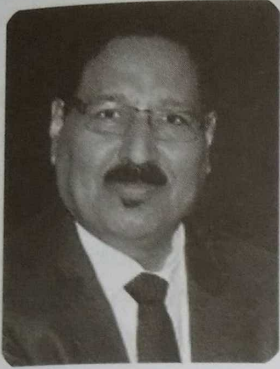


## LEADERSHIP IN COMPUTATIONAL GEOSCIENCES

*Professor T.N. Singh*



*Professor T.N. Singh has recently assumed charge as the Director of the Indian Institute of Technology Patna. MGMI's Honorary Editor, Dr. Ajay Kumar Singh took this opportunity to interact with him on multiple topics of interest to this journal's readership. A geologist by training, Professor T.N. Singh completed his BSc, MSc and PhD degrees from BHU Varanasi before serving as a faculty member there. Subsequently, he carried forward his research career at IIT Bombay serving at various levels, including as the Institute Geoscience Chair Professor and Head of the Earth Sciences Department there. During 2018-2021, he led the Mahatma Gandhi Kashi Vidyapeeth, an Uttar Pradesh State University, as its Vice Chancellor. During his career, he has received several important recognitions such as the National Mineral Award, ISRMTT*

*Contribution to Rock Mechanics Award, ISCA Young Scientist Award and MGMI's Sukumar Rakshit Award. He has also published more than 300 papers and supervised over 30 PhD theses. As such, MGMI's readership can benefit from his rich insights in teaching, research and academic administration.*

***Tell us a bit about your career in academics and how you developed an interest in earth sciences?***

Earth is mother for all the inhabitants and its surrounding environment. The curiosity to understand various phenomena related to earth from origin to dynamic changes has always fascinated me from day one of my educational career. Secondarily, I am also eager to understand the abundant wealth given by earth for survival of all, how it happens and its distribution on a global level. The various activities going on the earth and its response mechanism is also mesmerizing to me all the time and it has all landed me to understand the earth's mechanisms. I remember, Author Homes "One can understand the rock mass, when one should sleep and dream over it". While that is exactly required, but we failed at many fronts and it resulted in disaster at various kinds and modes. One should understand that the earth does not belong to us but we belong to the earth. Mahatma Gandhi said "Earth provides enough to satisfy

every man's need but not greed". As such, earth science is a science for everyone who wishes for the good health of the earth as well as their own health. The volatile environmental issues, changing price and geo-political issue always focused on accurate and appropriate operation of excavation to ensure maximum resource recovery. Once the useful ores/minerals/rock are depleted, it may not be possible to revisit it for extraction. The cost and time do not permit us to do so. Prior to planning ground excavation, we have to think about digitalization through computerization to make the mining operation have higher optimum productivity.

***How has your career evolved as a professor to later, an academic administrator as the Vice Chancellor of MGKVP and now Director of IIT Patna?***

My journey as a student, then faculty, various administrative positions, later full-fledged academic and administrative heads of a University and now Director is based on a few key prin-

principles which are very operational guides to me throughout. You have to give time in all of your assignments and always fix timelines to complete the work and give 100% in achieving it. During my tenure as Vice-Chancellor, Gross Enrolment Ratio increased manifold, several processes were automated and academic calendar was properly followed. I have joined IIT Patna in Sept'21 with my entire academic and administrative learning working to make IIT Patna a full-fledged top ranking IIT.

*What are the challenges in developing a new IIT to its full potential?*

IIT Patna is going on its development stage. Our own campus is functional since 2015. It will take some time to have full strength and capacity. IITs have their own brand name but definitely there are new challenges and opportunities also. New challenges are to retain good faculty members, open new courses and attract the best ranked students. To recruit and retain them, we have to develop and provide various facilities like good atmosphere, academic, social and cultural as well as good schooling facilities for their kids.

We shall try to keep the campus green and work in a sustainable way to retain its identity. Already, we have taken care of wastewater treatment and reuse it for gardening. Thus, like other waste, we wish to have our campus follow zero waste disposal concept. Providing 24 X 7 library to students and faculty, computer centre, library to give them an opportunity to perform their best to keep IIT Patna page high. My role as Director is to facilitate and to have maximum utilization of their energy, betterment of institute with greater sense of responsibility of surrounding society also.

We wish not to grow alone but keep all other technical institutions of the state on the right path on their education system with the help of the state government and we are working in this direction. Let's go ahead with a positive mind set and resolve the issue which will come in the way of the journey to make this institute more to solve problems related to society than only academic in nature.

*Coming to the theme of this special issue, what role do you foresee in the intersection of geosciences and computation?*

Information cited decision is now one of the important tools to make the project self-sustainable, stable, safe and secure. Computational knowledge is crucial these days in all-round development particularly in the area of geosciences. The activities draw a diverse set of skills due to its complex process. Geoscience's development and its analysis is very critical and crucial for decision to go-ahead for exploration, exploitation or not of the minerals/metals which were earlier due to non-availability of technology not extractable, now have possibility to exploit with aid of technology and better analysis of data with advancement of computational method with safety.

New tools like soft computing, numerical methods, and empirical analysis have boosted Geoscientists to think to resolve the outstanding question in a different fashion than earlier traditional ways. Now, it is possible to make the first virtual show prior to going to actual ground conditions. Some areas of geoscience are very crucial in terms of its importance like safe disposal of nuclear waste/spent waste. As we know, even spent fuel has some kind of decay of energy which transfers heat to the surrounding. How they react with rock or other barriers? The thermal mechanical and hydro thermal behavior of rock should be studied here as the best way to go far with numerical simulation, rather than actual small model tests to save time. So, computational techniques have made many problem-solutions easy, accurate and authenticated.

*Can information technology help in improving the efficiency of mining operations for coal and non-coal resources? We would appreciate a few examples.*

Information technology is now a part and parcel of all walks of life and similarly it has improved productivity, reduced the loss of production, improved the economics and enhanced the

safety of man and machinery. The mining and mineral industries are aggressively using soft computing tools to optimize operational processes, accelerate the decision-making process, extract and derive values from data and improve safety. Computational methods have reduced the loss of productivity, many examples are there, computerized blast designs have reduced the quantity of explosive charges and subsequently provide better fragmentation and enhance the excavability too. Such results were reported by several researchers. Handling huge data sets of blast induced ground vibration, computation model provides, how to reduce the vibration and other associated ill effects. There is the possibility to predict various complex parameters, which are time consuming and costly, and can be predicted by simple parameters with greater accuracy and better confidence.

*How well would you say the Indian geoscience data is available to researchers, and what may be some paths forward?*

Geoscience data are available to researchers in the Geological Survey of India, Indian Institute of Remote Sensing, DST and many other sources which are very accomplished with geo-science data.

GSI is generating almost all baseline geo-science data e.g. geological, geochemical, geophysical and aero-geophysical which are of paramount importance for effective mineral exploration. GSI is taking a leading role in the process of setting up of the National Geo-science Data Repository (NGDR) for benefit of all stakeholders wherein all mineral exploration data of the country will be made available at one platform.

Recently, the Minister of Science and Technology, Government of India has said, "All geospatial data produced using public funds, except classified geospatial data collected by security/law enforcement agencies, have been made accessible for scientific, economic and developmental purposes to all Indian Entities and without any restrictions on

their use. Government agencies and others need to collaborate and work towards open linked geospatial data". He added that "stakeholders benefitted will include practically every segment of society, from industry to academia to government departments".

*Please talk about your own work fusing various soft-computing techniques with novel geology problems.*

Geology problems are never simple ones, they have various complexity and uncertainty. Very difficult to replicate geological phenomena in laboratory scale or down scale in true sense. Here, nature is a laboratory and one can try to resolve some of the outstanding problems which need proper studies. Understanding the rock mass response behavior is very crucial due to variation of material properties, stress environment, dynamic forces, in-situ stress etc. Earth scientists generate huge data like geo-mechanical, geo-chemical, geo-physical etc. Management of data sets are challenging tasks. Soft computing tools and techniques are more popular and have capacity and capability to resolve complex, tedious problems related to dynamic earth problems.

Our group tried to use these tools long back in 1999-2000 to predict peak particle velocity after blast induced ground vibration. How to increase the utilization of explosives? Earlier, it was an empirical base and other parameters were ignored in soft computing, we have used 12 parameters to predict peak particle velocity. Then, we have used it in various fields of geo-sciences to predict slopes and stability, underground excavation, spent fuel disposal, time dependent rock behavior etc.

At present, many researchers are using these tools because it allows them to learn or recognize the pattern from a pool of data set which can be either from instrumentation or histories also without being programmed. One can use either alone or hybrid mode of tool like artificial neural network (ANNs), Fuzzy Logic (FL) or Genetic Algorithms (GA), Multivariate Adaptive Regression

Splines (MARS), Support Vector Machine (SVM), Adaptive Neuro Fuzzy Inference System (ANFIS), Gene Expression Programming (GEP), Random Forest Method (RFM), Decision Tree (DT), Logistic Regression (LR) etc. It provides good accuracy, self-validation and error estimate. There is scope to introduce more complexities and difficulties for decision making within a shorter time.

*As the director of IIT Patna, what are some avenues you are leading to develop computational and software techniques at the undergraduate and postgraduate levels?*

At IIT Patna, we are emphasizing on each department to use computational and software techniques in their teaching and research. During COVID-19 time, we are adaptable to various new teaching methods. Apart from this we are also teaching practical courses through simulation to UG and PG students.

IIT Patna provides a wide variety of fields for students who want to work for their own start-ups. We have TIH funded by the Department of Science and Technology, Government of India. The innovation hub will emphasize speech, video, and text analytics. In IIT Patna, there are several notable research centres or research facilities including Incubation Centre on Electronic System Design and Manufacturing (ESDM) focusing incubations in the field of medical electronics, Technology Business Incubator focusing research in the field of manufacturing and agriculture, Centre for Earthquake Engineering Research, Pandit Madan Mohan Malviya National Mission on Teachers and Teaching (PMMMNTT) for Internet-of-Things, Sophisticated Analytical Instrumentation Facility (SAIF) Centre, Centre for Endangered Language Studies, Elsevier Centre of Excellence for Natural Language Processing, CDAC-IIT Patna Centre on Digital Forensic, IIT Patna Centre of Excellence on Women and Child Safety etc.

*We know that your group has been active with reservoir studies in CO<sub>2</sub> storage. What are some of the potential challenges and opportunities in pursuing geologic CO<sub>2</sub> storage in India?*

As you know climatic changes are dynamic in nature and main contributors are CO<sub>2</sub> or equivalent gases. India climatic conditions have a wide range due to varied topography and abrupt change in weather conditions. We have warm conditions and flooding and excessive rain. It is clear that the uniqueness in geological set up will strongly affect the climatic condition.

India is one of the developing countries and we are a coal-based energy providing country followed by others like hydro, nuclear, wind, solar, biomass etc. Roughly 75% share in production is from coal. It releases CO<sub>2</sub> in the atmosphere and increases its percentage. From 180 ppm during Holocene and Pleistocene to 280 ppm in the time of the interglacial periods. As the industrial revolution started, CO<sub>2</sub> concentration touched 400 ppm and continues to be increasing at a faster rate. Today we have 418.44 ppm and change reported in one year is about 3.54 ppm (0.85%). As per international pressure as well as keeping climatic detonation under control, our group initiated the research work to find the suitable safe and secure place for disposal of CO<sub>2</sub> or sink the CO<sub>2</sub> in geological reservoir like decoaled mine, oil and gas field as well as saline aquifers in foot hills of high mountain chains. There are challenges knowing all locations, suitable site selection is challenging but equally challenging work is to capture CO<sub>2</sub> from the atmosphere, separate it from other gases and associated material. The geo-mechanical, geo-chemical understanding of the particular site is very pertinent and important. There is a need to have proper scientific understanding about the site as well as trapping capacity and sealing mechanism must be ensured prior to thinking of CO<sub>2</sub> sink in coal mines. There is a need to understand the permeability and porosity of coal and its response be-

havior under higher confining pressure. In spite of the challenge, there is a huge possibility to identify the space for sinking of CO<sub>2</sub> without hampering the local and global problem at the site. We have published an edited book named Geological Carbon Sequestration, where we have discussed all possibilities, opportunities and challenges one should foresee while selecting the site for CO<sub>2</sub> sinks.

*What are some key pieces of advice you would give to earth science students reading this journal?*

The Mining, Geological and Metallurgical Institute of India is one of the oldest and was established way back in 1906. The Journal provides excellent information about recent advancement in mineral Industries scientific changes and other issues related to development. As technology moves fast at a faster place, this Journal provides quick updated information to all. I request

students of Geo-sciences, mineral engineering to follow this Journal to understand and appreciate the advancement in the area, news and views of eminent persons from the industries, academic and R&D organization. These kinds of journals always provide some new ideas, problems to resolve by scientists and academic people to resolve the problems faced by the industries from time to time.

The Seminar/Symposia conference/technology exchange program/technical meetings always give an opportunity to present research findings in front of experts and receive their comments are always ascents for new scientists and professionals.

I strongly believe that students should follow the journals and associated activities to upgrade and enhance their knowledge base.

## INVITATION

We request our senior members to write articles for a proposed MGMI Publication on Indian Mining History. Any members having old photographs, booklets etc. related to Indian Mining experiences of the past may kindly send to the MGMI office for digital archival.