25-27, Vol. 1, 243-250.

46. Srivastava, K., **Rai, S.N.** and Singh, R.N., 1996. Water table variation in a sloping aquifer due to random recharge. Water Resour. Manag., 10(3), 241-250. **IF 2.463**

47. **Rai, S. N**. and Singh, R.N., 1996. On the prediction of groundwater mound formation due to transient recharge from a rectangular area. Water Resour. Manag., 10(3), 189-198. **IF 2.463**

48. **Rai, S. N.** and Singh, R.N., 1996. Analytical modelling of unconfined flow induced by time varying recharge - a review. Proc. of the Indian National Science Academy, Part A: Physical Sciences, 62A(4), 253-292.

49. Ramana, D.V., **Rai, S.N**. and Singh, R.N., 1995.Water table fluctuation due to transient recharge in a 2-D aquifer system with an inclined base. Water Resour. Manag., 9(2), 127-138. **IF 2.463**

50. **Rai, S.N**. and Singh, R.N., 1995a. Two-dimensional modeling of water table fluctuation in response to localised transient recharge. J. Hydrol., 167, 167-175. **IF 2.514**

51. **Rai, S.N**. and Singh, R.N., 1995b. An analytical solution for water table fluctuation in a finite aquifer due to transient recharge from a strip basin. Water Resour. Manag., 9, 27-37 **IF 2.463**

52. Gopala Rao, D., Bhattacharya, G.C., Ramana, M.V., Subrahmanyam, V., Ramprasad, T., Krishna, K.S., Chaube, A.K., Murty, G.P.S., Sriniwas, K., Desa, M., Reddy, S.I., Ashalata, B., Subrahmanyam, C., Mittal, G.S., Drolia, R.K., **Rai, S.N**., Ghosh, S.K., Singh, R.N., Majumdar, R., 1994. Analysis of multi-channel seismic reflection and magnetic data along 13^{o}N latitude across the Bay of Bengal. Marine Geophys. Res.,16, 225-236. **IF 0.763**

53. **Rai, S.N**., Manglik, A. and Singh, R.N., 1994. Water table fluctuation in response to transient recharge from a rectangular basin. Water Resour. Manag., 8(1), 1-10. **IF 2.463**

54. Srivastava, K., Singh, R.N. and **Rai, S.N.,** 1994. Transient random recharge: effects on the water table fluctuations in a sloping aquifer. J. Assoc. Expl. Geophys.,15 (3), 123-128.

55. **Rai, S.N**. and Singh, R.N., 1992. Water table fluctuations in an aquifer system due to time varying surface infiltration and canal recharge. J. Hydrol., 136, 381-387. **IF 2.514**

56. Singh, R.N., **Rai, S.N**. and Ramana, D.V., 1991. Water table fluctuation in a sloping aquifer due to transient recharge. J. Hydrol., 126, 315-326. **IF 2.514**

57. Singh, R.N. and **Rai, S.N.,** 1989. A solution of nonlinear Boussinesq equation for phreatic flow using integral balance approach. J. Hydrol., 109, 319-323. **IF2.514**

58. **Rai, S.N**. and Hoffmann, B. 1989. Numerical simulation of groundwater flow in Fuhrberg field, Hanover. In : Appropriate Methodologies for Development and Management of Groundwater Resources in Developing countries, Oxford & IBH Publ. Co., Vol.2, 595-606.

59. **Rai, S.N**. and Singh, R.N., 1988. On the predictability of the water table variation in a ditch-drainage system. Water Resour. Manag., 2, 289-298. **IF 2.463**

60. **Rai, S.N.** and Singh, R.N., 1987. Water table fluctuations with a random initial condition. Water Resour. Manag., 1, 107-118. **IF 2.463**
61. Singh, R.N. and **Rai, S.N.**, 1985. On an approximate analytical solution of the Boussinesq equation for a transient recharge. In: Scientific Procedures Applied to Planning, Design and Management of Water Resources System, (E. Plate and N. Buras Eds.), IAHS Publ. No.147, 140-148.
62. **Rai, S.N.** and Singh, R.N., 1985. Water table fluctuations in response to time varying recharge. In: Scientific Basis for Water Resources Management (M. Diskin Ed.), IAHS Publ. No. 153, 287-294.
63. **Rai, S.N**. and Singh, R.N., 1981. A mathematical model of water table fluctuation in a semi-infinite aquifer induced by localized transient recharge. Water Resour.Res., 17, 1028-1032. **IF 2.737**
64. Singh, R.N. and **Rai, S.N**., 1981. Steady state model of advection and diffusion of contaminants in an inhomogeneous aquifer. In: Quality of Groundwater, Studies in Environmental Science (W. van Duijvenbooden, P. Glasbergen and H. van Leiyveld Eds.), Elsevier Sci. Publ. Co., vol 17, 1007-1010.
65. **Rai, S.N**. and Singh, R.N., 1980. Dynamic response of an unconfined aquifer subjected to transient recharge. Geophys. Res. Bull., 18, 50-56.
66. Singh, R.N. and **Rai, S.N**., 1980. On subsurface drainage of transient recharge. J. Hydrol, 48, 303-311. **IF 2.514**
67. **Rai, S.N**. and Singh, R.N., 1979. Variation of water table induced by time varying recharge. Geophys. Res. Bull., 17, 97-109.

Paper communicated (2)

68. Thiagarajan, S., **Rai, S.N**., Dewashish Kumar and Y. Ratna Kumari, 2014. Exploring groundwater in basaltic Deccan traps. Hydrogeology J.(Communicated).
69. Rai, S.N., Thiagarajn, S., Shankar, G.B.K., Shateesh Kumar, M, Venkatesam, V., Mahesh, G. and Rangarajan, R., 2014. Groundwater prospecting in Deccan traps covered Tawarja basin using Electrical Resistivity Tomography, JIGU (Communicated)

(iv) Invited lectures (31):

1. Rai, S.N., 2014. Sustainable development and management of water resources in hard rock terrains under semi-arid climatic condition. National Institute of Hydrology, Roorkee, October 20.
2. Rai, S.N., 2014. Groundwater exploration in hard rock terrains. National workshop on “Groundwater governance and Regulation” organized by INC of IAH, New Delhi, September 23.
3. Rai, S.N., 2014. Groundwater management in hard rock areas using geophysical methods. Dept. of Hydrology, IIT Roorkee, Sept. 10.
4. Rai, S.N., 2014. Electrical Resistivity Tomography for exploration and sustainable development of groundwater resources in Hard rock terrains. In: Training program on 3-D Resistivity imaging for groundwater exploration’, Centre for Water Resources, JNTU, 25th March.
5. Rai, S.N. 2014. Introduction to groundwater system and groundwater flow modeling. SRTM University, Nanded, Maharashtra, 8th March.
6. Rai, S.N., 2014. Exploration and management of groundwater resources using electrical resistivity methods. SRTM University, Nanded, Maharashtra, 8th March.
7. Rai, S.N., 2014. Exploring groundwater in hard rock terrain. 50th annual convention of IGU and seminar on “Sustainability of Earth System-The Future Challenges”, CSIR-NGRI, Hyderabad, 08-12 Jan.
8. Rai, S.N., 2013. Groundwater management: issues and challenges. In workshop on “Water resources management for sustainable development. NIRD, Hyderabad, 18-30 November.

9. Rai, S.N., 2013. Groundwater exploration and management in context of India. In national seminar on “Earth sciences for the society”. CSIR-NGRI, Nov. 7-8.
10. Rai, S.N., 2013.Groundwater management for livelihood-Indian experience. In an international program on “Natural Resources Management for Sustainable Livelihood”, National Institute of Rural Development, Hyderabad, Sept. 23 to October 18.
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Details of work done:

My works carried out during last 35 years are of both basic and applied nature and can be grouped in to three disciplines: (i) Development of predictive groundwater flow models (ii) Groundwater exploration in hard rock terrains, and (iii) Geothermal modeling. These works are published in journals of high impact factors (IF) such as Journal of Hydrology (IF 2.514), Water Resources Research (IF 2.737) , Water Resources Management (2.201), Hydrological Processes (IF 2.068), J. of Asian Earth Science (2.215) etc. and are widely cited**.** Details about the works are presented below.

(I) Development of predictive groundwater flow models:

Groundwater plays an important role in augmenting water supply to meet the increasing demands for domestic, industrial and agricultural usages. Study of groundwater flow in unconfined aquifer is of special interest because storage of water in any quantity of economical and hydrological significance is possible in this type of aquifers. Pumping of groundwater from aquifer systems in excess of their natural replenishment leads to undesirable lowering of the water table which causes many kinds of geotechnical and environmental problems such as failure of tube wells, deterioration of water quality due to encroachment of polluted groundwater from nearby regions. Such problems can be alleviated to a large extent by maintaining the water table at some desired level through artificially recharging the aquifer systems. Therefore, prediction of the water table fluctuation in response to a proposed scheme of recharging and /or pumping is essential to alleviate such environmental problems by restricting the growth of water table up to a permissible level in order to maintain the regional water balance. It helps in achieving the preset objectives of groundwater resources development and management.

Mathematical models play a key role in predicting dynamic behaviour of water table to various schemes of recharging and pumping and in selecting an appropriate one out of many proposed schemes for sustainable development and management of a groundwater system. Most of the existing models were based on the assumption of constant rate of recharge applied continuously. However, rate of recharge largely depends on the infiltration rate which is influenced by several factors. Initially infiltration rate decreases mainly as a result of dispersion and swelling of soil particles. After some time it increases owing to displacement of the entrapped air. After reaching a maximum value it reduces again owing to clogging of the soil pores. The rate of recharge follows almost a similar pattern of variation of infiltration with comparatively less intensity and with some time lag. It has been demonstrated with the help of field examples that the solutions based on the assumption of constant rate of recharge are unable to predict the rise and subsequent decline of the water table which is due to decrease in the rate of recharge and has been suggested to treat the recharge rate as variable in time in order to simulate actual field conditions. My works deal with the development of analytical mathematical models to predict the spatio-temporal variation of the water table in different aquifer systems representing different physical scenario in response to time varying recharge applied from **strip basin** (Rai & Singh, 1979; 1980; 1981; 1992; 1995b; Rai, Ramana & Manglik, 1997; Rai and Srivastava, 1997; Srivastava et al., 1998; Rai and Singh, 1998; Rai et al., 2001; Rai and Manglik, 2001), **circular basin** (Rai, Ramana & Singh, 1998), **single rectangular basin** (Rai et al., 1994; Rai and Singh, 1995a; 1996; Ramana et al., 1995; Manglik, Rai and Singh, 1997; Manglik and Rai, 1998, Rai and Manglik, 2008), **multiple rectangular basins in the presence of pumping from wells** (Rai and Manglik, 1999; 2000; Manglik & Rai, 2000; Manglik et al., 2002), **multiple recharge basins in the presence of pumping and leakage** (Manglik et al. 2004, Rai et. al 2006, Rai and Manglik, 2012). Time varying recharge rate is approximated by either exponential function or a number of linear elements of different lengths and slopes. The advantage of later scheme of approximation by linear elements is that any complex nature of variation in recharge rate for one or more than one cycle of recharge consisting of dry and wet periods can be approximated with the help of a number of linear elements of different lengths and slopes depending on the nature of time vary recharge rate. This scheme of recharge estimation is introduced by Manglik, Rai and Singh (1997). This scheme of linear elements of different length and slopes has been also used for approximation of intermittently applied pumping rate. In a recent work Manglik, Rai and Singh (2013) have developed a generalised model to predict water table fluctuations in **anisotropic aquifer** due to intermittently applied time varying recharge from multiple basins.

In some heavily irrigated areas excess recharging of groundwater system through return flow of irrigated water and canal leakage leads to the growth of water table near to the ground surface causing many other kinds of environmental problems such as water logging, soil salinity etc. Mathematical models have also been developed to predict the water table fluctuation for ditch drainage system (Singh and Rai, 1980; 1989 Rai and Singh, 1987; 1988; Singh et al., 1981; Srivastava et al., 1994; 1996; 2002; Rai, 1997). Such knowledge of water table fluctuation is useful for the proper drainage design to check the undesired growth of water table near to the ground surface which causes different kind of environmental problems such as water logging, increase in soil salinity etc. The above mentioned models can be used for sensitivity analysis to study the effects of changes in various controlling parameters like rate of recharge, dimensions and positions of recharge basins, boundary conditions, intensity and duration of pumping rates, aquifer's parameters etc. on the dynamic behavior of aquifer system. Such information is useful in making judicious selection of an appropriate development scheme of groundwater resources. In addition, these models can also be used to verify results of numerical models under developing stages before their applications to the complex field problems.

In addition to above mentioned works, a numerical model has been developed to understand the dynamic behavior ground water system of Fuhrberg region from where water is being supplied to the Hanover city of Germany (Rai and Hoffmann, 1989). This model is useful in selection of suitable sites for pumping and recharging in order to maintain the regional water balance. Another numerical model has also been developed to evaluate the ground water flow direction in the region of Schoneiche near Berlin of Germany to protect the fresh water from waste deposit (Rai, 2002).

(ii) Groundwater exploration in hard rock terrains:

(a)Basaltic Deccan traps:

Chandrabhaga basin, Nagpur district:

Vidarbha region of Maharastra State as a whole is facing acute shortage of water supply for drinking and irrigation of agricultural fields and orange orchards which are the main source of livelihood. This region falls under Deccan volcanic province (DVP) and is characterized with complex hydrogeology.

Groundwater is the main source of water supply. The investigated region of Chandrabhaga basin falls under **Katol, Kalmeshwar and Rural Nagpur taluks of Nagpur district under Vidarbha region.** It is spread over in 500 km^2 area encompassing 50 villages. Presently in these areas ground water is explored only from dug wells of shallower depths (~10-15 meters) and is inadequate to meet the present demands of water supply. Deeper sources of groundwater within and below the traps were hitherto not known to the farmers of this region. Geophysical electrical surveys using Vertical Electrical Soundings (VES) and Electrical Resisitvity Tomography (ERT) have been carried out to delineate deeper sources of ground water in the form of intertrappeans within the Deccan traps and Gondwana sedimentary formation below the traps. Based on the results of geophysical investigations, several suitable sites (about 50) have been recommended for ground water exploration from deeper sources. Six exploratory wells were drilled to verify the results about the potentiality of deeper aquifers. Some are being used by farmers which have helped them in improving their economy (Rai, et al., 2011, 2012, 2013), Ratnakumari et al., 2012). Besides this, suitable sites for artificial recharging and for construction of check dams to retain groundwater in shallower unconfined aquifers have been identified. Groundwater available in shallower unconfined aquifers is the source of water in dug wells. **This work is a fine example of how Earth science can help in overcoming the problem of water supply shortage in backward rural areas of drought prone Vidarbha region.**

Tawarja basin, Latur district

Like Vidarbha region, Marathwada region in the central part of the Deccan traps is also facing acute shortage of water supply for irrigation which leads to huge economic losses to the farming community. ERT has been carried out in part of Tawarja basin under Latur district to delineate groundwater potential zones. Several sites of potential aquifers have been delineated which can be developed for groundwater pumping to meet the water supply demand. This work also led to the identification of suitable sites for managing aquifer recharge (Rai et al. 2014).

Chiplun Taluk, Ratnagiri district

Electrical Resisitivty Imaging has also been carried out in Deccan traps terrains under the administrative jurisdiction of Unhavare, Aravali, Tural and Rajwadi villages of Chiplun taluk, **Ratnagiri district, Maharashtra** to delineate sources of groundwater to meet the increasing demand of water supply. From this study two potential sites of groundwater reservoir have been delineated in Rajwadi and Arawali villages. Sources of geothermal fluid have also been delineated in the region of Unhavare, Tural and Aravali villages which can be explored for geothermal energy. (Kumar et al., 2011).

Tadkeshwar Lignite mine, Surat district

In Tadkeshwar Lignite mine of Gujarat Mineral Development Corp.(GMDC) Ltd, land slide due to groundwater movement occurs frequently. It not only disturbs the mining activities but also incur heavy financial losses to the GMDC. Hydrogeological investigation using 2-D Electrical Resisitivity Imaging has been carried out within the mining area to delineate water bearing zones in order to design pumping scheme to prevent land slide. (Tech. report Rai et al. 2011).

Granitic terrains:

Granitic terrains also occupied a large part of Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. Sever water scarcity is also reported in the granitic terrain. The campus of CSIR-National Geophysical Research Institute at Hyderabad is occupied by granites and was facing acute shortage water supply. This problem was solved by delineating groundwater potential zones using ERT (Rai et al , 2013). Based on our study, an exploratory well has been drilled to meet the demand of water supply. Similar groundwater exploration works have been carried out at several locations in and around Hyderabad such as CSIR-IICT campus, CSIR-CCMB campus, etc. (Technical reports: Rai et al. 2013a &b).

(iii) Geothermal modeling:

Knowledge of subsurface thermal field is essential for understanding the geodynamic evolution of the crust/lithosphere and thermally controlled other geological processes. The importance of subsurface temperature estimates in the studies on seismogenesis is essentially in estimating the depth of brittle-ductile (B-D) transition that represents depth of seismicity. 2-D crustel thermal models have been developed to estimate the temperature depth distribution up to Moho, surface heat flow distribution, Curie depths, depth of britle-ductile transition etc in the **Cambay basin** (Thiagrajan, Ramana and Rai, 2001), **Godavari graben** (Ramana, Thiagarajan and Rai, 2003), and in the **central India across the Narmada Son Lineament (NSL)** along the 7 Deep Seismic Sounding (DSS) profiles (Rai, Thiagarajan and Ramana, 2003; Rai and Thiagarajan, 2005 a, b). Results of these studies suggest that the lower crust in the central India (between 75^o to 80^o east longitude) across NSL is cooler (Moho temperature 470o-580^o C) in comparison to Cambay basin (Moho temperature 900oC) and Godavari graben (Moho temperature 620oC). This in turn makes the lower crust of this part of central India across NSL amenable to the occurrence of deep focus earthquake such as Satpura (1938) and Jabalpur (1997) earthquakes. The conductive heat flow value is found to vary between 45 to 49 m W/m^2 in central India across NSL, 57- 64 mW/m^2 in Godavari graben, and 82 - 84 mW/m^2 in Cambay basin.