Connect

WITH THE INDIAN INSTITUTE OF SCIENCE

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Nature Club
Into the woods

Reading rocks
The tales they tell

Pranay Lal
Unearthing India's past

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Editorial

The ground beneath our feet may seem stable and safe most of the time. But earthquakes and volcanoes remind us that Earth is a dynamic planet. In this issue of *CONNECT*, we throw the spotlight on planet Earth, and the clues that scientists are using to put together the puzzle of how it came to be. For instance, how rocks tell ancient tales to those who care to listen. And how earthquake scientists are attempting to understand the circumstances that led to massive subterranean upheavals in the past. Using this knowledge and modern computational technology, they are designing earthquake-resilient buildings. Other articles that are part of this theme reveal the important but often overlooked role of soil and its properties in civil engineering, the people who care deeply about its health, and its impacts on our lives. We also speak to biochemist and author Pranay Lal, best known for his path-breaking book on India's geological past – *Indica*.

As a fun experiment, we shadow a postdoctoral fellow to get a glimpse into his everyday routine. We bring you an interview with a retired Deputy Registrar who was simultaneously an international cricket umpire. Another story tells us how researchers at IISc are racing to develop technologies that can mitigate the effects of climate change, and reduce carbon emissions. Finally, a former student shares why they believe queer visibility and acceptance on campus is important, and members of the Nature Club take us on a walk into the woods.

Happy reading!

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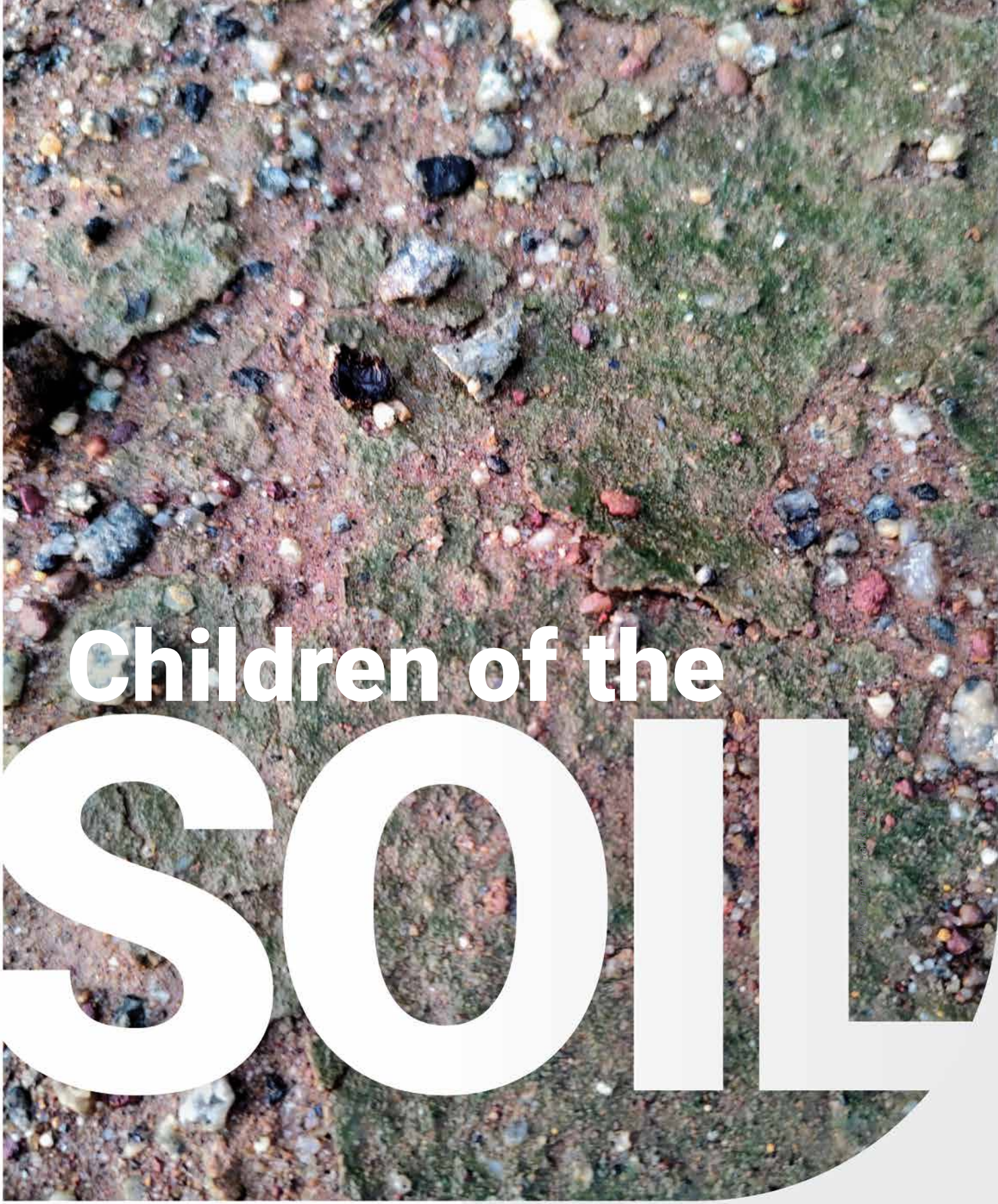


Photo: Narmada Khare

Children of the SOIL

- Narmada Khare

Biological soil crust along a path at IISc turns green after the rains

The soil under our feet is teeming with life, and understanding and nurturing it has a positive impact on our lives

A memory.

My friend and I followed the ball as it bounced towards the pit in the backyard. Heat wafted up, and the air was saturated with a warm, earthy smell that wasn't totally unpleasant. We had explicit instructions to not step into this pit, so we stood at the edge and mourned the ball that had fallen in.

"It's a compost pit," my friend explained. Theirs was a farming family, and the backyard housed some cows and chicken, and a lily pond. A gardener swept the yard every morning, and dumped the dry leaves and the dirt from the chicken coop into the pit. The kitchen waste and cow dung also went in there. "You can't see them," my friend continued, "but there are tiny creatures there that turn all that waste into soil." I was seven years old, and that was my first introduction to the creation of rich, nourishing, productive soil.

Over the years, I noticed other aspects of soil. The moist, spongy forest soil smelled the same as that pit did long ago, particularly after warm rains. The soil in Nagpur was black, and that in Bangalore was red. Silt from the Himalayas made the Ganga seem slate-grey in Rishikesh, and the Rann of Kutch was shiny white with salty, sandy soil. In short, soil wasn't just dirt. It had personality. I began to think of soil as a quilt that covered the Earth.

A leaf spread across the desert

Trent Northen, a scientist at the Lawrence Berkeley National Laboratory in the US, has a different way of looking at soil. He is more interested in the life thriving inside the 'biological soil crusts' that cover almost 70% of the desert landscape of the Colorado Plateau. These crusty sheets are teeming with microbes, living off the precious desert moisture trapped in the upper soil matrix. Many of them are species of *Cyanobacteria*, mistakenly called blue-green algae. In his 2013 *Science at the Theatre* talk, Northen says, "They are not plants. They are photosynthetic microbes. And they have productivity, as if you've spread a leaf across the whole desert!"

The dry and semi-dry lands across the world are covered with these living, breathing crusts. If you step off the beaten path, you are bound to tread upon them. They save the topsoil from being eroded by wind or rain. They trap nitrogen and carbon from the air, and make them available for other life-forms in the soil, including plants. And as for cyanobacteria, no book about the early days of our planet is complete without the humbling tale of how they made Earth's atmosphere 'breathable' for life.

The surface of the Earth has been the stage for an ongoing drama for some 4.5 billion years. The mellow planet we live on today, once raged under extreme temperatures, pressure, and humidity. The atmosphere of the young Earth had little to no free oxygen. It was all tied up as water (H_2O), carbon dioxide (CO_2) and other oxides. The single-celled cyanobacteria appeared on the scene about 3.5 billion years ago. They evolved a mechanism we now call photosynthesis, and began the production of carbohydrates – the chemicals that store energy – and oxygen. As their numbers increased, so did the proportion of free oxygen in the air.

Geoscientists believe that originally, the land was made of bare rock. Over time, with increase in oxygen, organic life began to thrive. Fossil records suggest that photosynthetic unicellular life paved the way for more complex algae and fungi, and later, larger flora with roots. Each generation died, decomposed, and filled the crevices of rocks to form a nutrient-rich bed of soil for the next.

Soil – a mixture of crushed rock, decaying organic matter and microbes – is an integral part of human life. Our history records civilisations that were lost because they were buried under volcanic ash, or because the land around them became infertile as the salinity in the soil increased. Our languages are replete with glorious imagery about soil: Ideas are said to 'take root in the fertile soils' of young minds, great leaders were often called 'sons of the soil', many of our once great cities are today just 'another layer on top of the soil', and finally, 'we go from ashes to ashes, and from dust to dust'. Most of us are aware of our connection to soil, but for some people, their lives are more deeply intertwined with it. P Srinivas, known to the farmers of Karnataka as "Soil Vasu", is one of those people.

Compost, cattle and microscopes

In 1984, when Vasu started working with farmers in Anekal, a town outside Bangalore, his goal was to educate them and document their culture. But as he spent more time with them, he began to notice certain things that made him aware of their hardships. "I used to be talking to them, and they would be laughing," he recalls. "But their eyes were not laughing." There was pain there that he did not understand then, he adds.

Working with the Institute for Cultural Research and Action (ICRA) in Bangalore, Vasu began to focus on agriculture. He educated himself about farming

through books and training sessions offered by the Institute. He had already noticed some obvious problems with the agricultural practices in the area. "Crops were failing, soil was eroding." Instead of replenishing the topsoil, "they were adding more chemicals," Vasu says. Soon, the more thoughtful among the farmers in Karnataka as well as other states began searching for alternatives to chemical-based farming, and Vasu invited several of them to talk to the farmers he worked with. He translated informative books from English to Kannada, filling a major knowledge gap. In simple, musical Kannada, he explained to the farmers how they could understand their soil better.

Photo courtesy: P Srinivas

Vasu teaches young farmers the art of reading soils

Vasu has designed and conducted intensive two-day-long demonstration and training sessions for farmers. He asks them to bring the soil from their fields, and shows them ways to assess its quality. Based on the proportion of sand, silt, clay and organic matter, the farmer can then choose the appropriate crop to plant.

Together with Prabhakar Buddappa, whom he describes as his guru and 'geleya' (friend, in Kannada), Vasu tries to explain the importance of soil biodiversity to the farmers. He explains that Prabhakar is a traditional farmer from Thondahalli village in Kolar district, Karnataka, and understands the hurdles in talking to the farmers about microorganisms. While they have seen the results of composting, few are aware that it is the process of decomposition of organic matter by microbes, and that the majority of microbes come from soil and dung of farm animals. How can one explain soil life when most of it cannot be seen by the eye? Although Vasu carries magnifying glasses with him on his training sessions, he acutely feels the need for equipment like microscopes.

"I want every farmer to have compost, cattle, and a microscope," he muses. "See, when a farmer starts looking at his own soil, his own water, then he asks, 'what is there in this soil? Last time, I applied this [chemical fertiliser]; has the soil life improved? Is there diversity of microbes? Oooh, it is not there!' Then he works on his soil. When he realises that chemicals are killing soil life, then he stops using them and starts using organic material. A kind of enthusiasm develops."

Vasu's enthusiasm is infectious. This is how he explains how one can 'read' one's land: "After the first rain, before ploughing, spread 20-30 types of sowing seeds (mixing them well before spreading) and then plough. After 30-40 days, they germinate and develop as tender plants. Observe which plants have come up well. Make a list of the best 10-15 crops. The soil is telling us that it can grow these plants better. This is considered as understanding the language of the soil. After making the list, now plough over all the saplings and bury them back in the soil. This improves its structure."

How can one explain soil life when most of it cannot be seen by the eye?

Vasu's efforts draw attention to the fact that farmers' concerns are a socio-scientific challenge. Educating them, making information available, convincing them to refrain from using chemicals and helping them through the transition to organic farming, is just one part of the solution. Several organisations like ICRA and people like Vasu are making inroads there. But the other aspect is that of understanding the biological issues related to soil, such as contamination from pathogenic microbes, the depletion of protective-chemical-producing fungi due to some reduced nutrients, and so on. These may not be obvious to the farmers, and so, are harder to address. That is where scientists like those at IISc step in.

In the early years of IISc, a lot of biochemical research was geared toward solving practical problems faced in farming. Analysing essential elements like nitrogen and carbon in soil, making them available to the crop by using bacteria that fixed them, treating sewage to make it amenable to microbes and unicellular organisms, and then using it as fertiliser, are just some of the many examples of projects that have been described in the IISc Annual Reports from the first five decades of the Institute. Later, with the advent of molecular biology, the focus of the researchers moved to more fundamental problems in biology.

One of the scientists whose interests still lie in soil and its relationship to agriculture is Dipshikha Chakravortty, Professor at the Department of Microbiology and Cell Biology.

Photo courtesy: P Srinivas

Prabhakar (second from left) and Vasu (third from left) stand in a model farm planted with a variety of seeds

A consortium of bacteria, fungi and viruses

Dipshikha has worked with *Salmonella*, a pathogenic bacterium, for many years. In 2014, when Kapudeep Karmakar, a student with a Master's degree in agriculture, joined her lab for a PhD, her interests turned to the impact of this microbe on farming. A paper had appeared in the Morbidity and Mortality Weekly Report (MMWR), published by the US Centres for Disease Control and Prevention. It discussed an outbreak of *Salmonella*, which had infected people via fruits and vegetables sourced from farms. The cause for the outbreak was thought to be 'post-harvest,' meaning the infection had originated from the handlers, rather than from the crop itself. Many California tomato farms had to shut down, and in other parts of the world, the chocolate industry was in trouble.

"We did not believe that such a massive outbreak could be caused by post-harvest handling," remembers Dipshikha. "Kapudeep came from Asansol in West Bengal, and knew that belt is quite heavy on *Salmonella* in the soil." They suspected that in California too soil contamination must be the real culprit.

But even if the soil were contaminated with *Salmonella,* the bacteria could not enter and infect a plant unless there was a breach in the plant tissue. After careful experimentation on the plant model *Arabidopsis*, as well as tomato plants, the researchers found that such a breach develops when the primary root sends out lateral roots. A natural wound develops in the plant tissue at this site, and *Salmonella* enter and infect the plant through it.

Dipshikha points out that microbes like *Salmonella* face enormous competition for survival. "Soil is a consortium of many billions of bacteria, fungi and viruses." She explains that many of these cannot even be cultured in a lab. This biodiversity in the soil keeps harmful bacteria in check. "*Salmonella* may even be killed by some soil bacteria. Kapudeep recently showed that *Lysinibacillus* is a bacterium in the soil that can kill *Salmonella* – like a biocontrol."

Dipshikha's team is also developing a sensor for farmers to detect even small concentrations of *Salmonella* in their soil. "It [the sensor] must be cheap and [work] rapidly – like a chip that will give a reading quickly, so that the farmer can prepare to control the outbreak."

And what can be done after the soil is contaminated? Dipshikha has several suggestions, starting from barricading the area completely.

"You cannot use that piece of land till some biocontrol comes." There can be human intervention, but Dipshikha believes that there are bound to be other soil microbiota that could outcompete *Salmonella*. She also suggests using beetroot as a 'trapper'. The beetroot plant secretes the pigment 'betalain' into the surrounding soil, and *Salmonella* are susceptible to it. She suggests planting beetroot around tomato plants as a co-culture. "The size of the beetroot is very small, because it gets infected with *Salmonella* and [at the same time] goes on producing [more and more] betalain. So, you cannot harvest the beetroot, but your tomatoes will be hale and hearty," she laughs.

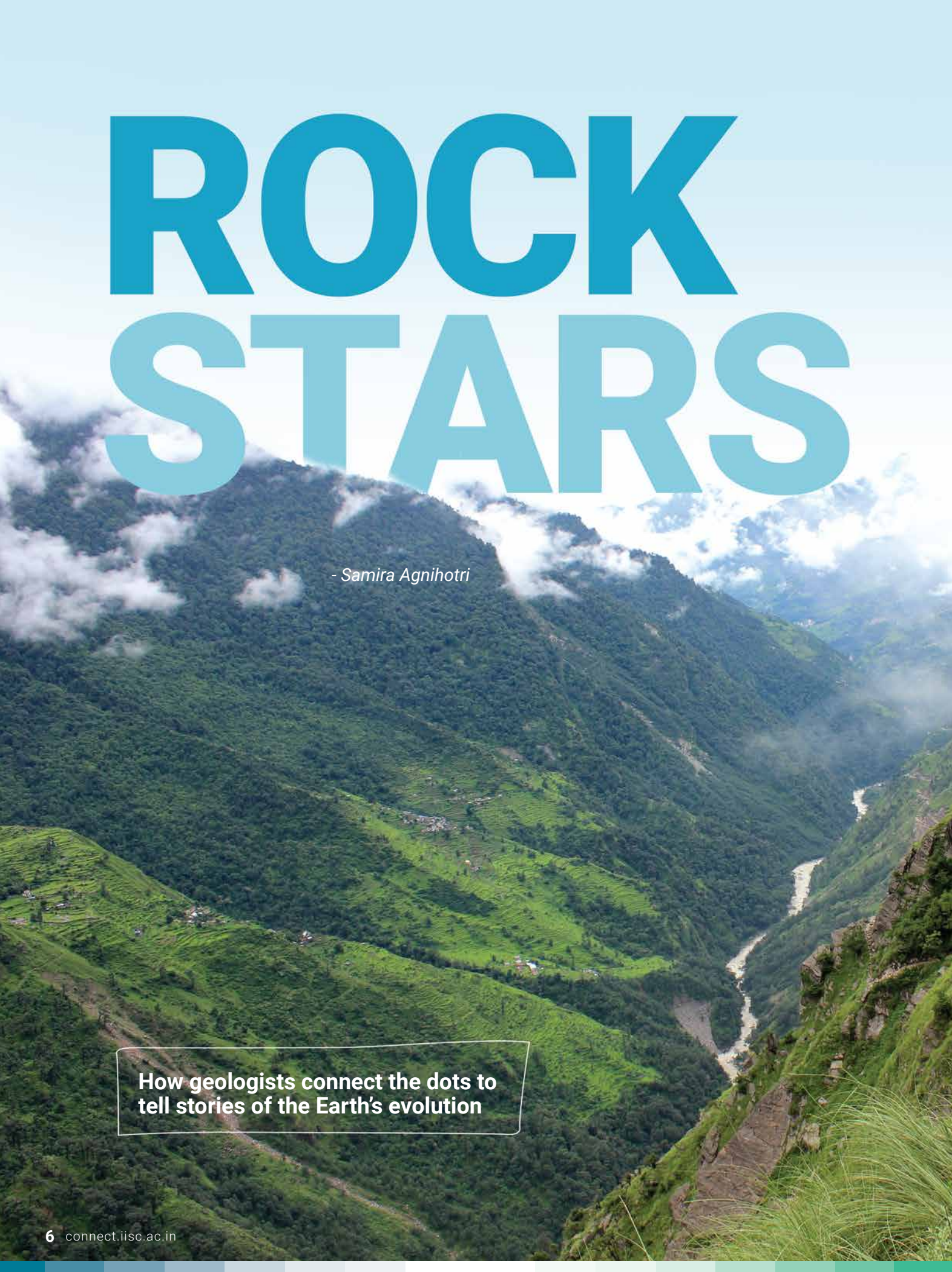
Photo courtesy: Kapudeep Karmakar

Dipshikha and Kapudeep observe microbial colonies in the lab

People like Dipshikha and Vasu may be looking at the same problem from different angles but they are united by a common purpose – understanding soil health and its impact on our lives. In a country that is among the largest crop producing nations in the world, there are several children of the soil, toiling away, above and below ground, whose lives are both shaping and being shaped by soil. Vasu says, "Know soil, know life." Or does he mean, "No soil, no life?"

ROCK STARS

- Samira Agnihotri



How geologists connect the dots to tell stories of the Earth's evolution

Photo courtesy: Prakash Arya

It was a clear but cold July evening in the Kumaon Himalayas in Uttarakhand. Prakash Chandra Arya and his younger brother, Vikas, were on day one of their 15-day trek from a village called Munsiyari to the Milam glacier, more than 4000 m above sea level. They had crossed the village of Babaldhar, through dense forests of oak and pine, and were hoping to reach the next village by dusk. The sun had set, but they could not see any sign of habitation up ahead. They continued to walk in the dark until 1 am, hoping to reach the next village, but to no avail. They had to take a break, and get some rest. On the narrow path overlooking a steep valley, they couldn't even pitch a tent. So, they opened the two umbrellas they had for shelter, and built a small fire to keep the wild animals at bay. They somehow made it through the night, and continued on their journey. By the third day, the terrain was rougher and they had to cross a collapsed bridge. Even though the brothers were born and brought up in these hills, and were trained mountaineers, Prakash felt like giving up. How could he face his parents if something happened to Vikas? His brother reassured him, saying, "Let us walk for one more day, and if we feel that it's too tough, we will come back."

Prakash, a PhD student with Sajeev Krishnan in the Petrology lab at the Centre for Earth Sciences (CEaS), IISc, was looking for two specific types of rocks (petrology is the study of rocks). These rocks are no ordinary pieces of stone – they contain critical clues to events that occurred 40 to 50 million years ago, when the Indian landmass collided with Asia. Sedimentary rocks found in the Himalayas contain evidence of the first life forms on Earth, which existed in oceans of the past approximately 600 million years ago, before the collision occurred. And metamorphic rocks contain information about the extreme temperature and pressure changes that the tallest mountain chain on Earth has undergone since its birth. "We study such processes [that happened] in the past to understand the present dynamics of the planet. We can then extrapolate to the future," says Prakash. "Imagine a book in which each page is a year in the Earth's evolution, and somehow all pages of this book are scattered all over the world. Suppose you find page number 10, which has a volcanic eruption; then page 15, that records the emergence of complex life forms on Earth, and then you find page 18, when a meteorite hit. This is what we do — we are trying to put together these pages to understand how the planet Earth, and life on it, has evolved."

The steep and narrow path to Milam glacier

Photo courtesy: Prakash Arya

Prakash Arya collecting samples at the snout of the Milam

Rocks tell tales

The science of rocks and minerals has fascinated researchers at IISc since the time of CV Raman, who studied them in the 1940s and 50s for their refractive properties. He published many papers delving into the mechanisms that make them shine and glimmer. Raman spent a great deal of time studying the geography and geology of the Krishna Valley to learn more about diamonds and their occurrence, according to a memoir written by former IISc Director S Bhagavantam. In the late 1970s, GV Anantha Iyer and his group from the Department of Inorganic and Physical Chemistry conducted research on the geochemical properties of ancient rocks from south Karnataka. AG Menon, who later became the Chair of CEaS, was also a part of this group. Since its inception in 2007, faculty members at CEaS have been carrying on the baton. The Petrology group at CEaS works on textural and chemical signatures of rocks and minerals from various parts of the world, and in the process has built one of the largest collections of rare rock and mineral samples in the country, says Sajeev.

Prakash is insistent on clearing up a common misconception about geology – it is not just the study of rocks or minerals. "It is that too, but it is much more. We study time. Earth was formed 4.5 billion years back, and some of the processes [that started then] are still going on," he says.

The evidence for these processes is preserved in very old rocks only in a few places around the world, says Sreehari Lakshmanan, Assistant Professor at Shimane University, Japan, and a former project assistant in the Petrology lab. Karnataka is one of these key regions. It contains the Dharwar Craton, formed between 3.6 and 2.5 billion years ago. A craton is a very stable part of Earth which has remained undisturbed for millenia. "We are born and brought up above these ancient rocks, but very few people know that. Even IISc has a few fragments of some special rocks – very old granite that is 2.5 billion years old," he says.

Photo: KG Haridasan, sample from Sajeev Krishnan's collection

Iridescence in labradorite, a calcium-enriched mineral rock. CV Raman discovered the mechanism that produces this effect (called labrodorescence) in 1950

"We need multiple pieces of evidence to understand the evolution of Earth through time," says Ishwar Kumar Cukkemane, currently Assistant Professor at IIT Kanpur and an alumnus of the Petrology research group. He uses satellite imagery to identify lineaments – deformations in the Earth's crust and upper mantle, which can be detected as faults and folds in the terrain.

One such piece of evidence is minerals like chromite that are resistant to the effects of high temperature and pressure. This makes chromite an excellent candidate to study how rocks have formed under extreme conditions in nature. Veni Sudarsan, a final year PhD student who is currently at the Institut de Physique du Globe de Paris, has studied this mineral extensively. "I have samples from almost all over the world. I am looking at their chemical characteristics and how they have changed over geological time, from 4,000 million years ago to a 100 million years ago," she says. Veni is developing a new technique to enable a deeper study of the structural characteristics of chromite.

Thamam Mubarish, who is the Petrology lab manager and has an MSc in Applied Geology, is interested in rock textures. For his Master's project, he studied the texture and mineral compositions of two rock samples, one from South India and one from Antarctica, and found that they were very similar to each other. "That's because they were once together, part of the same landmass, millions of years ago. Textures tell stories. You can sit here in India with a rock from around here, and it can tell you a story about a rock from Antarctica," he says.

"You can sit here in India with a rock from around here, and it can tell you a story about a rock from Antarctica"

In all geological studies, selecting the right location for sample collection is crucial, Thamam points out. Once such a location is identified, their team visits the site to collect rock samples and take on-the-ground measurements. "It's a bit like Indiana Jones – going on a treasure hunt. You follow the map looking for a particular rock type. When you reach [the destination], there may not even be a road there. Or most of the rock has been lost to quarrying for construction. But you have to look at the landscape around you, and figure out a way to find the rocks." Then they bring the samples to the lab and carry out tests to trace the samples' origins.

Geological studies are not only helping scientists piece together Earth's history, they also have practical applications, such as the detection of mineral ores, and assessing whether such a site is suitable for mining or not. "Everything we use in our daily lives is made from minerals, and in that aspect, geology has played a very important role. But we also need geology to help us extract these minerals in a sustainable manner, and understand when to stop," says Sajeev.

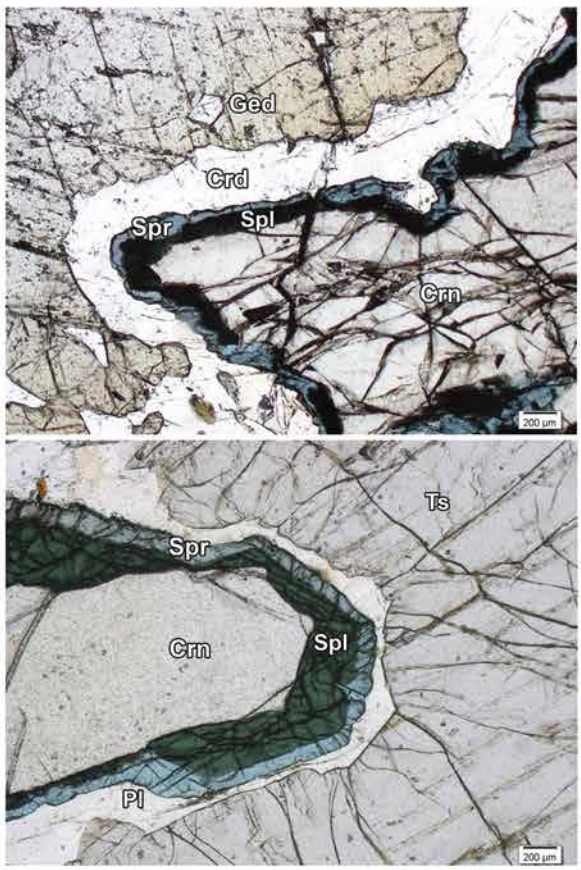


Image courtesy: Thamam Mubarish

Photomicrograph of a rock sample from south India (top) and a sample from Antarctica (bottom), showing structural similarities

Labour of love

Though field trips can be fun, and something that many geologists look forward to, there is also a lot of labour involved. Rock samples collected from such trips must be labelled and stored systematically, so that they can be easily retrieved when needed. "When I joined, we did not have a proper space to keep our rock samples. They were all placed in tall stacks of crates. It was a big problem – I spent most of my time searching for specific samples," admits Athira PG, a project assistant who has been with the Petrology lab since 2014. Thamam then introduced a field collection protocol, specifying guidelines for the maximum weight of samples, and listing the meta-data required for cataloguing, and so on.

Photo courtesy: Sajeev Krishnan

Sreehari thinking about rock structures in 3D after observing them on a 2D plane at a field site in Namakkal, Tamil Nadu

In the lab, for each rock sample, the researchers prepare a thin section – a slice that is about 30 microns thick – and then stick it onto a glass slide to look at it under a microscope. The textural architecture of this thin section provides information about several processes when viewed under a polarising or electron microscope.

Athira remembers an incident that happened a few years ago when they had temporarily set up their thin section lab in a corner of another faculty member's lab. The process involves using a grinder and cutter, and the rock cutting machine needs to be cleaned thoroughly with water after each use to remove the mud, rock chips, and powder that is generated. The space they were working in didn't have the proper drainage required for it. "One day, when another team member and I were working in this corner, Prof Rudra Pratap, who was the Deputy Director at that time, came to visit that lab. I didn't know who he was. He asked us what we were doing, and we told him. 'You are working in IISc, you deserve a better work space,' he said to us," Athira recalls.

A few months later, in 2019, Sajeev was informed that the empty building that had once housed the Nisarga restaurant close to the D gate had been allocated to them to set up an interim lab until they were permanently moved to a new building. "I still remember that when the Deputy Director came to hand over the key, he recognised me and he said, 'You all are rock stars – you need a good space to work,'" Athira says. She remembers how enthused they all were. "Everybody in the lab stopped all their other work, and came together to set it up."

A museum for the masses

In 2020, the group had to move out of the Nisarga building, but they are now hoping to move soon into the newly constructed Earth Sciences building. And their aspiration is not just to have a larger lab or storage space for their samples, but to go one step further and create a space that can help them tell their stories to others.

The goal, Sajeev explains, is to set up a museum-cum-exhibition which will house the huge collection of rock samples from all over the world that they have collected. Thamam elaborates that each rock sample displayed in this space would also be accompanied by information on the rock type, the exact location where it was collected, the minerals in it, and eventually an image of the thin section. They also plan to have a QR code in the display that links to publications that came from each sample, and a map showing the distribution of the rock type in other parts of the world. "These are the only pieces of evidence left of that. I am very much in awe of this idea – that we can take a symbolic walk around Antarctica and come back, just through this rock display. You don't have to [actually] go there, you can see it from here, in IISc. In that sense, we are all connected, right?" he adds.

Such a museum has the potential to become much more than just an archive. For instance, if a student from a state university in Kashmir or Kerala wants a rock sample from southern India, Nagaland or Greenland for their research, they don't need to go all the way there. They can simply submit a request to the archive facility at IISc, Ishwar explains. "All universities and institutes have their own museums. The number of samples might vary, but they have such archives. In IIT Kanpur, for example, we have a sedimentary core archive. Such a repository is also very useful for teaching." The small museum that was recently inaugurated at the CSIR-National Geophysical Research Institute in Hyderabad is another example.

"We use public funds to study these rocks, but the public doesn't know much about their importance. That is where I think museums or exhibitions are very important. Outreach is very important," says Sreehari. When he went to Japan for his higher studies, he was impressed by the geological parks there. "In general, it's a very different scenario [there]. For instance, a farmer is very aware of the land that they stand on." He adds that even though these parks are very small, they attract a lot of people. There are interactive boards and animations to explain the importance of these places to visitors. Funds generated from tickets are used to employ trained staff. "India can also do this – we have the resources, the manpower and the technologies," he says. Thamam agrees. "Other countries have done this very successfully and they are very proud of it. We should be proud [of our collections] too."

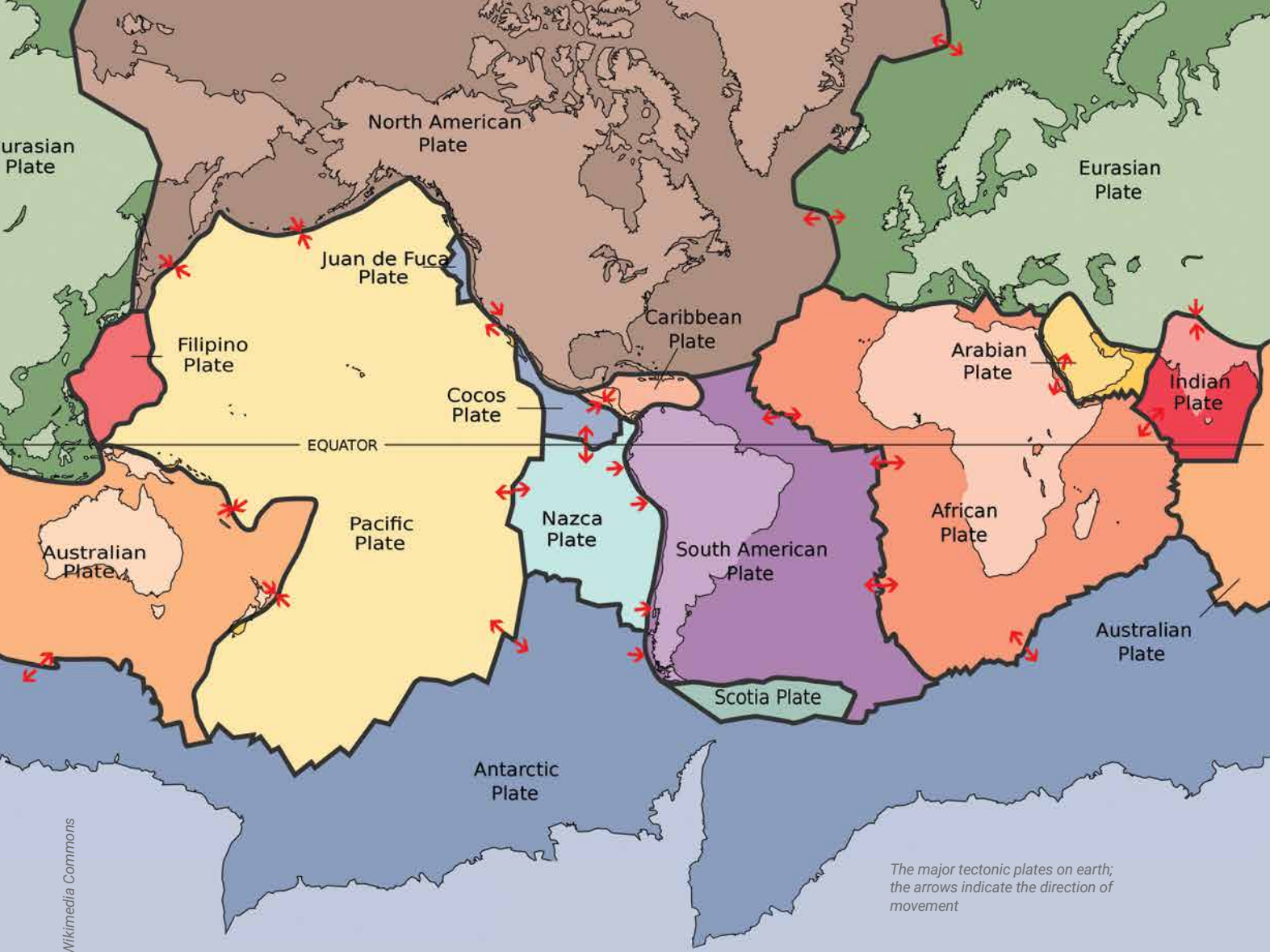
"We are born and brought up above these ancient rocks, but very few people know that"

Sajeev says that he has been privileged to collect samples from all over the world because he is part of a large and generous international scientific community. "We have rocks ranging from 10 years of age to those that are 4.2 million years old." And he wants to pay it forward, by making these samples available for other researchers in India, as well as school and college students. "They should be in a place where people can come and see them," he adds.

Photo: KG Haridasan; from Sajeev Krishnan's collection

The oldest dated zircon on earth (~4.375 billion years old) is from this sample from Jack Hills, Australia Conglomerate

Sajeev points out geology as a subject that has a low profile in the country because it is not taught in schools. Prakash concurs. "We know more about our universe than about what is inside our Earth." His trek in the Himalayas turned out to be more than worth the effort. The rock samples he collected have revealed ancient secrets which he believes could add a new page to their magnum opus – the complete history of the formation of the Earth.



The major tectonic plates on earth; the arrows indicate the direction of movement

Image courtesy: Scott Nash/Wikimedia Commons

When Continents Collide

- Mohammed Asheruddin

Seismologists have their work cut out when it comes to understanding and predicting earthquakes and their impact

Beneath the serene snow-capped mountains of the Himalayas, danger lurks. Scientists are increasingly worried about a big earthquake overdue in the Himalayan region, anticipated to have a magnitude greater than 8.0 on the Richter scale. To give some context, the 2015 earthquake in Nepal had a magnitude of 7.8, resulting in 9,000 deaths, 22,000 injured, and the flattening of large parts of Kathmandu city. One can only imagine the scale of damage that the predicted Himalayan quake would inflict.

"Himalayas is an active plate boundary where the two plates (Indian plate and Eurasian plate) are converging at about 20 millimetres per year," says Kusala Rajendran, former Professor at the Centre for Earth Sciences (CEaS), IISc. She explains that the rocks in these areas are weak and under stress due to this collision of plates, which is why earthquakes are common in this region. But what are these plates?

The Earth's lithosphere (the crust and the upper mantle) is brittle and broken into massive, irregularly shaped interlocking slabs known as tectonic plates. Attreyee Ghosh, Associate Professor at CEaS, explains that the Earth can be imagined as a chocolate with a hard outer crust and an interior filled with gooey matter. Now, if a fine knife cuts the crust without taking the pieces apart (still intact as a sphere), the resulting pieces of the hard shell are representative of tectonic plates.

Although we can't see it in action, the land below us is in constant motion and has rifts and drifts. When two plates come close to each other, the interactions between their boundaries can create high mountains or deep trenches and, more often than not, earthquakes. The Himalayan plate boundary is active because of the way it was formed. "The Indian plate was in the southern hemisphere, close to Antarctica. Suddenly, it just broke away and accelerated northwards to the current position north of the equator," says Attreyee. This rapid northward motion and its collision with the Eurasian plate, around 40-50 million years ago, formed the Himalayas. While this might be common knowledge, the reasons for the plate's fast movement are not well understood. Attreyee believes that the acceleration of the Indian plate could be attributed to the Reunion plume – an active volcanic hotspot in the southern Indian Ocean, which is thought to be responsible for the eruption of the Deccan Traps, one of the largest volcanic structures on Earth. Plumes are massive eruptions of hot, low-density material from the mantle, and the Reunion plume is believed to have been active for over 65 million years, last erupting in December 2020.

Attreyee and her team employ physics as a tool for time-dependent mathematical modelling – they consider the Earth's configuration millions of years ago and simulate specific conditions leading to its current state. They modelled the Indian plate close to Antarctica, in the state that it was millions of years ago, and simulated its interaction with the Reunion plume. "The plume was able to remove the base of the Indian plate, possibly contributing to the anomalously low thickness [of the plate]; the reduced thickness and thereby the reduced mass of the plate potentially aided in the Indian plate's sudden acceleration," says Attreyee.

Earthquakes are also observed in stable regions away from plate boundaries, like in Latur in 1993 and Bhuj in 2001. Kusala explains that tectonic activity millions of years ago has left some residual stresses even in such stable landmasses, and old faults get reactivated, leading to earthquakes. "When seismic waves from a plate boundary translate through the plate interiors, the waves simply dissipate, but in regions with a fault, these waves can amplify and trigger earthquakes. Somewhat like rubbing on old and healed wounds, yet subject to pain if activated," she says.

> ***"Earthquakes originate several kilometres (ten to hundreds) below the surface, and it is hard to make direct measurements of the factors that cause them"***

While earthquakes in active zones like the Himalayas are common, those in stable regions are very infrequent. Estimates are uncertain, but they typically occur once in hundreds or thousands of years. There has been no significant earthquake in Latur prior to 1993 and none after that (as far as experts know). Kusala remarks that the extended time gap between these events in such regions leads to a false sense of security among people. With no prior experience of earthquakes, buildings are not designed to withstand them, leading to disproportionate damage.

A question that is frequently posed to Kusala is about the unpredictability of earthquakes. "In predicting the weather, for example, all the constituent elements – humidity, temperature, cloud cover, wind speed – are measurable, yet the weather can only be fairly predicted. But earthquakes originate several kilometres (ten to hundreds) below the surface, and it is hard to make direct measurements of the factors that cause them,"

says Kusala. So, what is the best way to deal with the situation? With the information currently on hand, scientists are able to map the faults, identify their potential, predict the maximum magnitude expected, the extent of ground shaking and even suggest a time window. "However, we still cannot fix a date," explains Kusala.

Photo courtesy: Kusala Rajendran

Kusala and her team investigating a landslide in Kerala

Better safe than sorry

Given the unpredictability of earthquakes, the only option is to be prepared for them. Structures like nuclear power plants can be constructed far from known earthquake faults. But bridges, dams and hospitals are needed everywhere. Understanding the nature of earthquakes and designing structures to withstand them is essential, says Swetha Veeraraghavan, Assistant Professor in the Department of Civil Engineering at IISc.

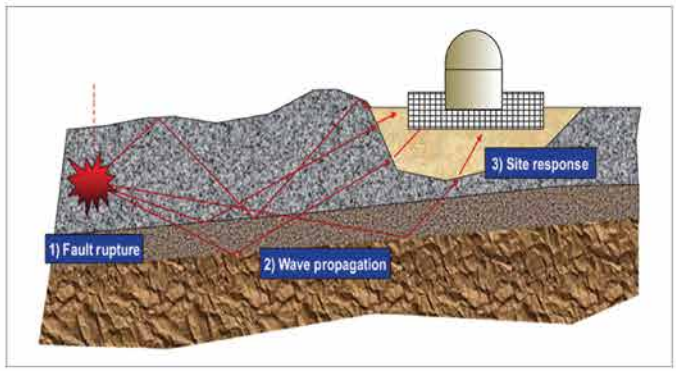
Swetha, along with her collaborators, had previously developed an open-source simulation tool to determine the response of a structure to an earthquake of a specific intensity. The output of the simulation – potential stresses and strains in the building – can be used as parameters in designing the columns and beams. Swetha's team at IISc is now augmenting the tool with additional features. She adds that other than making changes in the design, the influence of earthquakes can also be reduced by using isolators – dampeners made of rubber and lead – at the base of the structures to dissipate the waves.

"We work on the seismic safety of structures like underground tunnels and dams, and on metamaterials development," says Swetha. She explains that a metamaterial is a composite fabrication in which different materials are placed in a periodic fashion to give it the ability to weaken the impact of an earthquake. When placed around a structure, these metamaterials shield it from the seismic waves.

The design of an earthquake-resistant dam is challenging as there is a combination of water and soil – "a two-phase system," remarks Swetha. The water causes the dampening of earthquake waves in some cases, but beyond a certain threshold, the earthquake can potentially reduce the strength of the construction material leading to massive destruction.

Currently, only a few parameters like soil properties at varying depths are taken into account for designing civil structures. But for efficient seismic design, other factors also have to be taken into account. India is divided into four seismic zones and each zone is assigned a specific earthquake intensity. "And all structures are designed based on the zone-specific earthquake intensity without considering the proximity of the earthquake fault to the structure and the complexity of the wavefield incident on the structure," remarks Arun M George, a PhD student in Swetha's group. Unlike these traditional approaches, he designs dams after considering their shape, the soil type (which varies with the location), and a range of such site- and structure-specific parameters that would make these structures more efficient in withstanding earthquakes.

Image courtesy: Swetha Veeraraghavan

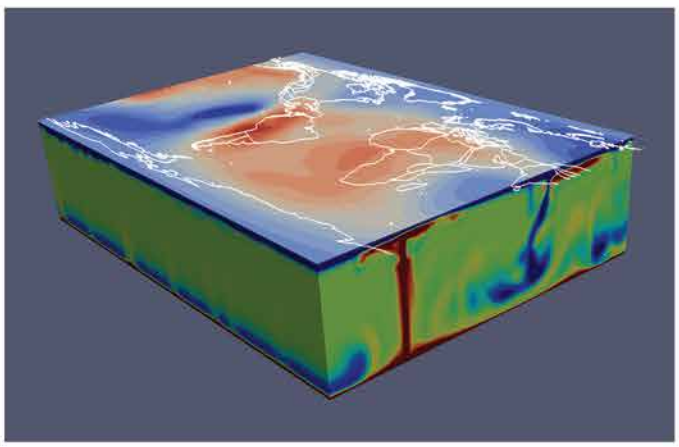


Schematic of earthquake fault rupture and wave propagation from the fault to the structure through multiple soil/rock layers

Seismology – the study of earthquakes and the movement of related waves through the Earth – is not always about death and destruction. Swapnil Macche, a project associate who works with Kusala and her collaborators, applies machine learning techniques to analyse data from geophysical explorations to locate oil or gas fields. These explorations involve setting up artificial micro-explosions to induce controlled earthquakes at a source point. These explosions trigger pressure waves, and the readings of these waves are taken at different locations in the site of interest. A variation in pressure waves indicates a change in the composition of the bedrock and also points to the presence of oil or gas fields. "In the available approaches, only 30% of the explorations result in identifying an oil or gas field; that's a lot of money wasted," says Swapnil. Swapnil's research focuses on using algorithms to obtain sharper signals to identify the oil and gas fields.

Is our Earth in shape?

Image courtesy: Attreyee Ghosh



3D cross section of the Earth showing cold, dense material (blue) sinking in the Earth's mantle, and hot buoyant material (red) rising from the surface of the core. The red areas on the surface represent where sea level is pushed up while the blue areas represent where it is pulled down

While Swapnil explores the domain of oil and gas fields within the earth, Debanjan Pal, a PhD student in Attreyee's research group, focuses on the Earth's overall shape."If we see the shape of any planet, it is ellipsoidal (egg-shaped), but through satellite images, geologists have observed the Earth to be potato-shaped," he says. Irregularities in the Earth's shape are referred to as geoid anomalies.

If the Earth were made of just one material, gravity would pull the surface uniformly, resulting in a perfect ellipsoid. But, when our planet started to cool after its formation, the heavier material sank to the core and the lighter material moved up towards the surface. In addition, other processes within the earth, like thermal convection (transfer of heat due to movement of liquid matter), stirred up the constituents resulting in a very non-uniform distribution of mass. Since the effect of gravity is directly related to the mass of an object, this uneven distribution led to the irregular shape of the Earth, explains Debanjan.

Debanjan's work focuses on the genesis of the Indian Ocean geoid low, a 106-metre depression in the seabed and the lowest gravity or geoid anomaly on Earth. He employs numerical techniques to compute the Earth's mass distribution over time – starting from 140 million years ago. One of his preliminary findings is that the African superplume caused a mass deficit within the mantle, indirectly bringing about the observed low gravitational anomaly in the Indian Ocean.

Breaking down the science of quakes

One of the critical challenges researchers face in studying the Earth and earthquakes is limited data availability. Physical measurements hundreds of kilometres below the surface are unfeasible and obtaining data to train Swapnil's machine learning tool or validate Debanjan's theory is difficult.

In addition, the study of earthquakes, Kusala believes, is complete only with observations in the field. "Speaking to the local people, exploring the area, and digging up the history provides valuable insights into earthquakes beyond the data recorded by instruments," she says. She recollects post-earthquake surveys in Chamoli, Uttarakhand, in 1999, after an earthquake of magnitude 6.3 hit. At the Gopinath temple at Gopeswar, where the earthquake had created minor cracks, the priest pointed to damage from a massive 1803 event in the Garhwal Himalayas. And the evidence? Recycled bricks with misaligned and inverted inscriptions in Devanagari. Here was proof that a larger earthquake can level the structures. "Historical data helps to frame the window, or the time elapsed since the last earthquake," she explains.

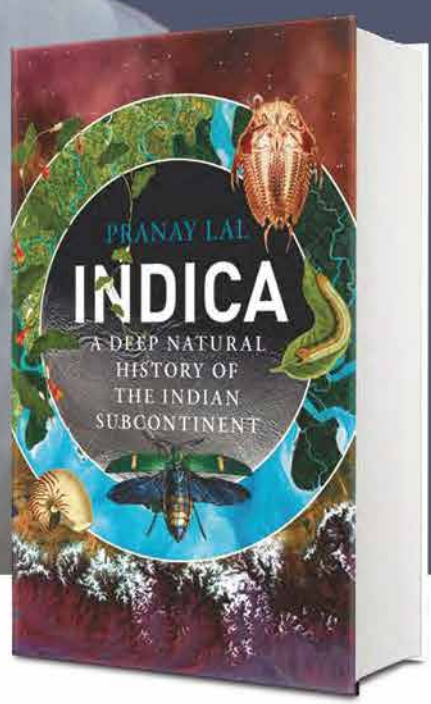
Due to her vast experience in seismology, students, young researchers and science journalists often flock to Kusala to get clarifications about various aspects of earthquakes. She is now co-authoring a popular science book on earthquakes with CP Rajendran, an adjunct professor at the National Institute of Advanced Studies. The book's narrative is packed with anecdotes from her years of fieldwork, she says. "Our [Kusala and C P Rajendran] USP has always been trying to relate what you see today to what could have happened in the past."

Mohammed Asheruddin is a PhD student at the Centre for Sustainable Technologies, and a science writing intern at the Office of Communications

Terra Indica

Decoding Pranay Lal's books

Photo courtesy: Pranay Lal



- Devayani Khare

In November 2016, biochemist and author Pranay Lal's ground-breaking book Indica: A Deep Natural History of the Indian Subcontinent *was published. It was a first-of-its-kind, definitive book on natural history and geoheritage celebrating everything from fossils to fish, volcanoes to viruses, in a quest to understand the processes that shaped Earth and the life on it. The book tries to answer some key questions: What do we know about the age of the planet? How were continents formed? What constitutes life and how did it evolve to give rise to such baffling diversity? How was India's landscape shaped and sculpted? What strange creatures have roamed across it over time?*

Geoscience writer-blogger Devayani Khare interviews Pranay Lal about the inspiration behind the book, its journey since publication, and other natural history writings he has in the pipeline

Why did you choose to write this book on India's geological heritage?

Living in Mumbai, I was curious about how the western slopes of the Western Ghats received most of the precipitation, yet more rivers cut across the peninsula [east] to drain into the Bay of Bengal. We were taught that rivers would make their way to the nearest coast to discharge themselves [in this case, the Arabian Sea], yet rivers like the Tungabhadra, Kaveri, and Krishna, seemed to defy that. Why? I thought about what made Chhatrapati Shivaji, despite his short reign, among India's most prolific fort builders. As I grew up, those questions remained with me. I was surprised to learn how a billion years of natural history was interconnected, and how deep time held so many answers.

Indica is a culmination of that quest, and draws from over 20 years of research, interviews, travel, conversations, and a continued awe of nature.

Why was it important to write *Indica*?

An online search yields numerous hits for natural history books on England or the British Isles, California, the Americas and even Peru. Yet it was a crying shame that despite its size and geodiversity, there weren't enough books on India. *Indica* retraces the evolution of the landscapes and creatures, across different geographies through time, to tell a four billion-year-old (and counting) story of the Indian subcontinent.

Is there a reason you decided not to include the standard geological scale along with the analogy of the Earth Woman?

[Note: the Earth Woman analogy reimagines the 4.6 billion-year-old Earth as a 46 year-old woman, and retraces the evolution of the planet over her lifespan.]

For most people, timelines beyond a hundred years are very confusing. Thousand, ten thousand, or a hundred thousand years, don't make much of a difference. Imagining timescales of a million or a billion years is far more bewildering and astronomical.

When the manuscript was circulated among friends, some suggested that I use a simpler analogy to explain deep time. My friend Pradip Krishen (author of *Trees of Delhi*) introduced me to the Earth Woman analogy by astrophysicist Nigel Calder.

Pradip was also the inspiration behind the book. I wasn't sure I had a book in me, but I kept showing him short writings I'd done on the Deccan plateau or the Aravalli mountain range, and he encouraged me to piece it all together. That's how *Indica* was born, and he gave me the idea to abandon the million- and billion-year timescales and incorporate the Earth Woman analogy instead.

Photo: Ankita_GSD/Pixabay

Prabalgad fort in the Raigad district of Maharashtra, with a rich history from before and after the days of Chhatrapati Shivaji, can be seen along the Mumbai-Pune expressway

In an interview with *The Hindu* a few years ago, you'd mentioned that *Indica*'s journey is not over yet and that it will be a living document. Could you kindly elaborate on this?

Of the material I had gathered, only 30-40% found its way into *Indica*. I had to cut down on so much, with a heavy heart. If I ever publish an anniversary edition, I hope to include more photos, illustrations, writings, and news reports from 2016 onwards, for a comprehensive, updated version. I wouldn't want the next edition to be the same, so I'm compiling notes on what more we've learned, what new creatures we've discovered, and hope to include fresh pieces of evidence.

Moreover, *Indica* explored just one of the many ways in which one can tell stories about a landscape. So much can be written about India from several different perspectives of time or geography – from north to south, or east to west. One can even write about creatures from different geological periods. Like the kid's book by DN Wadia *saheb* which starts with a rock talking to a child, there are several ways in which you can tell the story of Earth, or retrace the history of a landscape. I hope other people take up the challenge of writing different natural histories of India, and tell their tales in other ways. In that sense, I hope *Indica* can be a living document, or a legacy that inspires researchers, writers, and storytellers to adopt new voices, metres and perspectives to shed new light on the way we look at landscapes, and weave different narratives around them.

I hear you have two books on natural history in the pipeline: *Malabarica* and *Cretaceous*, apart from another on viruses that was just published. Could you tell me a little more about each?

The deep history of the Indian subcontinent, as explored in *Indica*, was pieced together with the help of fossils, among other evidence. But what if we couldn't rely on fossil evidence? Could we still retrace the history of Earth, and of India? After Indica, I wanted to challenge myself, to tell distinct natural history stories from different geographies. I hope *Malabarica* will be one such book. *Malabarica* will focus on the Malabar region, which has a conspicuous lack of fossils, yet I'd like to tell you why this landscape is different from the rest of the country. Travel restrictions over the past few years have made it difficult to gather material for *Malabarica*, but the book is nearly complete and I hope to publish it soon.

Beyond *Malabarica*, I also dream of writing other books on the ancient geological provinces of India – the Himalayas, the Indo-Gangetic plains, the Deccan, and even the Gondwana region which comprises ancient cratons like Bundelkhand and Singhbhum, among other landscapes.

Cretaceous, on the other hand, is an illustrated children's book that will focus on life along the Narmada river between 145 and 66 million years ago. Most children's books, I find, are either over-the-top or oversimplified. *Cretaceous*, illustrated with the help of a paleo-artist, will feature authentic reconstructions of dinosaurs in their natural setting, detailing their routines from dawn to dusk. Imagine a Rajasaurus waiting in ambush in the undergrowth. Or a Stegosaurus walking under a sky full of ancient flying, screeching reptiles. This book is also almost ready; we are stuck with just a few illustrations.

In 2021, *Invisible Empire: The Natural History of Viruses* was released – a contrarian view on how viruses form the backbone of all life. In the wake of the pandemic, this book offers interesting insights into how not all viruses are bad. It explores the invisible, enigmatic world of viruses that have sustained and enriched not just all life forms on Earth, but also human bodies and human civilizations, across time.

Highlighting India's geoheritage means championing its conservation. Have you heard of any marked conservation efforts since the publication of Indica?

Since the publication of *Indica*, I believe the wonderful Dudhinala site near Ranchi, mentioned in chapter two of the book, has now been protected. For a long time, round boulders were being extracted at Dudhinala. These boulders were formed 255 million years ago, just before the Permian period, and bear testimony to the last glacial event in India. Similarly, other such sites have been notified by different agencies like government officials, district collectors or forest officials.

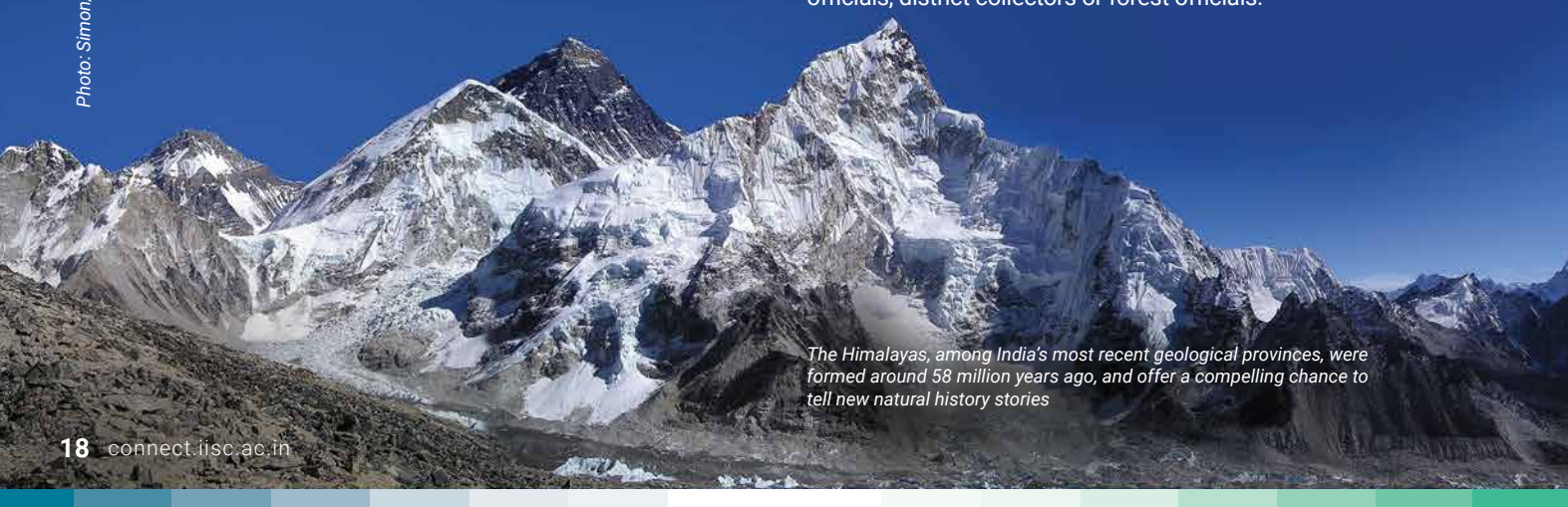


Photo: Simon/Pixabay

The Himalayas, among India's most recent geological provinces, were formed around 58 million years ago, and offer a compelling chance to tell new natural history stories

Photo: Pranay Lal, originally printed in Indica

Rocks and boulders embedded between alternating sedimentary rock layers in Dudhinala, providing some of the best evidence of the last glacial event

There has been increased interest and visits from nature groups and college students. For example, a couple of colleges were inspired enough to set up small museums to tell the story of where their campus is located, or the region around it. You don't have to have a grand museum. You just need to respect the land on which we stand to tell the story of how it is worth preserving too. All land masses, at some point in time, would have witnessed creatures that roamed across them, and were part of a grand history, even if the evidence for it, like fossils, is no longer present. I've heard of 20 or 30 such local-level initiatives.

There has also been interest from people to learn more about fossils. A few geological collections have been opened up to the general public, and there's been pressure for better signages, outreach and science communication efforts at some sites.

At a national level, the book sparked off a conversation between Prof K VijayRaghavan, former Principal Scientific Adviser, and Sanjay Kumar, a distinguished science writer. Not solely inspired by *Indica*, but also by Sanjay's article for *The Science*, on India's paleontological legacy (and how we are squandering it), this conversation led to the idea of *The Indian Museum of Earth (TIME)* – a repository for some of India's vast natural history collections. The title was given by Nigel Hughes, a paleobiologist and Indophile, specialising in trilobites. Sadly, the idea hasn't taken off and nothing more came from that conversation [For now, TIME stands still].

Yet, the fact that such conversations are happening is exciting in itself. The idea that museums are coming up, geological collections are being improved upon, and signages are being changed are all signs of how educational institutions can become nodes of scientific communication, communicate better with local communities, and foster a grander appreciation of natural history and geoheritage. This is the crucial role that small and big institutions can play. For instance, why don't institutions like the IITs with grand foyers recreate small stories rather than just showcase fossils?

As an author, drawing public attention to natural history and geoheritage might lead to unwelcome attention too, such as commercial interests or vandalism. Awareness is one part of the equation, but it carries a responsibility with it. Does the possibility of exploitation or vandalism weigh heavy when considering what to include and exclude in a book?

Lamentably, our natural history sites are more threatened by neglect than over-attention – sometimes, by the scientific community itself. This is evident from the fact that there is no single [national] repository for natural history, which means that after retirement, geologists and palaeontologists are forced to throw away their collections. I have joked about how the best places to find fossils and rocks are not necessarily fossil sites but the areas at the back of geology departments.

Neglect happens at many levels; fossils do not even feature in India's legislation. The lack of notification by the Archaeological Survey of India (ASI) – especially, of pre-Indus sites such as megaliths or petroglyphs – is a serious issue. The same could be said of the Geological Survey of India (GSI); sites like Dudhinala in Ranchi, or the Dhala crater in Madhya Pradesh have not been notified or protected. This has resulted in the decrepitude of many significant sites across India.

While writing the book, I relied on the advice of many geologists and other scientists: they seemed to have little fear of reckless action from readers or citizens. If anything, increased public attention has led to some on-the-ground action and pressure on authorities.

In some countries, gem-hunting is promoted as geotourism. For instance, in Sri Lanka, one can go looking for coloured stones at Ratnapura, yet India offers no such activities. All things considered, [I feel that] the information in *Indica*, rather than inviting commercial interests or vandalism, may inspire natural history-focused initiatives across India.

Devayani Khare is a communications consultant specialising in environmental advocacy and fundamental sciences, with a keen interest in geoscience. She publishes the free monthly newsletter, Geosophy, focused on geoscience topics across India, and writes summaries on geoscience research publications for the Geobites blog

Soil sleuths

- Ranjini Raghunath

Geotechnical engineers, who investigate soils and their properties, play an important and sometimes overlooked role in civil engineering

Mohit Jadav, an MTech student in the Department of Civil Engineering, investigating a slope failure due to rainfall in Chikkamagaluru district

A vacation on a Spanish beach in the 1960s sparked a revolution in the construction industry.

French engineer Henri Vidal was piling up sand to build a sand castle when he realised that no matter how hard he tried, he could not make the angle of the mound steeper than its natural incline. This is because sand, like all soils, has poor tensile strength – it comes apart easily as the individual particles don't cling tightly to each other. But when he stuck pine needles into the sand, he found that the friction between the needles and sand helped stabilise it and allowed him to make steeper mounds. Excited by this discovery, he went on to develop a construction technique and later a multi-billion-dollar company called "Reinforced Earth" that changed the way many modern structures are built.

The idea was simple: If you alternate layers of soil with strips made of materials like steel, you could make the layers strong enough to build walls, bridges, even dams. Since the 1980s, engineers have switched from steel to polymers called geosynthetics that are more lightweight, cost-effective and corrosion-free. Today, thousands of structures are being constructed with such polymer-blended soils using the reinforced earth technique.

"Even the engineers building the new airport terminal in Bangalore are using this technique for expanding the access roads," says G Madhavi Latha, Professor in the Department of Civil Engineering at IISc. "If you see most of the abutments of bridges or flyovers these days, from the outside, they all look like [they are made of] concrete, but inside it is all soil."

Photo: Vibha S

Madhavi's lab studies reinforcement techniques using a variety of sophisticated instruments. With a universal tensile testing machine, they are able to stretch geotextiles – fabrics made from polymers – to test their tensile strength, the maximum load they can support when stretched. A 3D printer helps them print not only geosynthetics but also sand particles in desired shapes, sizes and textures using polymers. One of her PhD students, Rizwan Khan, is using video cameras set up in the lab to track how the interfaces between different soil layers, and between soil and geosynthetic layers, behave as they rub against each other. Madhavi is particularly proud of the digital microscope she has set up that helps her students peer at the tiniest of grains in a soil sample. Such digital imaging-based explorations, she says, have brought a lot of "freshness" and innovation to the more traditional field of civil engineering.

"When you say civil engineering, people think of huge structures like dams or buildings," points out Raghuveer Rao Pallepati, Principal Research Scientist at the Department of Civil Engineering. "All these structures have to rest on the ground. How good the ground is to support the structures is assessed by geotechnical engineers."

Geotechnical engineers like Madhavi and Raghuveer are fascinated by how various soils behave under different conditions. Soils are classified into different types – clay, silt, sand or gravel – depending on the fraction of the different-sized particles that they contain. With concrete now being recognised as the most destructive material on the planet, soil is rapidly making a comeback as a construction material. Soils with clay-sized particles are also being explored as liner materials to stop leaching from landfills and hazardous waste pits. Crucially, soil is at the heart of many natural and climate-change induced disasters – its collapse can bring buildings to the ground and lead to landslides and flooding.

"Superstructures like concrete buildings are [made of] manufactured materials. We know their properties and we can control them," says Raghuveer. "But the ground is naturally formed with different-sized particles, mineral content and conditions. We have no control over that."

On solid ground

If you take a spoonful of sand and sugar side-by-side, you might think that the individual particles are of the same size. This is true for sugar, but not sand, explains Raghuveer. Soils are an uneven mix of particles of different shapes and sizes. The texture and colour of the soil varies depending on the type of material that weathered over millions of years to give rise to it. A soil patch in the IISc campus is usually red in colour because of minerals rich in iron, whereas the cotton-growing soils found in North Karnataka's Gulbarga and Bidar districts are pitch black due to the presence of iron and aluminium as well as the soil's ability to retain a lot of water.

This variability is a major reason why soils "cannot be taken for granted," says Sudhakar Rao, former Professor in the Department of Civil Engineering. If you dig up the soil at a specific spot, and then dig at another site just 100 metres away, there is no guarantee that the composition will be the same, he explains.

Another important feature of soils is how much water they can retain, called the level of saturation, which determines their ability to support structures built on top of them, like buildings or walls.

"Imagine you have constructed a structure when the soil was unsaturated [devoid of water]," says Raghuveer. When it rains and the ground water level rises, filling the air pockets between the soil particles, the weight exerted by the structure on the ground will initially be taken up by the water, which forms an interconnected matrix inside the soil. Later, when the water dries up, the weight gets transferred to the soil particles, which causes them to deform, and makes the building "settle", developing cracks or sagging floors. "In the lab, we can estimate and extrapolate how much will be the settling for a building over time, before construction begins," he explains.

Photo: Prince Kumar

Kalore Shubham Arun, a PhD student in Sivakumar Babu's lab, studies geocomposites that can reinforce pavements

Some expansive soils, like the black cotton soil, swell when they are in contact with water during the rainy season, and shrink during the summer as the water evaporates from the ground surface, adds Raghuveer. "If you construct buildings at a shallow depth in North Karnataka, most of them will get cracks. To prevent that, you have to rest the foundation at a depth where the moisture changes are minimal."

Soil stability is especially critical when it comes to earthquakes. When tremors travel through the ground, the shockwaves loosen and separate the soil particles,

making the soil flow, almost like a liquid – a process aptly called liquefaction. Two of Madhavi's students, Balaji Lakkimsetti and Prerana Krishnaraj, are currently creating earthquake-like conditions in the lab using cyclic simple shear and shaking table experiments, and trying to understand how soils liquefy and how they can be strengthened to withstand various degrees of shaking.

With advances in technology in recent years, even the weakest of soils can be reinforced before constructing any structure. "If you look at the Burj Khalifa, people never thought about the fact that it is so close to the sea, that marine soils have a lot of problems," says Madhavi. "Because there are solutions which can make soils take any amount of load."

One of those solutions is using geosynthetics, like the polymers in the reinforced earth technique. Geogrids, for example, are rectangular mesh-like structures that can strengthen the aggregates used for roads and pavements, and reduce the thickness of the layers paved. For a 100 km-long road, reducing the height by one-fourth of a metre can save a few thousand tonnes of natural soil, Madhavi explains. A large cyclic triaxial setup in her lab – the only one of that size in the country – helps her study the strength of these reinforced aggregates under simulated vehicular loads.

Such geosynthetics can also be made from recycled materials. Kalore Shubham Arun, a PhD student in the lab of Sivakumar Babu, Professor in the Department of Civil Engineering, is using geocomposites produced from crude oil waste to design improved pavements that can help drain water faster, and prevent water logging and potholes. "Not much research has gone into this area for Indian conditions," he says, adding that results from such studies can contribute to road and highway management policies.

With land space becoming scarce in cities like Bangalore, such reinforcement techniques are only gaining momentum.

"Earlier, if you found a piece of land that was not conducive to construction, you could ignore it. Land was available in plenty. Now, it is no longer that situation," says Sudhakar.

Sudhakar, who has studied soils for decades, also laments the loss of many traditional practices that involved using soil for construction. Centuries ago, villagers in North Karnataka used to mix the black cotton soil with grass, hay and cow dung and let it age for decades to build strong walls for their houses. "We went to those sites, brought these samples to the lab and examined them to figure out how the villagers did it. We got some interesting results," he says. But the practice has long since been abandoned, and none of the local people the team spoke to was able to remember what their ancestors used to do. "Unfortunately, with the advent of easy construction technologies, people forget about these things."

Photos: Indra Prasad Acharya and Sudhakar M Rao

Fly ash (left), a by-product of coal-fired power stations, can be converted to geopolymer sand (right) to use in construction

Leaks and landfills

In the late 1990s, a few years before Sudhakar started working on the black cotton soils, many countries were waking up to the looming problem of disposing nuclear waste safely. For highly radioactive waste, the plan was to bury them deep into the bedrock (more than 1-2 km below the surface) in canisters made of steel or a similar strong material. But what if this steel cracks, and radioactive waste begins leaching into the ground, making its way to the groundwater? The answer lay in a type of clay that you might find in your acne face mask – bentonite. Bentonite is nearly impervious to water and has excellent self-healing – it can absorb liquids that may leak, and swell, plugging any holes or punctures. It can also remain stable for millions of years. Bentonite blocks surrounding the steel canisters can therefore provide a rugged and long-lasting barrier.

"We had a project with the Board of Research in Nuclear Sciences to identify the type of bentonite that could be used for a high-level waste repository," recalls Sudhakar. "We scouted around the country, identified a type of bentonite in a place called Barmer in Rajasthan, brought the soil to the lab and did a lot of tests to evaluate its usefulness as a waste containment material. The lab was very successful in identifying, characterising, and comparing it with bentonites in other countries."

While such repositories are still way off into the future, a more immediate challenge is staunching leaks in urban landfills. Anjali Pillai, a PhD student in Madhavi's lab, is trying to figure out how a combination of a material called geosynthetic clay liner (GCL) – which contains bentonite at its core – and M-sand – artificial sand made from crushed rocks like granite – can be used to line landfill slopes. "Sand mining is illegal now, and causes a lot of environmental problems. Instead of sand, we can lay this material as the bottom-most layer to line landfills," she says. Anjali is particularly interested in understanding how efficiently the M-sand particles interact with GCL. This 'interfacial strength' is

important because many landfill failures have been linked to poor interactions between the various layers that line its slopes. “Once you prepare [the landfill], there is no going back, because its lifespan can be 30-50 years,” she says.

Some geotechnical engineers are not only interested in building such landfills but also in managing the waste inside them. “Solid waste ultimately degrades into a soil-like material … that’s the reason why we apply the same principles of soil behaviour to it,” explains Sivakumar Babu. Several of his students are working on various aspects of landfill management. “We have 300 acres of dumpsites in Bangalore … there are significant problems like leachate, methane emissions, and water contamination. We have to solve these problems as well.”

Photo: KG Haridasan

Anjali Pillai, a PhD student in Madhavi Latha’s lab, using an optical microscope to study the interaction between geosynthetic clay liner and M-sand particles

“If you visit any landfill in Bangalore, you rarely find any that have a proper lining system. Most of them are not engineered,” says Prince Kumar, one of his PhD students who is working on models to estimate the amount of toxic gas generated from landfills, and design effective gas extraction systems. Another student, Anusree N, is focusing on ways to enhance the breakdown of materials in landfills by using natural enzymes. “Waste management is an area in which people are usually hesitant to work,” she says. “At the same time, this is also one of the most burning issues.”

Saving soil

The image of a burning Bellandur lake is something that Bangaloreans have become uncomfortably familiar with in recent years.

But it is not the only area in the city where both water and soil are being polluted by effluents from industries. Soil pollution, a serious issue in many urban areas, is also something that people like Sivakumar Babu are working on. Two of his students, Kalyani Kulkarni and Prathima Basavaraju, have been collecting soil samples from the Bellandur lake area and Peenya industrial district to determine the levels of pollutants like chromium, nickel, cadmium and zinc, and come up with ways to reduce them. “Chromium contamination is one of the more serious problems as it is carcinogenic,” says Sivakumar Babu.

“When these heavy metals are in the soil, they enter the crops and then the food chain,” explains Kalyani. The goal, therefore, is to convert the metals into forms that are less available to plants, either using compounds that bind to and stabilise them, or precipitate them out of the contaminated soil. Some nanoparticles they are testing in the lab, for example, can convert the more toxic form of chromium (hexavalent) into a less toxic form (trivalent). “Soil chemistry is quite complex. Every metal reacts differently to the same remediation method,” Kalyani says.

Sivakumar Babu’s lab is also interested in landslides, a recurring disaster in several parts of Karnataka which receive heavy rainfall. The reason why civic authorities are unable to effectively prevent and manage landslides is due to a lack of understanding of soil behaviour, he says. His lab has been exploring the use of various geosynthetics like geotextiles and geogrids, which can hold the topsoil in place and reduce the impact of landslides.

“We can also use sensors to track and predict what could be the soil movement during landslides, and forewarn people,” Sivakumar Babu says. “[But] at the same time, the response from government agencies is not very effective. They say, ‘Let the problem come, we will solve it later.’”

Raghuveer echoes this sentiment. Most of the government or private contractors he consults for call him only for “forensic” analyses, to try and figure out what went wrong after a building or structure has collapsed. He highlights the example of a major research facility that was recently built by a governmental agency, which began developing water leakage in the basement due to lapses in soil investigations and design of the foundation. Many “settled” buildings across Karnataka and slope failures due to rainfall – such as one that his PhD student Vibha S and MTech student Mohit Jadav are currently investigating in Chikkamagaluru district – could have been avoided by proper site investigation, analysis and design, he says.

“Unfortunately, people pay a lot of attention to the elevation of the building. They will pay the architect a lot of money and ask them to make it look nice, but they will not be willing to pay a geotechnical engineer to do the site investigation. But once it goes out of control, they will come to us,” he says, with a chuckle.

“Our accomplishments are not visible outside, but they are very important,” Raghuveer says. “Everyone says you need a strong foundation. That strong foundation is built by geotechnical engineers.”

Photo: KG Haridasan

Sudip working on equations on his laptop and with pen and paper simultaneously

A Day in the Life of a Postdoctoral Researcher

- Bitasta Das

CONNECT *shadowed Sudip Ghosh, a CV Raman postdoctoral fellow at the Centre for High Energy Physics*

It is a pleasant bright morning, unlike the last few days that were rainy. Sudip enters the Indian Institute of Science campus through the D gate. It is just a 10-minute walk from his apartment. Today, he is brimming with excitement as he is looking forward to sharing his recent progress with his supervisor, Aninda Sinha, a Professor at the Centre for High Energy Physics (CHEP). Sudip is a CV Raman postdoctoral fellow at the Centre. Once at the CHEP building, he leaves his belongings in his cubicle on the second floor and goes to meet Aninda.

Aninda has recently made interesting connections between 'scattering amplitude', which is the primary topic of study in Sudip's research work, and an area of mathematics known as 'knot theory'. He discusses this with Sudip. Sudip, on the other hand, is glad to describe the solution to the problem that he had been struggling with for a long time. After several extensive discussions with his postdoctoral colleague, Prasanth Raman, he has finally solved the problem that had obstructed his progress. It was only yesterday that they had found this appropriate method to resolve the problem. Today definitely looks like a promising day.

Back in his office, Sudip switches on his laptop and works on some equations. He does his calculations with a pen and paper, in the old-fashioned way. A large part of the work of a theoretical physicist like himself involves complex mathematical problems. Every now and then, when the calculations get tough to solve, he uses a software programme called 'Mathematica'. Today, he is working on the paper that he is writing with Aninda and Prasanth.

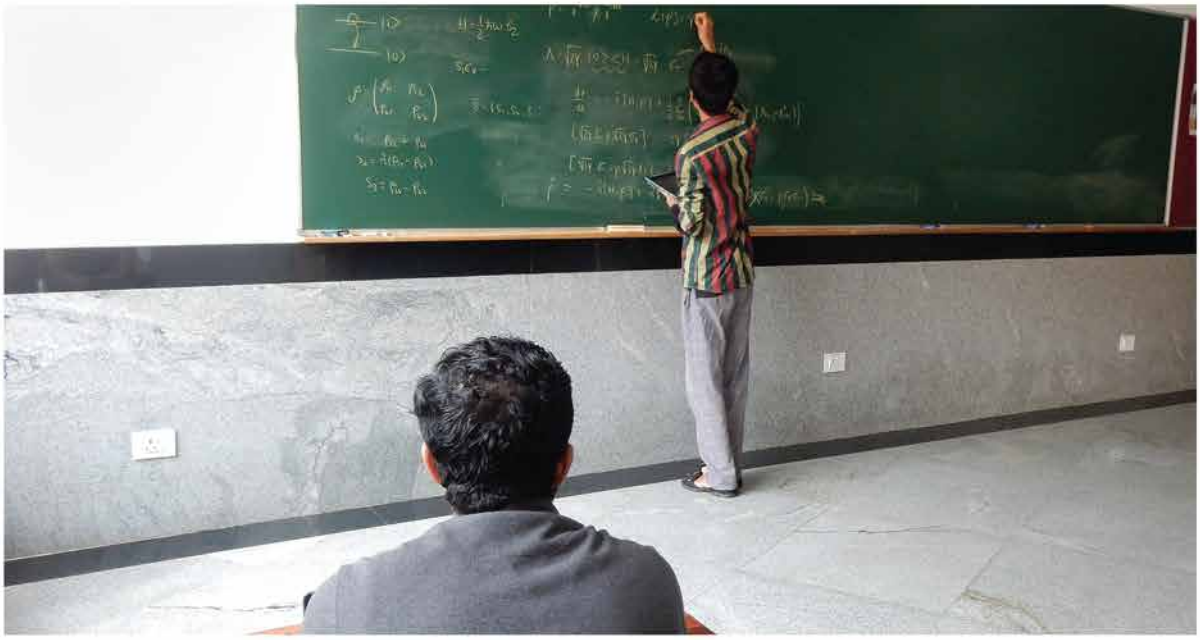


Photo: Bitasta Das

Discussion space at the Centre for High Energy Physics

Most often, postdoctoral fellows work independently, with only a little guidance from their supervisors. He refers to a paper on arXiv.org, a repository site where research scholars upload their unpublished papers. Sites such as this help researchers exchange ideas. In the past, Sudip has uploaded 14 of his papers to this site. He is currently referring to a paper on "Applications of Alpha Space" by Daniel Rutter and Balt C van Rees. He wants to understand how the authors approached a particular mathematical function. He says, "It helps me understand the properties of the function, and think about possible methods to break down the function to use for my own calculations."

Sudip joined IISc in October 2021. Before that, he was a postdoctoral fellow in Okinawa, Japan for three years. He completed his PhD from the International Centre for Theoretical Sciences (ICTS) in Bangalore in 2018; therefore, IISc is not new to him. He had, in fact, used the JRD Tata Memorial Library at IISc extensively during his PhD, since the ICTS library was still being set up at that time.

When he was in Japan, Sudip learnt to cook. He enjoyed cooking biryani there. In Bangalore, however, he misses cooking, as now he lives with his mother, and she takes care of it entirely. He misses the view of the East China Sea from his balcony in Japan the most. "The unobstructed view of the never-ending sea was out of the world," he says.

It is lunch time now. Sudip and Prasanth walk towards the balcony seating area of the CHEP building where they usually have lunch. But today the balcony is being cleaned, so they walk down to the Physics canteen. One table in this canteen is already occupied by a large group of students who are with their supervisor. Their vibrant discussions are interspersed with laughter. Sudip and Prashanth occupy a table nearby and eat their home-cooked meals. Among other topics, they ponder over the skewed gender distribution in the departments of physics and mathematics. There are only a handful of women in these departments. Their conversations, unintentionally, always end up becoming discussions related to their work.

At IISc, the postdoctoral researchers are asked to mentor the first year PhD students. Sudip is mentoring an integrated PhD student named Shubhashis Mallik. As a part of this assignment, he is required to guide the student in his final project at the end of the coursework. Sudip enjoys his interactions with Shubhashis and meets with him twice a week.

In Sudip's view, the pressures of academia are more like a healthy competition. He sets deadlines for himself. There are researchers in other countries who are working in the same broad area that he is. It is the drive to reach that goal ahead of others that motivates him. By the end of the year, Sudip will start applying for faculty positions. He also feels a sense of urgency to find a job soon. He would like to apply for teaching positions in India and abroad.

In his free time, Sudip enjoys watching English and Indian regional language films. He finds it relaxing. He prefers watching them in the theatre. Reading science fiction is another of his favourite pastimes, and Jules Verne is the author he loves best. He does not own a television, as neither he nor his parents enjoy watching it. They prefer the content available on YouTube.

Sudip wanted to become a scientist since his school days, but understandably, did not know then which field to choose. According to him, the advantage of being a theoretical physicist is that s/he can work uninterrupted from anywhere, so long as there is a

Photo: Bitasta Das

Vibrant conversations during the group discussion with the supervisor

good internet connection. The pandemic, which affected all walks of life, had practically no impact on Sudip's work. He worked from home, and when the lockdown was over, he started coming to the campus. He prefers working from the campus though, since the internet at home is inconsistent, particularly these days when there are frequent power cuts because of the rain.

Today is Friday, and a group discussion is scheduled at the Centre in the evening. Seminars, conferences and group discussions are important components of postdoctoral life. As researchers work on original problems in the field, such occasions give them a chance to reflect upon and review their work and receive feedback from their peers. Lecture hall 3 is soon filled with the PhD and postdoctoral students of Aninda Sinha.

Aninda is scheduled to speak first, followed by a PhD student, Parthiv. Aninda begins his discussion on 'scattering and knots'. He uses the blackboard to elaborate on his ideas with equations and diagrams. Sudip's point on knots and polynomials is appreciated by Aninda. As the discussion becomes intense, Parthiv offers to forgo his turn, and urges Aninda to continue. The discussion ends on a light note as Aninda urges the students to Google scholars in the field before going to bed, instead of cricketers' statistics.

It is now dusk, and time to leave for home. Sudip and Prasanth walk out of the campus together, talking about the group discussion on the way. Each carries an umbrella, a notebook, a tiffin box and a laptop. Sudip would enjoy a cup of coffee after reaching home, rest for a while, and then continue to work on his equations. Today has been another day of interesting conversations and discovery in the life of a theoretical physicist.

Photo: Bitasta Das

Sudip and Prashanth leaving for home after an engaging day of research

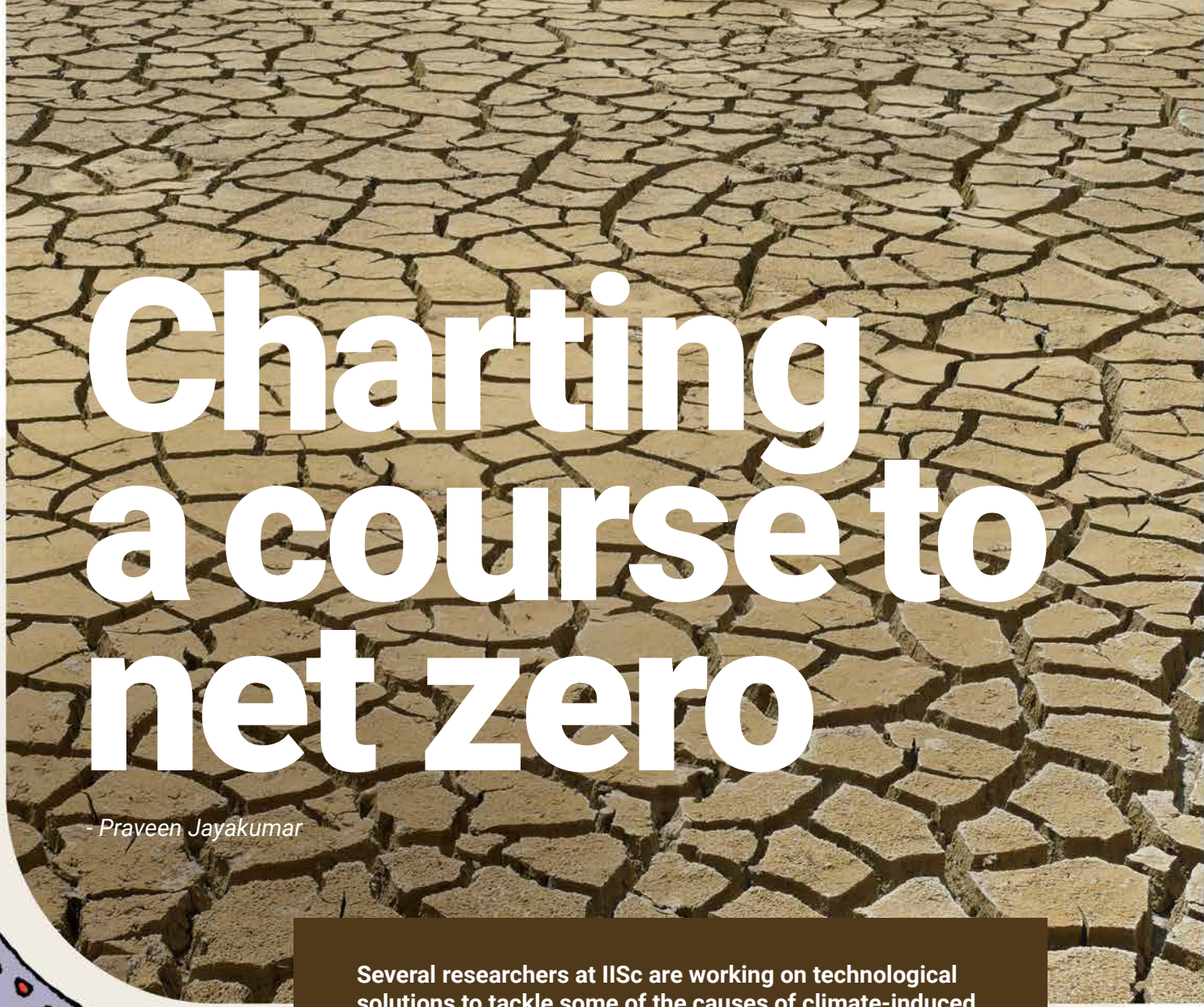


Photo courtesy: Pixabay/MrsBrown

Charting a course to net zero

- Praveen Jayakumar

Several researchers at IISc are working on technological solutions to tackle some of the causes of climate-induced disasters, and reduce carbon emissions

A sizzling heatwave across North India, prolonged power outages, and 20 million dead. Fortunately, this is a work of fiction, the setting in the first chapter of *The Ministry for the Future*, a novel by Kim Stanley Robinson. If you thought that this was a news headline, you are not far off from reality. Severe heatwaves hit India and Pakistan earlier this year, leading to the hottest recorded temperature in March since 1901. In the past few years, there has been a steady increase in the number of such extreme weather phenomena, taking lives and livelihoods. From recording-breaking snowfall to extreme flooding, all these can be attributed to climate change and an increase in the global mean temperature.

The predictions outlined in the 2022 IPCC report – published by the Intergovernmental Panel on Climate Change, a UN body tasked with tracking climate change – are extremely alarming. As one of the developing countries in the tropical region, India is set to be among the most affected by climate change. The dominant contributors to global warming are developed countries in Europe and North America, says J Srinivasan, distinguished scientist and former Chair of the Divecha Centre for Climate Change at IISc. "If we want to solve this problem, these developed countries need to ensure that the technology for shifting to renewable resources must be easily available and must be funded by them partly," he adds.

However, as one of the most populous countries, India cannot afford to rely on developed countries alone and needs to step up its own efforts to mitigate and adapt to the impacts of climate change. The Indian government has set ambitious goals for achieving an energy capacity of 500 GW from renewable sources by 2030 and net-zero emissions – cutting down greenhouse gas emission as close as possible to zero – by 2070. But achieving these goals is not easy; it needs technological innovation and intervention on a large scale.

"Climate change has been a crisis in the making for the past few decades, and we need efforts on a war footing," says Srinivasan.

IISc researchers are no strangers to technological innovation. From microelectronic technologies to water purification, they have been working on many socially-relevant as well as futuristic solutions. For example, a new quantum technologies initiative has recently been started to bring together researchers in various disciplines to make quantum computing a reality. Researchers in electrical, electronics and computer sciences are pioneering 5G technologies. During the COVID-19 pandemic, many innovations were developed including ventilators, oxygen generators and sanitisation devices. Like these efforts, developing sustainable technologies aimed at reducing the carbon footprint and building a sustainable future has also been a major focus. Many researchers at IISc have been working on diverse technologies to help battle climate change – from solar cells and electric vehicles to bioplastics.

Bioplastics and alloys

Every year after the harvest season, in the months after September, fires rage across fields in North India. These fires are intentionally set to burn the stubble on farms after the grains have been harvested. The resulting air pollution has significantly affected the air quality index in Delhi and other adjoining regions. Its proponents argue that stubble burning is necessary to remove the crop residues. But is burning the only solution to get rid of them?

Researchers at IISc have recently found a way to convert this stubble into bioplastics – plastics that can be made from organic sources. The team, led by Kaushik Chatterjee and Suryasarathi Bose, associate professors at the Department of Materials Engineering, and including Indranil Chakraborty, a research associate, has come up with a process that converts the cellulose in the stubble to a plastic-like material that can be reused.

Currently available bioplastics are based on starch and their manufacturing processes involve the use of certain catalysts. They also require specialised enzymes and processes for degradation. Unlike these, the ones developed by the IISc team are made using processes that do not require harmful catalysts like BPO (benzoyl peroxide). These bioplastics are completely degradable and are not expected to affect the environment by producing harmful chemicals when buried under the ground.

Photo: Indranil Chakraborty

Biodegradable carry bag, cutlery and tumbler made using non-edible oil and cellulose

"There are no byproducts from this process. We use precursors from oils and certain things from the stubble and combine these two to make a plastic," says Suryasarathi. This process is also scalable. Starting with a few grams, they have now been able to produce many kilograms of bioplastics in the lab. Currently, these plastics are awaiting certification and are being tested for their mechanical strength. The team is also checking to see what products these bioplastics degrade into. "Since the precursors are organic, we are hopeful that the final products, on degradation, would also be organic, something like carbon dioxide or water, something which can be safely released into the environment," adds Kaushik. Using the stubble to produce bioplastics not only provides the farmers an additional source of income, it also reduces carbon emissions while providing alternatives to commonly used plastics.

Another innovation that has come out of the department is the development of magnesium and titanium-based alloys which can help reduce carbon dioxide emissions. Aircrafts and other automobiles use aluminium alloys since they are resistant to corrosion and have a high weight-to-strength ratio, thus making aircrafts light and efficient. Yet, air travel continues to be a major contributor to global

warming. In multiple labs at the department, researchers have been working for many years now on magnesium and titanium-based alloys as alternatives to aluminium. These alloys have great potential to make automobiles and aircraft fuel-efficient by making them lighter than they are now and reduce carbon emissions.

Satyam Suwas, Chair of the department, has been leading efforts to make magnesium-based alloys a reality. These alloys are known to be stronger and lighter than steel and aluminium. "Magnesium alloys are anisotropic – on deformation they expand differently in different directions. Our focus was to reduce this anisotropy, so that the components made using this alloy will be perfect and would serve their purpose," he says. Another drawback is that magnesium alloys are not ductile enough to be made into parts, and that's also a challenge that the researchers at IISc are currently working on.

Electric vehicles

Just like the aviation sector, the transportation sector is also a major contributor to carbon dioxide emissions – around 23% of the total emissions in 2010, for example, according to the IPCC. Governments of many countries have been pushing for the adoption of electrical vehicles (EVs) with the goal of adopting a 'cleaner' method of transportation, and reducing emissions. But as much as they are touted as being 'zero-emission sources', they aren't really so if the source of the electricity supplied to such vehicles is itself not green. A major fraction of electricity supplied to cities is still from either coal power plants or other carbon emitting sources. In India, as of January 2022, renewable energy stands only at 38.56% of the total capacity. Continuing to use electricity from standard power sockets to charge your EVs does not technically reduce carbon emissions to zero.

However, one way to really achieve zero emission transport is to power the charging stations using renewable sources such as solar panels. Researchers at IISc have been testing the viability of setting up such zero emission EV charging points. Ashish Verma, Professor at the Department of Civil Engineering, and his team have set up one such charging point on campus behind the JRD Tata Memorial Library. Over a year, they tracked how much power was being collected and stored by the charging point and how frequently it was being used. The study, which was launched as an Indo-UK joint initiative, reported some positive results, and moreover was very well received by the IISc and Bangalore community, Ashish says. Many IISc community members had even purchased EVs with the reassurance that they could charge their vehicles on campus. But once the study was completed, the charging point was discontinued. "Many members of the community wrote to me enquiring about the charging point, expressing their disappointment on finding out that it was closed," says Ashish. Given the overwhelming response, he is currently working with the Institute administration to scale up the charging points on campus.

Photos courtesy: Ashish Verma

The zero emission EV charging point set up on IISc campus

But just one such point isn't enough. Would people buying EVs be able to find enough charging points across the city and state, and be able to make long-distance rides without worrying about running out of power? This is one of the challenges that Ashish's lab is trying to address. They have developed computer simulations and methods to optimise the locations where EV charging points can be installed after taking into account various factors, including the load on the power grid, usage, and population. Ashish and his team have been working closely with BESCOM, the government agency in charge of electricity supply in Bangalore, to set up optimal charging points and grid modifications.

The road for EVs has not been smooth so far. In the past few months, there have been various reports of EVs catching fire. Ashish says that while adoption might be hampered temporarily due to such incidents, he expects that the technologies will "mature" over the next 10 years, by which time more people would be more willing to adopt them. He argues that now is the right time for all the stakeholders to come together and set down ground rules for these technologies – standards for battery shapes and sizes, battery swapping policies and other battery-related needs.

Organic solar cells

EVs are only recent entrants in the energy race, but solar power-based energy generation has been around for several decades. Even though solar energy is considered a purely 'green' source, manufacturing

solar cells can be both resource and energy intensive. First and second generation solar cells that are currently available in the markets are silicon-based and India does not have large reserves of silicon, leading to large imports and reliance on other countries. In the year 2021, silicon imports cost our country about USD 3.5 billion, with nearly 90% of the material coming from China, according to Mercom India Research, a clean energy communication and consulting firm.

"To fully harness the potential of sunlight and reach the goals of sustainable energy for all, solar cells made with organic and perovskite materials are key players," says Satish Patil, Professor at the Solid State and Structural Chemistry Unit at IISc. He, along with other researchers at IISc, is working on enhancing the efficiency of organic and perovskite-based solar cells. These solar cells, which mimic the green leaves of plants that carry out photosynthesis, use photosensitive organic chemicals and polymers for light absorption and charge transport in order to produce electricity. They offer the promise of being less expensive, more flexible, thinner and more amenable to a wide range of lighting conditions, all of which make them suitable for a host of applications beyond rooftop and solar-farm panels, Satish says.

Photo: Manasi Venkatramani

The facility used to fabricate organic solar cells in the Solid State and Structural Chemistry Unit, IISc

Currently, Satish's team has been able to achieve 17% power conversion efficiency for these organic solar cells. A major challenge in developing organic solar cells is their lifetime and durability, which depend on the stability of the molecules used. His team is currently evaluating several candidate molecules for their stability and efficiency.

Another challenge is integrating solar panels with greenhouses. Organic solar cells are particularly attractive, because their light-absorbing capacity can be tuned, and they are inexpensive, thin and light-weight.

Unlike silicon-based solar cells, the main advantage of organic photovoltaics is that they can be made semi-transparent. These solar cells can be installed above existing agricultural lands and greenhouses. The organic molecule is chosen such that the panels allow light that the plants require to pass through and absorb light from other parts of the visible light spectrum. "Making dual use of the land has several benefits, both in the context of climate change and economical benefits for the farmers," says Satish, whose team plans to develop such semi-transparent cells.

Miles to go, and time too short

The ultimate question, however, is whether such innovations that happen inside the labs of IISc are enough to combat climate change on a large scale. Srinivasan says that while various scientists are doing their part in developing new technologies and improving existing ones, many of these technologies take years to materialise in the markets. He also stresses the importance of collaborations with industries as a driving force for research. In fact, the early efforts to study and develop magnesium-based alloys by Satyam and his colleagues at IISc was first initiated and funded by General Motors, who wanted magnesium-based alloys to manufacture lightweight parts for their automobiles.

Srinivasan also believes the current academic system needs to be revamped so that it rewards researchers who work on socially-relevant issues such as sustainability.

Climate change is a "problem that transcends generations," as scientist and educator Carl Sagan put it, requiring efforts that are both large-scale and long-term. And time is running out to initiate them. "We have been using fossil fuels for more than 100 years and now we need to reduce carbon emissions to zero within the next 30-40 years. Unfortunately, right now, in most countries, leaders cannot plan beyond 10 years," says Srinivasan.

During World War II, the US civilian industry was completely overhauled to make vast quantities of military equipment in an exceedingly short time frame. But such organised efforts shouldn't wait until 20 million people lose their lives in a heatwave.

Praveen Jayakumar is a former Master of Science student at IISc and a science writing intern at the Office of Communications

‘I was the umpire who said “Out!”when Kapil Dev took his record-breaking wicket in 1994’

- Kavitha Harish

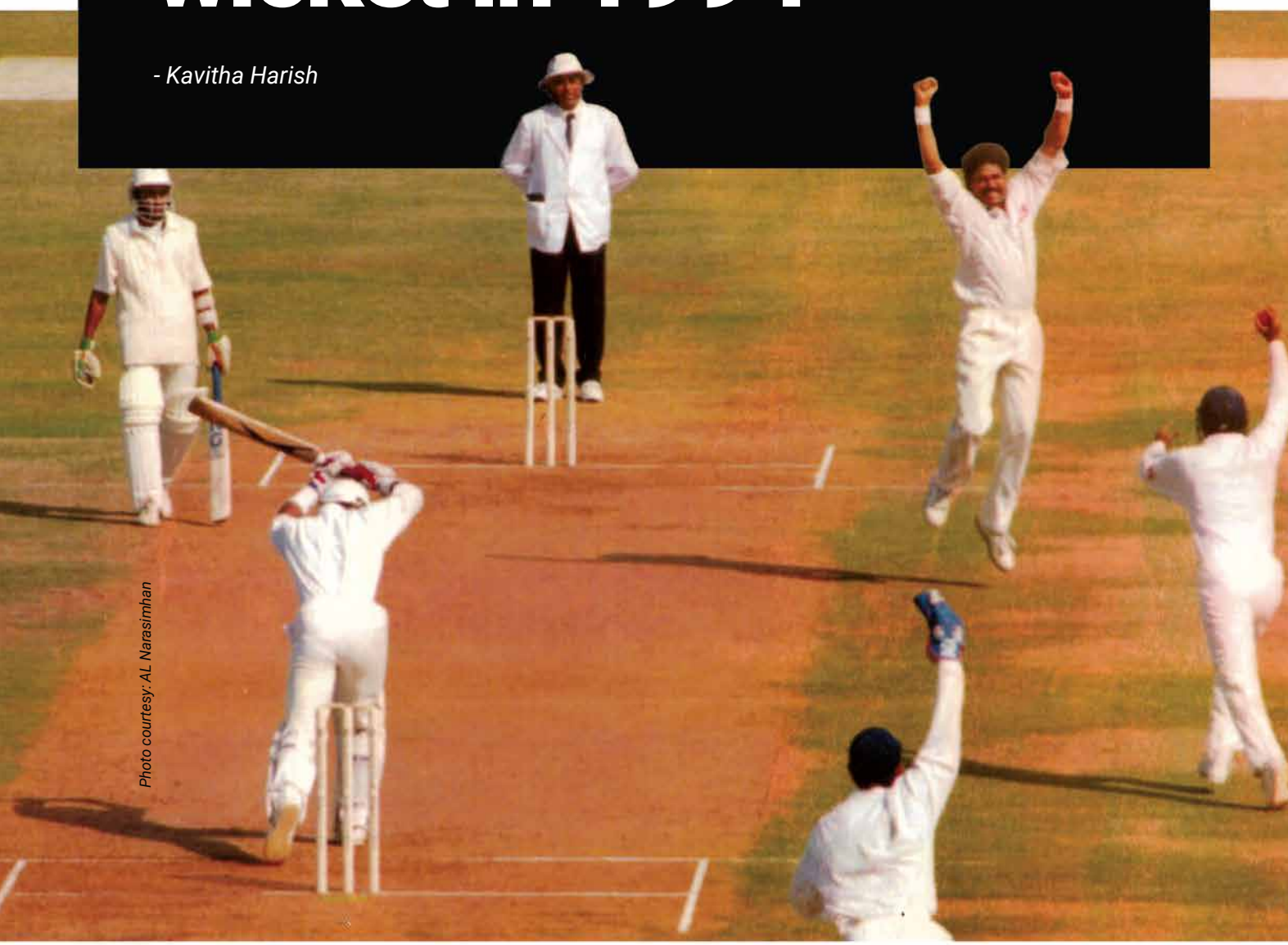


Photo courtesy: AL Narasimhan

AL Narasimhan, former Deputy Registrar at IISc, was an umpire at the India vs Sri Lanka test match in Ahmedabad in 1994, in which Kapil Dev dismissed batsman Harshan Tillakaratne. That was Kapil Dev’s 432nd wicket, making him the highest wicket-taker in the world at the time

AL Narasimhan joined IISc in 1965. At the time, he was 25, had just completed an MSc degree in statistics, and had also just fled from a job in Gulbarga, Karnataka, after only a month. Despite this false start, he got the chance to join IISc, and begin a lifelong career in administration. During the 36 years of his service, he handled large responsibilities such as admission, academic and student-related matters as a Deputy Registrar, and worked on activities related to the GATE exam, IISc's programmes for continuing education, and IISc publications. At the same time, he even served as an umpire in international cricket for over two decades! Now 82, Narasimhan spoke to CONNECT *about the many roles he has juggled over the course of his career.*

What brought you to IISc?

My first job was in the Karnataka government's statistics department, and I was posted to Gulbarga. I found the climate severe, and I was unwell, and within 30 days of reporting, I left for Mysore, my hometown. On the way, I stopped to visit my uncle in Bangalore. He informed me that a letter had arrived for me from IISc, calling me for an interview for the post of Junior Scientific Assistant. I had already written the test for this post. Unfortunately, my cousin had misplaced the letter, and the last date for the interviews had already passed. I felt dejected that I had lost the chance of appearing for the interview. My uncle encouraged me to approach the concerned person at IISc about it. Initially I was hesitant, but due to the persistence of my uncle, I came to the Institute.

I met Mr Vaidyanathan, who was the Assistant Registrar, Students Section. He is practically responsible for my joining IISc. He told me, "What is this, I say. We were searching for you, we also sent one person (Mr Ananthapadmanabhan, the supervisor) to your address twice; there was no response! The interview date is over … Okay, now that you have come, don't go anywhere, there is a canteen, go have your food and come back. Don't run away." Remembering those words now makes me emotional. An interview was arranged for me immediately (although the initial selection committee meeting was over, no candidate had been selected). The next day, I met with the new selection committee headed by Prof Satish Dhawan, who was the Director, and other stalwarts of the Institute such as Prof Arcot Ramachandran, Prof PL Bhatnagar, and Prof PS Sarma.

The big interview was over and I came out. Again, Mr Vaidyanathan said, "Don't run away, stay here till I return." Then he asked me to come the next day and issued an appointment letter signed by Prof Satish Dhawan. I was Junior Scientific Assistant, Statistics, assisting with admin work. I was later selected as Assistant Registrar.

What was it like working as an Assistant Registrar?

When I became Assistant Registrar, I first reported to the Council Section and then to the Admissions Unit as Deputy Registrar (Academic). My team and I had a huge responsibility – we had to create a timetable to manage the entire admissions process carefully. We would release the advertisement for admissions and send it to newspapers and other institutions, as well as print the Admission Brochure, Scheme of Instruction, Student Information Brochure and Handbook of Information. The last three publications would have to be ready in order to hand them over individually to all students at the time of admission.

We had to arrange for the IISc entrance exams in centres across the country. We would have to arrange for the printing of question papers, coordinate with faculty members, and maintain confidentiality, which was very challenging. We had to assign and depute faculty members and officers for the exams. In those days, examiners were sent by train with big sealed trunks carrying printouts of question papers. It was only much later that we started sending our academic staff by flight. Then, we'd have to collect the answer sheet checklists and keep them safe, and when it was time to evaluate the papers, we'd have to send them in sealed covers to the concerned faculty. If boxes with answer scripts ever went missing from the examination centres, we had to face severe consequences.

Photo courtesy: AL Narasimhan

AL Narasimhan (third from left) during a visit by Prime Minister Morarji Desai. In the photo, the Prime Minister is being shown a device used to make bricks developed by the cell for Application of Science and Technology to Rural Areas (ASTRA). Satish Dhawan, IISc's director, and Amulya Reddy, the head of ASTRA, are to the Prime Minister's left.

Finally, the results would have to be communicated to students and they would be called for interviews via postal mail (from 1972 onwards, we did this via Telex).

Back then, everything was manual, and the selection of students through the joint faculty meetings was a major task. Those meetings would stretch from 8 in the morning till 9 at night. I have seen the admissions process at other institutes, and I have to say that the cooperation between the academic staff and faculty members of our Institute was unique. I remember Prof CV Joga Rao, who was the Dean at the time, for his enthusiasm – he would remain till late in the section and help with the process, guiding staff and officers when the team had to work until 9 pm and beyond.

Computerisation has made all of the hectic tasks we went through for admissions very easy nowadays. But despite everything we had to go through at the time, we always ensured that we met the deadline of 1 August, when the academic year would begin.

Was it challenging handling student matters at the Institute?

The hardest was dealing with suicides. During Prof CNR Rao's time, a committee was set up to handle these serious problems, and I was a member. Handling enquiries by the police and witnessing the emotions of affected families were quite tough.

Did you work at any other departments?

I worked in the Council Section for five years, handling the Council and Court meetings, and other important meetings of the Institute such as the Investment Committee and Finance Committee meetings. In those days, there were two Court meetings in a year; now we only have them once a year. I also served as the Secretary at the GATE exam office for seven years.

I was a Liaison Officer for three years, Assistant Registrar at the Centre for Continuing Education (CCE) for five years, and Officer-In-Charge of the Hindi Cell for a couple of years. I managed the translation of the Annual Report and Annual Accounts in Hindi, sometimes with the help of my sister, Dr A Janaki, a Sahitya Akademi awardee. I also headed all the Institute publications during my tenure.

I feel I have many achievements over the course of my career, but I wish to particularly mention my involvement in faculty appointments and the streamlining of the procedure, and managing the sabbatical leave of faculty members to avoid misuse of the leave in some cases.

Photo courtesy: AL Narasimhan

From left: Former President of India R Venkataraman; JRD Tata, who was the President of IISc's Court; AL Narasimhan; IISc's Director CNR Rao, and GK Chandiramani, who was the Chair of IISc's Council

You mentioned that you also had an interest in teaching. What courses did you teach?

With IISc's permission, I taught business statistics and applied statistics as a faculty member at St Joseph's College of Business Administration (evening) from 1971 to 1983. I have taught students of business administration, production management and marketing management classes.

At IISc, for six years, I also taught employees Hindi as part of the in-service training programme.

How did you end up as a cricket umpire?

I was fond of cricket, but I could not play the sport, as according to our belief system at home, we were not supposed to wear pants.

I was born and brought up in Mysore, in an orthodox family. My ancestors were priests and academicians. Our family culture was strict; we were not supposed to drink tea or coffee until we were 20 years old. If we had to go to the temple, we were not allowed to wear slippers to get there – we had to walk barefoot. You won't believe it, but I never wore trousers, only dhotis, until I got into my MSc course! I got my first pair of pants tailored then, and I got my first pair of shoes so that I could attend my MSc convocation at Mysore University.

My interest in learning cricket and going for professional training wasn't nurtured when I was young. But I was so keen on the sport that I started the Jai Hind Cricket Club in Mysore in 1959, when I was 19 years old. I played against BS Chandrasekhar, EAS Prasanna and GR Vishwanath while playing First Division league cricket. And in order to remain involved in the sport by any means, I decided to try and become an umpire. I stood first in the country in the written exam conducted by the Board of Control for Cricket in India (BCCI). In 1992, I was one of the umpires nominated from India for the

World Cup conducted in Australia and New Zealand. I made my Test cricket debut as an umpire in Ahmedabad in 1993-94. I am proud to say that I was the one who said "Out!" when Kapil Dev took his 432nd wicket in 1994, which made him the world's highest wicket-taker at the time.

I officiated in Test and One Day International matches between India and visiting teams such as the West Indies, England, Australia, South Africa and Sri Lanka. I also officiated in major national tournaments such as the Irani, Duleep, Ranji, Wills and Deodhar trophies and others.

I officiated as a match referee and as an umpire coach for the BCCI. I was the Founder Member and President of the Association of Cricket Umpires, Karnataka, and Member of the Board of Examiners for Cricket Umpires, Karnataka State Cricket Association. I also served as a cricket commentator – I've had the opportunity of interviewing cricketers GR Vishwanath and BS Chandrasekhar on All India Radio.

Photo courtesy: AL Narasimhan

AL Narasimhan with Sachin Tendulkar and Ravi Shastri at Chinnaswamy Stadium, Bangalore, during the 1996 World Cup match against Pakistan

Members of the Institute were most encouraging of my role as an umpire. The Director, Prof G Padmanaban, and the Registrar were very happy for me on my Test debut. Before Choksi Hall came up, people used to play cricket on the open ground that used to be in its place. I have played cricket with Prof Satish Dhawan, who was the captain of my team, and Prof Padmanaban as well.

Being an umpire means making quick decisions and maintaining composure even under tense situations, a quality which greatly helped me interact with my staff and successfully manage my office.

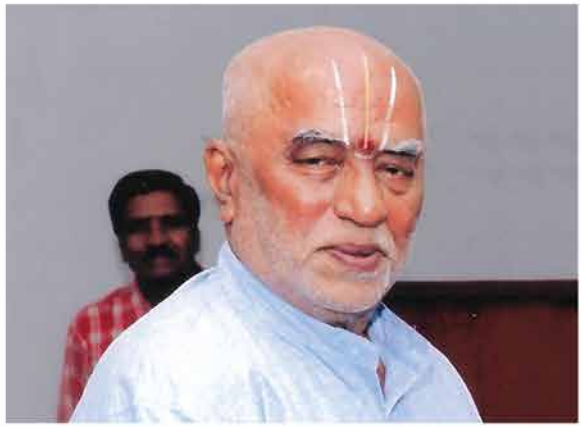


Photo courtesy: AL Narasimhan

What are your best memories of IISc?

I shouldn't forget to mention the day I was felicitated on my retirement. The staff of the Admissions and Academic units expressed their respect and affection, writing a song about me and singing it on that day, which was very touching.

The Institute is a wonderful place to work; I was very lucky to have gotten in. Right from the top management to all the staff, all my work interactions were memorable, though at the end of my career, I did feel that a lot of things changed, and I miss the culture of unity we once had.

I lived on campus until 2000. There were 16 Officer's houses behind Canara Bank, where the hostel blocks are now. All of these were independent houses with a big compound. During festivals, all families would gather, exchanging sweets. We would have musical events once a month. We invited Prof G Padmanaban, the Director at the time, for Krishna Jayanthi. He attended along with his wife, Mythili, and sang for half an hour during the event. If I had had the opportunity to take a video of it the way we do now, I would have cherished that video.

After such a busy career, what is retired life like now?

I am a practising Vedic scholar. I conduct discourses and organise *bhajans and keerthanas* at gatherings of friends and family. All these activities keep me mentally positive and enthusiastic even now. My senior acharyas call me 'Cricket Narasimhan'.

Looking back, I think I have attained everything I desired in my life. IISc is a nice place to work and I was fortunate to have spent my lifetime in the IISc administration as well as on its beautiful campus.

Kavitha Harish is Personal Assistant to the Assistant Registrar (HR, Council)

The Lure of the Fiddlewood

- Karthik Ramaswamy

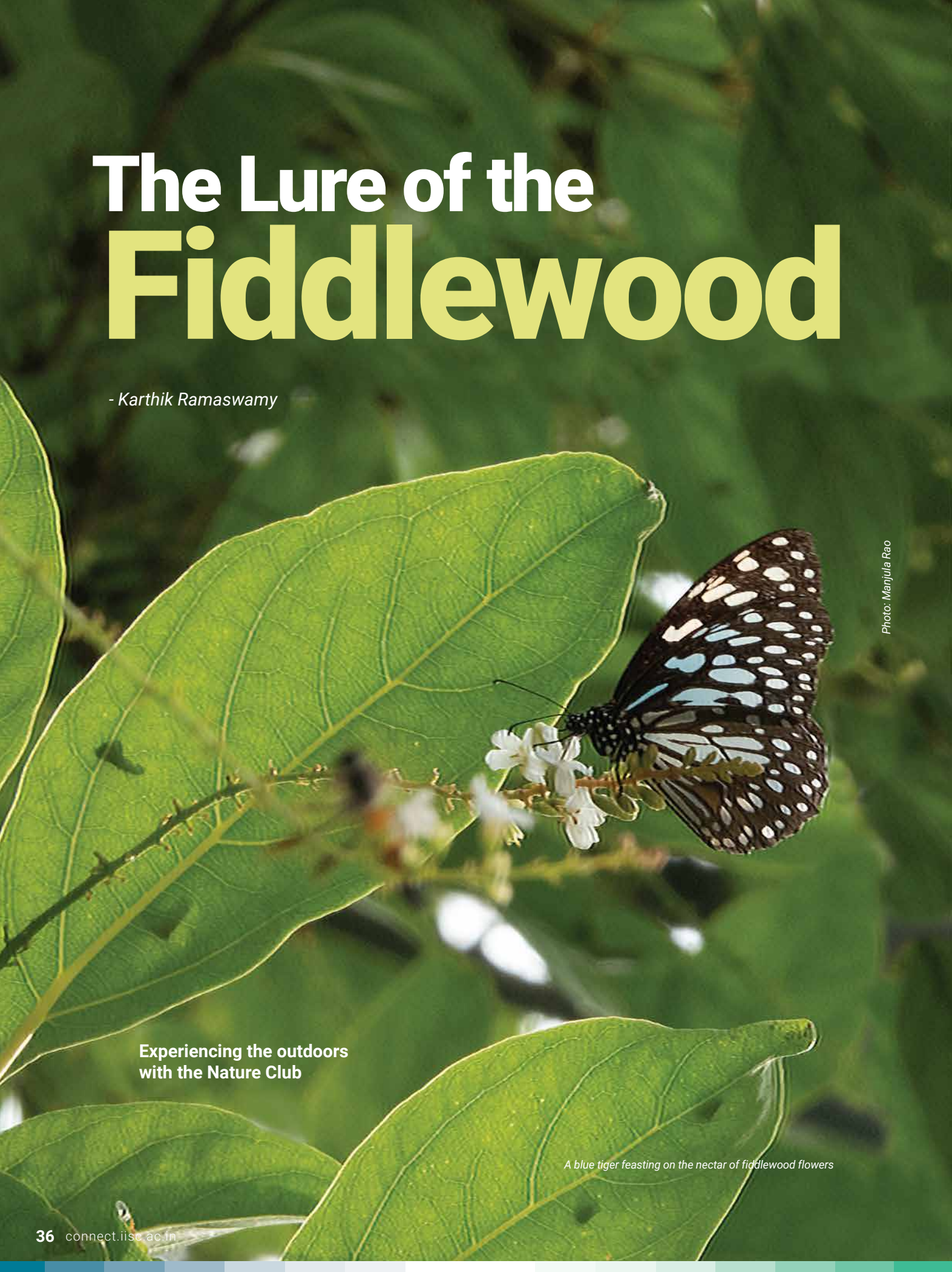


Photo: Manjula Rao

Experiencing the outdoors with the Nature Club

A blue tiger feasting on the nectar of fiddlewood flowers

On a surprisingly pleasant Sunday morning in mid-April, a carpet of bright yellow copperpod flowers greets visitors at the parking lot near the main entrance of IISc. Among them are participants of the “Butterfly Walk", organised by the Nature Club of the Institute. They make their way to the gates of IISc’s plant nursery, the pre-decided meeting venue. Soon, Chandra Sekar Bandi, who would lead the walk, scurries towards the participants and introduces himself as “Chandu”.

Chandu is an IT professional with Hewlett Packard R&D but moonlights as a naturalist on weekends. His name was recommended to Sagarika Jaiswal, the Co-Convenor of the Nature Club, by Shubha Bhat, a birdwatcher who lives on the IISc campus.

Chandu’s journey as a naturalist began in 2008, when he attended a training programme conducted by S Karthikeyan of the Jungle Lodges and Resorts. “I can proudly say my life can be divided into two parts: the one before the programme [Naturalist Training Programme] and one after the programme. It allowed me to appreciate and understand nature as well as spend time watching and questioning things around. It opened a different world to me,” he says.

Chandu soon became a regular at the Sunday jaunts of the Bangalore Birdwatchers Club. Not long after, he started leading nature walks himself. “I found immense joy in sharing knowledge and making people, especially children, interested in nature. Slowly, my interests expanded [from birds] to butterflies, then trees and then other insects.”

Though he claims that it is hard for him to pick favourites, Chandu seems to have a special fondness for butterflies. When pressed, he explains why he is partial to them: “Butterflies help connect people to nature since they are all around and catch one's attention with their beauty and charm. Secondly, knowing about butterflies will help us explore and learn about trees. Besides, one doesn't need to travel long distances to see them as they can be found right in our backyards.”

Since the gates of the nursery are yet to open, the small but enthusiastic band of nature enthusiasts leisurely ambles towards the staff quarters. Along the way, Chandu flips over stones and points to the barks of trees, revealing curious-looking critters that would have easily escaped the attention of an untrained eye. A few stray butterflies are also spotted in the undergrowth, but most of them still seem asleep in their shelters beneath the leaves of their cherished trees and shrubs.

Photo: Kiran Ghadge

A bird walk on campus in November 2019

As the walk continues, Chandu intersperses insights about the plants, animals, and even fungi the group encounters with engaging accounts of the natural history of the main attraction of the show – butterflies: how many species exist, what makes them different from moths, how the lives of these insects and plants are intricately connected, why some of them undertake arduous annual migrations, how their mouthparts have been modified for sucking nectar, what dramatic developmental transformations they undergo as they metamorphose into adults, and why they frequently engage in the ritual of congregating in moist soils.

Photo: Kiran Ghadge

The club organised a visit to Munnar in Kerala in the fall of 2018 to see the Neelakurinji flowers

The discussion serves as an appetiser for the visual spectacle that follows at the first butterfly hotspot: a fiddlewood tree. Standing tall in one of the many gardens of the staff houses, its numerous inflorescences carry several milky white flowers that emit a pleasant odour. The overnight dew on the wings of the resting butterflies has evaporated by now. And the hungry insects make a beeline for an elaborate breakfast buffet in the neighbourhood. Clearly, the most sought after item on the menu is the nectar served up by the fiddlewood flowers.

The butterflies, decked up in their Sunday best, come in an array of colours – white, yellow, blue, black, grey, brown – and some have intricate patterns to boot. They fly from one fiddlewood inflorescence to another, almost as if they are taste testing nectar before choosing the best vintage. The tableau elicits "oohs" and "aahs" from the butterfly watchers, some of whom have now pulled out their binoculars and cameras. Those in the know excitedly whisper the names of butterflies for the benefit of the novices in the group: "Common Crow!", "Blue Tiger!", "Common Banded Awl!", "Red Pierrot!", "Jezebel!", "Small Branded Swift!". But after a few minutes it is time to bid a reluctant goodbye to the fiddlewood tree and its visitors.

The next stop is a Pala indigo tree. "*Wrightia tinctoria* [the scientific name of the Pala indigo] is the tree whose wood is used to make the famous Channapatna toys. And because it is a native tree, it attracts a lot of butterflies," announces Chandu to whet the appetite of the group, as the small procession marches towards the new Chemical Sciences building.

Revitalising the club

Nature walks, like the one led by Chandu, are conducted somewhat regularly by the club. But for much of its existence – it was started in the late 1980s – it was more of a hiking club, according to Kiran Ghadge. Kiran became its Convenor in 2014, the year he joined IISc as a PhD student at the Centre for Product Design and Management.

"When I joined in 2014, the club had become a bit dormant. There was not much activity." Under Kiran's stewardship, the club continued to focus on trekking but with a renewed sense of vigour.

Back then, Kiran was new to Bangalore. "So I started doing treks with some clubs outside IISc. And I learnt about the trekking destinations close to the city." The first hike that he organised as part of the Nature Club was to Shivagange, a mountain peak northwest of Bangalore near the city of Tumkur. Gradually, he and other members started visiting more places, mostly in the vicinity of Bangalore. And occasionally they would do a camping trip. "We have camped in places like Mullayyanagiri [Karnataka's highest peak in Chikkamagaluru district]."

The club also organised longer trips – with a duration of 10 to 15 days – in the Himalayas with the help of Sanjay Raut, a librarian in IISc who has been associated with the club since its inception until 2017, the year that he retired from the Institute. "And thanks to Mr Raut, we also did some adventure events – water sports at Vani Vilasa Sagara near Chitradurga, rock climbing near Ramanagara, and some others," adds Kiran.

Kiran says that perhaps his most memorable trekking experience was seeing the Neelakurunji. To catch a glimpse of these purple-blue flowers that bloom once in 12 years in the Shola forests of the Western Ghats, the club organised two trips in 2018 – one to Kodaikanal and the other to Munnar. "We were lucky that we got to see them."

Once the club had firmly re-established itself, Kiran began to look for successors who could continue its activities and also take it forward. However, finding students with the right fit to take charge of the club's activities was not easy. A couple of them were appointed, but because they moved on from IISc, Kiran had to reprise his old role again. He got lucky three years ago. "In 2019, we sent out a broadcast mail. Surprisingly, compared to earlier years, more people applied." Kiran decided to make the applicants help organise a small weekend trek. "One of them was Ambarish Mallick, an undergraduate student majoring in Biology. I gave him some tasks related to organisation. He did well and he was appointed as the Convenor. I'm happy with the choice," he recalls.

Photo: Kiran Ghadge

A trek in Arunachal Pradesh in 2017 organised with the help of the National Institute of Mountaineering and Adventure Sports

Campus walks

Ambarish was soon joined by Sagarika, a PhD student from the Centre for Neuroscience, as a Co-convenor. "When I joined IISc, I was looking for other birding enthusiasts," she says. Through a friend of hers in Delhi, she got in touch with Deepa Mohan, a well-known member of the birding community in Bangalore. "They organise birding events in different parts of the city on Sundays. I went with their group to Turahalli Forest [just outside Bangalore] and that was a lot of fun."

Photo: Kiran Ghadge

Kayaking at the Vani Vilasa Sagara Dam in December 2015

Sagarika then approached Kiran asking if the Nature Club could also organise similar birding trips or nature walks on campus. "It was my way of finding out if there are people on campus with similar interests." She organised the first walk in IISc with the help of Deepa. "That's how I met Ambarish. He has a vast knowledge about insects. I also met Shubha Bhat then."

The next event that Sagarika organised was a three-day bird count in IISc's campus. "That went very well. After a few months, Kiran asked me if I could become a Co-convenor along with Ambarish." Sagarika readily agreed. Since then, she and Ambarish have facilitated several nature walks for members of the IISc community, including alumni. "We have students, young kids and even elderly people joining us at these nature walks."

These nature walks owe their success in large part to the sheer diversity of the flora and fauna of IISc's campus. "I have visited several college and university campuses across India," says Ambarish. He feels that most campuses try to incorporate nature into their buildings by creating patches of greenery. But the IISc campus, he says, gives one a sense that buildings are nestled in nature, making it an oasis of urban wilderness in the midst of the sprawling metropolis.

The biologist and natural historian, Edward O Wilson, argued that humans are biologically predisposed to seek connections with nature. He coined the word *biophilia*, meaning "love of life", to describe the human urge to connect with other life forms. The Nature Club is providing members of the IISc community with an opportunity to express and nurture their own biophilia.

Photo: Ezaz Ahmad Siddique

Why it is important for queer people to be seen in IISc

- Rohith KMS

IISc students marching on Gulmohar Marg on the first IISc Pride

As an undergraduate student I had to hide my true self from faculty and peers. But now, I see a growing visibility and acceptance that can help take the weight off non-binary and trans students like me

On 19 December 2021, I went to IISc's first Pride March.

Over a hundred students, faculty and staff, wearing all the bright colours of the rainbow, started marching along Gulmohar Marg, holding up banners that proclaimed "Love is Love" or demanded "Stop splitting humans into Blue and Pink". Even the IISc security guards who flanked the parade were dressed in their neon-yellow waistcoats, unwittingly adding to the spectrum of hues. The parade turned onto the road that passes in front of the Director's bungalow, as the voices of queer folk and allies shouted slogans in unison, demanding changes such as gender-neutral housing and washrooms, and an anti-discrimination policy. Like Pride marches everywhere, IISc's Pride March was both a protest and a celebration, culminating at the platform opposite the Main Building, with students performing music, dance, and poetry.

IISc Pride meant a great deal to me because it seemed to mark a significant milestone for queer visibility at the Institute. Queer people have always existed on this campus, but there is a huge stigma surrounding being queer, even today, that prevents many of us from being openly 'out', especially to our professors and lab mates. A 2020 comment piece in the *Lancet* states, "The problem of invisibility is exacerbated in STEM fields due to heteronormative stereotypes, which can lead to challenges for LGBTQ+ individuals in the workplace."

Heteronormativity is the assumption that gender is binary – that there are only two distinct genders, male and female, one of which we are all assigned at birth – and that romantic and sexual relationships are only meant to take place between a man and a woman. Tied to this assumption is the idea that all people are cisgender, which means that they identify with the gender they were assigned at birth, thereby stigmatising people who are transgender. Lab environments are typically heteronormative, and any deviation from this is usually treated with disapproval, which can negatively impact the mental health of queer students and employees. "How people perceive us can also affect our professional life, and the projects, grants and opportunities we get," explains Prarthana, a first year PhD student who identifies as queer and non-binary, and prefers to be referred to by "they/them" pronouns, rather than gender-binary pronouns such as "she/her" or "he/him".

Simba*, a former student at IISc who is currently employed at another Bangalore-based academic institution, identifies as a cisgender gay man. He says that even though he would like to wear nail polish or kohl in his workplace, he doesn't feel comfortable doing so owing to an undue pressure to be 'professional' that is often conflated with heteronormativity. This pressure hinders visibility, and the lack of queer visibility can prevent queer students from connecting with each other, which can add to the isolation that many of us already feel. Thus, events like IISc Pride are very important for queer folk to find a sense of community within the campus. Prarthana says that they did not know any other queer person in IISc when they joined, but they met a lot of other queer folk at IISc Pride, which gave them a sense of belonging within the campus. "It's nice to have people around who understand me without me having to explain my whole background to them," they say.

The start of QueerIISc

IISc Pride is the culmination of decades of effort by the LGBTQIA+ students on campus and our allies to increase queer visibility and acceptance. Rajnish Rao, a data scientist working in Germany, did his PhD at the Department of Molecular Reproduction, Development and Genetics (MRDG) from 1998 to 2006. In a Journal Club meeting in 1999, Rajnish presented on "Same-sex behaviour in the animal kingdom" to an audience of PhD students, professors, and postdocs. He also talked about homosexuality in humans and mentioned famous people in history who identified as homosexual, a scandalous topic at the time. "Most people were too shocked to react, except for one senior professor who had a million questions and asked me for a printout of the list of famous queer people to cross-check on the Internet," he recalls with a chuckle.

When he came out as gay, Rajnish did not know any other queer person at IISc. He reached out to GoodAsYou, one of the oldest surviving support groups for LGBTQIA+ people in Bangalore. That's where he met Neruj Mohan, another queer student on campus. Figuring that there must be more than just two queer students on a campus of over 3,000 students, Neruj and Rajnish started a support group for queer students called QueerIISc. Through posters and events, they raised awareness about the group, and soon a small community of queer folk (largely gay men) nucleated around them.

Being part of this queer community on campus helped Vivek Nithyananda, now a BBSRC David Phillips Fellow at the Centre for Behaviour and Evolution and the Biosciences Institute at Newcastle University, come to terms with his identity. Vivek did his PhD in animal behaviour at the Centre for Ecological Sciences (CES) from 2002 to 2008, and realised that he was gay halfway through his time at IISc. This was followed by a string of postdoctoral research positions at universities in Minnesota, London and Berlin, where he experienced a much more accepting environment to explore his queer identity. He adds, "I think it was easier partly because I was in foreign countries without prior social connections, letting me be anybody I wanted to be without too many repercussions." Vivek recalls that in his time, CES and MRDG were the "gay hubs", indicating a relatively more queer-friendly environment in these departments. Vivek came out to his Principal Investigator (PI), and has even introduced his boyfriend to her. Even now, the biology departments seem to have a higher proportion of students that are 'out', including amongst those that are only out to the members of QueerIISc, according to Asha*, the current convenor of QUASI (IISc's peer support group which has both queer folk and straight allies). "Perhaps it is because biologists are more tolerant of complexity," reckons Vivek.

Bittu KR, currently Associate Professor of Biology and Psychology at Ashoka University, puts it bluntly, "Being both a good biologist and homophobic is impossible." Bittu did his postdoc at CES in the same lab as Vivek from 2010 to 2013, and was one of the first trans people to be 'out' to the campus queer community. "I knew other trans and non-binary folk from campus, but most of them were not comfortable being 'out,'" he says. Conversations about queer issues in his lab were made a little easier because Vivek was already in the lab, and by then it had quite an inclusive culture. However, Bittu recalls that in his time in IISc, conversations about being queer or trans were discouraged. Nevertheless, he engaged in conversations with his peers about the need to create a trans-friendly workplace.

Non-binary, trans inclusion

When Asha, who is also transgender, joined IISc in 2018, they had already gotten in touch with Bittu, who assured them that they could reach out to him anytime for help. Asha also reached out to QUASI through its Instagram account (@quasi_iisc). At the time, QUASI and QueerIISc had very few active trans and non-binary members. However, this changed when Asha became an active and visible member of the IISc queer community. "Soon, [trans and non-binary] people started coming out to me, and we formed a supportive group for each other," Asha says. Eventually in 2020, Asha became the convenor of QUASI and helped drive conversations around trans and non-binary identities within the IISc queer community. Their own personal experiences were a driving factor in trying to improve trans visibility on campus.

Nyx*, a transgender UG student in her first year, has not yet come 'out' to her project supervisor even though she is in a department considered to be relatively queer-friendly. She is wary of people's tendency to be inconsiderate when their heteronormative expectations are not met. Sharaj, a transgender UG student in their fifth year, recalls one such experience as a performer in a Rhythmica music show. "As I was getting ready to perform, some people came up to me and started questioning why I was wearing kajal. One of them even told me that I looked scary." Trans and non-binary folk hear such inconsiderate comments every day, reminding us that some people don't want to accept us the way we are.

When I asked Nyx about whether she feels comfortable among her peers and in the IISc queer community, her face lights up. "It's great having people around that understand my experience," she explains. Nyx realised that she was trans during the lockdown, a tough period for a lot of queer people. However, she managed to find a lot of friends online, like Asha, that helped her come to terms with her identity. The increased visibility caused by openly non-binary and trans folk such as Asha has brought together a community in which people feel at home and accepted: new students like Nyx and Prarthana say that watching other queer people thriving in IISc gives them the confidence that they can do it too. "Most people in the UG community refer to me by my correct pronouns," Nyx adds happily.

The visibility and acceptance of queer folk in the UG community has followed a slightly different trajectory than in the broader IISc community because of the UG programme's relative isolation. In the early days of the programme, queer visibility was poor despite the campus having a thriving queer community. "I wasn't aware that there was a queer group in IISc, so I didn't have anyone to contact," says Simba, who was in the UG programme in its initial years. I could relate to Simba's experience. As a UG fresher in 2016, I was bullied by my classmates for having a non-normative gender expression. I knew some queer people in my batch, but I was one of the very few that were 'out'. I had access to QUASI and QueerIISc and I met a lot of wonderful people, but I never fit in because of the lack of non-binary visibility in the IISc queer community.

Photo: Aniket Ingole

Rohith KMS performing poetry at Pride

That distanced me from the community, and I left QueerIISc because I felt lonely there. After graduating, however, my friends told me about the vibrant community of non-binary and trans folk that had become visible, and I joined the group again. Simba too, found out about QueerIISc after graduating, and he is now an active member, in the process of starting a similar queer support group in his workplace.

The road ahead

In my time at IISc, I have seen a steady and gradual shift towards increased queer visibility and acceptance. This shift was driven by outspoken queer folk who started conversations around queerness and sensitised their peers to queer identities, and faculty who were empathetic to the queer movement and were willing to change their conditioned beliefs, allowing for a more inclusive lab environment. Mohit Jolly, Assistant Professor at the Centre for BioSystems Science and Engineering (BSSE), says that he is learning to use gender-neutral pronouns such as they/them to avoid misgendering non-binary people. Vivek, who just started a new lab in Newcastle University, says that the key to providing a safe and conducive space for students is starting conversations about queer rights and discrimination, and sensitising people. Mohit, who also values open communication in his lab, does not tolerate deliberate misgendering of people, and has enlisted the help of Sharaj, who is his student, to sensitise the members of the lab to issues of gender and sexuality. "Telling people your pronouns when you introduce yourself, even if you don't identify as queer or trans, signals that you respect pronouns and are an ally," Sharaj says.

"There is a significant increase in queer visibility, but that is because of the efforts of queer students themselves," adds Sharaj. QueerIISc and QUASI are hoping to receive an official IISc email address where students can reach out for support. There have also been reassuring efforts from a few faculty members who are allies to the queer movement, though there is still a long way to go in terms of providing support to queer people. Two close friends of mine from IISc took their own lives recently. Although they were dealing with a lot of other problems, I know that their lives would have been a lot easier if their environment was more accepting of their queer identity. As I stood on the stone platform opposite the Main Building during Pride, performing poetry and dance in a lovely blue dress and purple lipstick, I thought of my friends. Wherever they were, I hope they were watching. I hope they were looking into my heart, for they would have seen how much I wanted to walk the first IISc Pride March with them. I hope they see how things have been changing, and will continue to change.

Listening to the stories of queer folk in IISc across several years, I discovered how queer people inherit social capital from the torchbearers of the previous generation, using it to question and confront heteronormativity, generate more social capital, and pass it on to the next generation of queer folk. The trail that Bittu and Asha blazed is now walked upon by people like Prarthana, Nyx, Sharaj and me. When Prarthana and I were talking over lunch outside the Sarvam complex, they said, "The reason I am sitting here, wearing suspenders and a bow tie, is because I've seen people like Asha express their truth unapologetically." I, with my painted nails and just a hint of kajal, nodded in agreement.

* Name changed'

Rohith KMS is a former UG student at IISc and a science writing intern at the Office of Communications

Photo: KG Haridasan

Why are Archives Important?

- Deepika S

A view of the entrance to the IISc Archives

A peek into the IISc Archives and the world of archiving

Among the IISc Archives' many treasures is a large, heavy book called the "Distinguished Visitors Book", a record of signatures from famous visitors to the Institute from 1948 to 1973. To look at, it is a worn book with crumbling pages onto which smaller sheets with signed names have been pasted – on the face of it, not an impressive document. But reading the names in it gives one an enormous sense of history: Jawaharlal Nehru, who visited IISc as Prime Minister of India in 1948 and 1951, and signed his name in Hindi, English and Urdu; Nikita Khrushchev and Ho Chi Minh, communist leaders of the USSR and Vietnam respectively, who visited IISc separately in the 1950s; Queen Elizabeth of England, who visited IISc in 1961 and signed her name "Elizabeth R" – the R for Regina, which means queen in Latin. There's even an entry by the mountaineer Edmund Hillary, who visited IISc in 1987 as the Commissioner of New Zealand in India, and wrote, "A magnificent Institute – although I am a non-academic!"

What is the value of this crumbly old book, and why do we keep it in the IISc Archives? What purpose do archives and archival material serve, and why are they important to us? These signatures tell us not just of the people who made them and their stature, or the timing and purpose of their visits. They also tell us, among other things, about the Institute, its standing in India and the world, and the historical role of scientific research in international relations.

Photo: KG Haridasan/IISc Archives

IISc's "Distinguished Visitors Book"

What is an archive?

An archive is a space for the preservation of records and material for their long-term value. It is a "documentary by-product of human activity", according to the International Council on Archives (ICA), therefore providing a direct window into past events. Archives can be physical, containing items such as books, reports, letters, notes, photographs, objects and artefacts. They can be digital too, documenting human life that is increasingly lived online, or making digital copies of archival material available for reference. They contain primary sources of information that can give us insight into the actions and decisions of governments, institutions, communities and individuals, and at the same time serve as a repository for our memories.

However, an archive isn't just about keeping a bunch of cool old stuff in one place – it's important to record material while preserving the context in which it was created and to be able to show how it is connected to its source. Where possible, storing material in an archive also involves being able to provide a complete picture of how and why it came into being. The job of ensuring this falls to archivists, who are prescribed a code of ethics that includes protecting the authenticity of documents and ensuring "widest possible access" to the material within their archive.

Archivists are also required to document their own work and decisions in the archive (and do plenty of record-keeping about record-keeping!). For instance, the decision to accept or refuse a set of letters, or to repair a group of fragile papers, or to deny access to a particular item, has to be documented so that the archivist's actions can be understood. S Ponnarasu, Archive Project Leader at the Archive of IIT Madras, says that of all his tasks as an archivist, the hardest is appraising documents and deciding what to keep (or not to keep). As the Archive of IIT Madras is in the process of being set up, decisions need to be made – and recorded – about which documents to retain and how long to retain them for. "I can't anticipate what researchers in the future might want to look for," he says. "I find the appraisal part of the archival process the most complex, requiring my full attention."

Although archives can contain valuable material of historical importance, an important aspect to remember is that archival material doesn't necessarily represent the "truth". The ICA cautions that material in an archive ought to be seen "only as a contemporaneous record from an individual or organisation with a particular level of involvement and point of view." It goes on to suggest that users of archives – the general public, historians, researchers, students and so on – should be aware of this context when we interpret the material in these archives. It adds that we must also be aware of how our experiences and culture affect the way we 'read' an archival resource.

Where archives do exist, they don't always provide a complete or exhaustive picture. Arun Chandrashekar, a biochemist in his 60s, has been trying to find out more about his grandfather, who was also a biochemist – and a rather famous one at that. V Subrahmanyam was Chair of the Department of Biochemistry at IISc in the 1930s and 40s, and went on to head the Central Food Technology Research Institute (CFTRI) in Mysore. Arun's mission to document his grandfather's work and other significant food technology research from that era is both a biochemist's quest and a personal one. "It's been a very tough journey," he says, talking about his four-year search for records and primary documents across institutes, which has been physically taxing. He has found some material from speaking to people who knew his grandfather directly, some material that he gleaned from the Internet, and a little from the IISc Archives. But so much remains to be found, he says, and the lack of record-keeping in India and the dearth of archival material has proven a huge roadblock to his efforts.

Photo courtesy: INTACH Conservation Institute

A workshop on preventive conservation at the IISc Archives by INTACH Conservation Institute in 2020

How is archival material protected?

Because archival records offer such valuable insight into human activity, preserving them is key. As archival material such as letters, photographs and books can be old or fragile, several precautions need to be taken while storing and handling them. Items may need to be stored in a room that is temperature- and humidity-controlled, as large fluctuations in both can cause damage to the fragile material over time. They will also need to be kept in acid-free containers, and in conditions that are free of pests such as rodents and insects.

At a workshop held in November 2020 by conservators at the INTACH Conservation Institute, the staff at the IISc Archives were trained in preventive conversation – which means taking measures to avoid damage, rather than taking measures to repair damage *after* it has happened. We were shown the importance of maintaining ideal conditions in the archives, such as the right temperature, humidity and light; pest control, and the importance of keeping the area dust-free. We were also trained to use acid-free boards to transport fragile papers, clean the dust off documents by gently rubbing them with eraser dust using small cotton wads wrapped in lens tissue, to smooth out creases using de-ionised water, blotting paper and weights, and to mend tears or holes in documents using starch paste and Kozo tissue.

However, the training we received was to handle minor problems in the archives: for heavy duty work, there is no substitute for a professional conservator trained to restore documents, photographs, paintings or other items, depending on the archive's needs. Multiple debacles in the art world with outcomes unfortunately similar to Mr Bean's version of 'Whistler's Mother' – like an amateur painter's botched restoration of a Spanish church fresco of Jesus now infamously known as "Monkey Christ"– have shown just how important professional conservators are.

The conservation of physical objects also extends to audio and video recordings. While it is important to preserve material in its original form, it may also be necessary to update the format in which they are available as older forms of technology become obsolete, so that the content remains accessible to users of the archive.

How can archives be accessed?

In an archive, it isn't enough to simply preserve material: providing access to the material is equally important. To make this easier, all the material is listed and described in a way that explains the content and context of what is in the archive. Archival records are typically maintained according to "provenance", which means that all of the material that originated from a single source is kept together, so that the context for individual documents is not lost. The convention for describing archival material may differ from country to country, however, there are broad recommendations for a universal template. The ICA recommends the General International Standard Archival Description, known as ISAD(G), to be used either alongside or as the basis for national standards.

Every item in an archive is assigned a number or code based on the group they belong to. These codes and descriptions of the material within an archive together form "finding aids", which help users to understand the way an archive has been organised and to locate material within it. The IISc Archives has been working on building a finding aid, with the goal of completing it by the end of this year.

The way that material is described, and the keywords and metadata assigned to an item in an archive, can play an enormous role in whether the item is accessible to the user of the archives or not. "One of our jobs as archivists is to ensure we describe and contextualise the object in such a way that users have multiple entries into it," says Venkat Srinivasan of the Archives at the National Centre for Biological Sciences (NCBS) in Bangalore. He sees the object in an archive as being like a castle surrounded by a moat; the castle remains empty unless someone – "like the occasional historian" – attempts the strenuous task of swimming across the moat. When an archivist provides adequate context to an object, he says, it is like opening multiple drawbridges so that different kinds of people have multiple ways of getting into the castle.

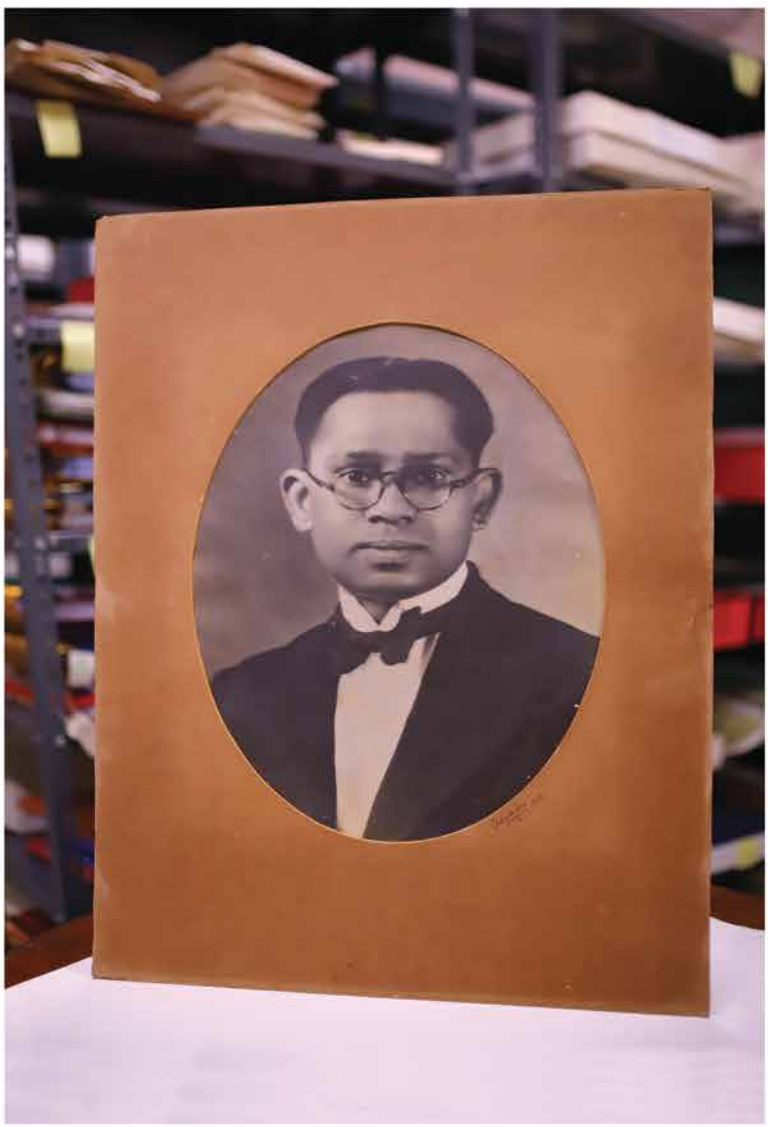
Sometimes, even historians who attempt to swim across the moat find themselves with no way in when there are errors in the finding aid. Savithri Preetha Nair, historian and author of the forthcoming book *Chromosome Woman, Nomad Scientist: EK Janaki Ammal, A Life 1897-1984*, says that her search for Janaki Ammal's letters of correspondence led her to one of the world's leading university library-archives. Typing the name "Janaki" into their system didn't reveal a whole set of related correspondence that had been filed under "Jawaki", a typo that had inadvertently crept in. Trying alternate search terms and finally going through all search results for just "Ja" eventually led her to the letters she was hoping to find. "I told them about the error so that they could correct it," says Preetha. A simple spelling error at the time of data entry very nearly rendered those letters invisible to anyone trying to search for the name of the renowned Indian botanist.

Access to archival material can also be dictated by institutional policy (where records may be classified, for instance), or by privacy laws, issues of ethics or the personal wishes of donors. This was one of the focal points of discussion during International Archives Week in June 2022, where members of Milli, an archives collective, met at NCBS to discuss issues related to ethics, law and archival standards with the aim of developing resources and guidelines that can be used by archives in India. Another key area of discussion was the creation of a common technology platform, which people trying to access archives could use to annotate archival material online, adding context to this material and thereby making it more visible to other users.

So, why archive?

Historically, countries and institutions have had archives mainly as tools for record-keeping and administration. Archives are central to governance, though this has a fraught history – colonial governments, for example, have collected information about their subjects as a method of control. And decisions about what is deemed "worthy" of archiving can be deeply subjective. However, having a good archive can also help to hold governments accountable to their citizens. According to the ICA, "well-managed archives and records are the means by which a country can understand the who, when, where, how and why of government actions. They enable the delivery of human rights and the ability for a government to explain and defend its actions."

Photo: KG Haridasan/IISc Archives



Portrait of V Subrahmanyam, former Chair of the Department of Biochemistry from 1931 to 1949

Apart from their value in governance, archives and archival material are also vital to culture and memory. "Archives enable a diversity of stories," says Venkat. "Every object around us is a by-product of a variety of stories – some by luck, some by process, and some by deliberation." Archival objects, he says, are not of value solely for their content, but also for the things that they are symbols of. A recent example of this is a historic dress that actress Marilyn Monroe once wore in the 1960s, which modern celebrity Kim Kardashian wore again during the Met Gala in May 2022 – a decision that sparked alarm and criticism from conservators and museum curators who were concerned that even those few minutes for which it had been worn might have caused permanent damage to the iconic dress. Kevin Jones, curator of the museum at the Fashion Institute of Design & Merchandising, illustrated the historical value of the dress when speaking to the *LA Times*. He told the publication, "Our job is to get the garment to the next generation with as little damage as possible, so that 500 years from now, these objects are around to talk about our history, our collective history as people, design, technology, arts and culture. […] All of that gets blended into a single object, in this case a garment. It represents a moment in time."

In showing us these moments in time, archives help us to build a picture of our past, and thereby to reimagine and shape the future.

ABSTRACTS

IISc Photography Club