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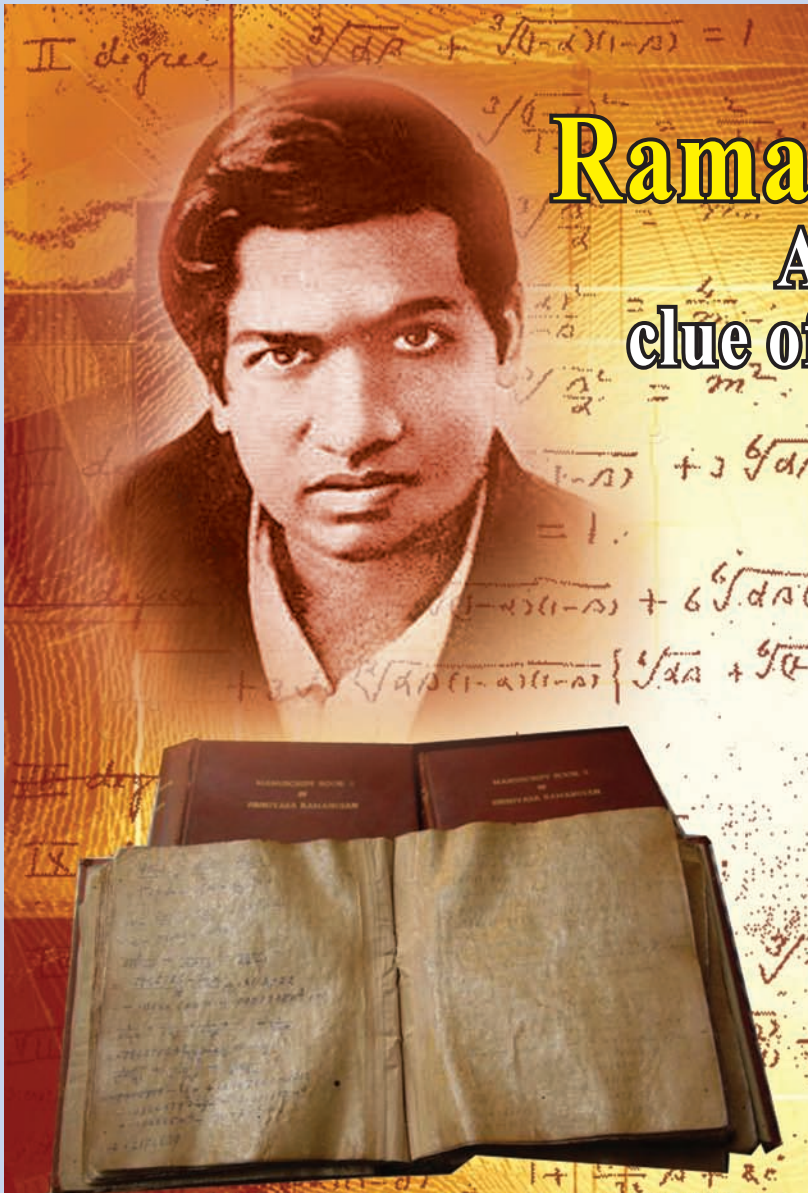

Ramanujan's legacy: Another cryptic clue of Ramanujan solved

Mathematician Srinivasa Ramanujan's handwritten notebooks in the possession of University of Madras Library. Photo: V. Ganesan

Mathematics of Planet Earth 2013

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Renewed impetus for Science and Technology Initiative in India

Dr. R. Gopichandran

The hallmark of success of the 100th Indian Science Congress was the inclusive approach announced through India's most recent Science Technology and Innovation Policy. Importantly, it appears to have generated significant enthusiasm in the hearts of researchers in our country. Innovation receives a specific highlight, aligned with India's efforts to consolidate her position through a strategic knowledge niche that will enable locally relevant and feasible action with implications for quality of life; much as she marches ahead through the present decade and onwards.

The policy statement reflects renewed rigour for technical and institutional support in the form of additional institutions for focussed research that will be in response to the felt needs for scientific and technological support in various sections in our country. The fact that a 100 years of scientific pursuit has progressed through various phases of knowledge consolidation and leadership in traditional, and emerging areas of research and development, signifies India's spread and depth of preparedness to suitably adapt and evolve in the present milieu.

Hundreds of scientists including six Nobel laureates, decisions makers from governments and students converged at the 100th Indian Science Congress. The fact that the President and the Prime minister launched the deliberations, amply resonated with the spirit of the call for value added research and scientific progress voiced by other leaders too, from across the country. The latter was evident through the interactions organised by the Indian Science Congress Association at more than a score of locations across India. A special publication on 21 women scientists, released at the inaugural of the conference, highlighted the convergence and mainstreaming of equity and gender balance considerations, central to sustainable development.

The Science, Technology and Innovation Policy of our country has therefore set the context for inclusive action so that the science and technology fraternity can deliver value added and strategically important services for the benefit of her people. The Indian Science Congress also saw an attractive, educative and focussed display of all institutions of the Department of Science and Technology through a snapshot exhibition. This was truly inspiring. The way forward should actually see synergies and targeted human resources and institutional development initiatives with awareness as a forerunner to appropriate capacity building and applications. There is space for all institutions to deliver through mutually reinforcing cooperation. This coming together has to be guided by a logical framework that suitably integrates empirical evidences of needs and impacts.

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Anna Modayil Mani
A Visionary Scientist with Boundless Energy

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"It was to her (Anna Mani's) credit that India was among the five countries in the world to have its ozonesondes. The data collected by the Indian ozonesonde over two decades enabled a clear picture of the seasonal and geographical variation of ozone in the upper atmosphere over the tropics. She helped to publish a number of papers on the ozone climatology over the tropics in reputed journals."

C. R. Sreedharan in *Resonance,* November 2008

"Her (Anna Mani's) formative years were spent engrossed in books. By the age of eight, she had read almost all the books in Malayalam and, by the time she was twelve, all the books in English at the public library. On her eighth birthday, she declined to accept her family's customary gift of a set of diamond earrings, opting instead for a set of *Encyclopedia Britannica*. The world of books opened her mind to new ideas and imbued in her a deep sense of social justice."

Abha Sur in *Resonance,* November 2008

"In the 1950's when Homi Bhabha was setting up the infrastructure for atomic energy Anna Mani's feminist sensibilities were searching for solar and wind energy. Mani made sterling contributions to the development of meteorology in Independent India.

Arvind Gupta in *Bright Sparks: Inspiring Indian Scientists from the Past*, 2009

Anna Modayil Mani (commonly known as Anna Mani) is one of the most distinguished Indian scientists. She greatly contributed to India's self-sufficiency in meteorological instruments. On realising the potential of solar energy as an alternate source of energy for a tropical country like India she took upon herself the task of generating data on seasonal and geographical distribution of solar energy in India. She worked on a number of projects for harnessing wind energy. Much before the role of ozone in shielding all life forms on Earth was understood, Anna Mani started working on atmospheric ozone. In recognition of Anna Mani's phenomenal contribution to ozone studies, she was made a member of the International Ozone Commission.

Anna Mani was greatly influenced by the ideals of Mahatma Gandhi who led the India's freedom struggle. She wore *khadi* all her life. She is regarded an early feminist. Describing her personal attributes C.R. Sreedharan of India Meteorological Department (IMD), Pune, wrote: "Although she belonged to an ancient Christian Church, she was an agnostic. She never distinguished between people of different faiths. Nature was her passion. She loved going to mountains, to the sea, enjoyed bird-watching, reading, and listening to music. She was emotional and sensitive to the sufferings of others. She loved dogs and always used to keep one or two with her.

Anna Mani

She had friends from all walks of life all over the world. She was a good communicator and made conscious effort to keep with her friends." She did not marry and devoted her to pursuit of scientific studies.

Anna Mani was born on 23 August 1918 in a wealthy family in Peermedu in Kerala, then part of the state of Travancore. She was the seventh of eight children of her parents. Her father was a successful civil engineer and an owner of cardamom estates. Unlike her other sisters, who got married early as it was the custom in those days, Anna Mani decided to pursue higher studies. In this respect she followed her brothers. She developed an avid interest in reading in her childhood.

In 1939, she obtained her BSc (Honours) degree in Physics and Chemistry from the Madras Presidency College. She got a scholarship for graduate studies in the Indian Institute of Science (IISc) in Bengaluru. Anna Mani started working for her PhD degree under the supervision of C.V. Raman at the IISc. She worked on the spectroscopy of diamonds and rubies. She conducted elaborate and painstaking experiments and often spent long hours in the laboratory, stretching to late in the night. Commenting on the work done in Raman's laboratory, Abha Sur, a science historian at Massachusetts Institute of Technology, wrote: "Anna Mani recorded and analysed fluorescence, absorption and Raman spectra of 32 diamonds. She studied temperature dependence and polarisation effects in these spectra…Between 1942 and 1945 she published five single-authored papers on luminescence of diamonds and ruby."

Anna Mani submitted her PhD dissertation to the Madras University, as in those days it was the Madras University which formally granted degrees to the research students working at the IISC. However, she never got the PhD degree. The reason for not awarding her a PhD degree had nothing to do with the quality of her work. The university took a view that she did not qualify for PhD degree as she

did not have an MSc degree. Commenting on the Madras University's decision Abha Sur wrote: "They (the Madras University authorities) chose to overlook that Anna Mani had graduated with honours in physics and chemistry, and had won a scholarship for graduate studies at the Indian Institute of Science on the basis of her undergraduate degree."

C.V. Raman

After working for three years at Raman's laboratory, Anna Mani won a scholarship for higher studies in England in 1945. She wanted to pursue her research interest in physics but the scholarship was meant for working in the area of development of meteorological instruments. In England, she first worked at the Harrow laboratories of the Instruments Division of the British Meteorological Office. Here she studied the evolution of weather instruments, their calibration and standardisation procedures. She also got the opportunities to visit field observatories and manufacturers of meteorological instruments. She also worked for some time at the National Physical Laboratory at Teddington on standards and standardisation for different weather parameters.

Anna Mani returned to India in 1948 after spending three years in England. She joined IMD, Pune as a meteorologist in the Instruments Division at Pune. At the time Anna Mani joined, the Division was headed by S.P. Venkiteshwaran. Later in 1953 Anna Mani became head of this division. Venkiteshwaran had set up a workshop with the purpose of producing simple meteorological instruments like rain gauges, evaporimeters, thermometers, anemometers, wind vanes, and others. Venkiteshwaran was a nationalist and he wanted to develop the required meteorological instruments in the country rather than importing them from England. Anna Mani, who herself was a nationalist, was inspired by Venkiteshwaran to make India self-reliant in weather instruments. She decided to achieve this in shortest possible time by utilising her expertise gained in England.

But then it was not an easy task. The immediate problem was to find enough skilled people having the right kind of expertise to operate the machinery. Such people were not to be found in the country. In those days even simple meteorological instruments like barometers and thermometers were imported. Not much could be expected from the private sector and almost everything had to be done in-house. So Anna Mani's first challenge was to train enough people to make them expert in design, manufacture, calibration, installation and observation. She also standardised and prepared detailed drawings and technical manuals for over 100 different instruments. She helped the Indian Standards Institution (ISI) to publish Indian standards for various weather instruments.

After making significant contribution towards attaining India's self-reliance in meteorological instruments she shifted her attention to solar energy. She realised that India being a tropical country solar energy can provide an alternate source of energy provided it is properly harnessed. To achieve proper harnessing of solar energy the first requirement was a sufficient knowledge of seasonal and geographic distribution of solar energy. Sufficient data on this was not available. Fortunately there was a network of stations in the country for measuring solar radiation. The network was the result of the growing interest in atmospheric physics brought about by the International Geophysical Year (IGY, 1957-58). K.R. Ramanathan played an important role in making India's significant involvement in IGY. The stations were initially equipped with solar radiation instruments produced outside India. It was Anna Mani who took up the task of designing and manufacturing a whole range of solar radiation instruments in the country. Anna Mani ensured that calibration and standardisation meet the world standards. The Instruments Division of IMD at Pune headed by Anna Mani was designated as the regional centre for Asia. As a mark of recognition of Anna Mani's notable contribution to radiation measurements in the tropics she was made Chairperson of the CIMO (The Commission for Instruments and Methods of Observations) Working Group on radiation instruments. She also became a Member of the International Radiation Commission.

K.R. Ramanathan

In 1960, Anna Mani started studying atmospheric ozone at a time when the danger of destruction of atmospheric ozone by human-made activities was not yet appreciated. She undertook the task of developing ozonsonde in India. In this endeavour she got encouragement from K.R. Ramanathan. Ozonesonde is an apparatus for measuring ozone. Because of Anna Mani's dedicated effort India became one of the five countries to have its own ozonesondes. This made possible for India to generate reliable data on atmospheric ozone and the data generated over two decades helped to establish a clear picture of seasonal and geographical variation of upper atmospheric ozone over the tropics. Anna Mani published her research findings on atmospheric ozone in reputed research journals. The World Meteorological Organisation (WMO) took note of Anna Mani's significant contribution to ozone studies and she was made a Member of the International Ozone Commission.

At the request of Vikram Sarabhai, founder of India's space programme, Anna Mani took up the task of setting up a meteorological observatory and an instrumentation tower at the Thumba Rocket launching facility. She and her team completed the task successfully within the stipulated time.

Vikram Sarabhai

In 1976, Anna Mani retired from the India Meteorological Department. At the time of her retirement she was the Deputy Director-General (Instruments). After her retirement from IMD she worked in the Raman Research Institute in Bengaluru as a Visiting Professor. She helped to set up a millimeter-wave telescope at Nandi Hills.

She prepared important publications on solar and wind

energies. Her two publications on solar energy were *Handbook of Solar Radiation Data for India* (1980) and *Solar Radiation over India* (1981), which were produced under a project sponsored by the Department of Science and Technology, Government of India. She had rightly anticipated the potential of wind energy in India and also organised round-the-year measurement of the wind pattern from over 700 sites in the country by using the state-of-the-art equipment so that a plausible assessment of the India's wind energy could be made. This also led to an important publication – *Wind Energy: Resource Survey in India-I* (1983).

Anna Mani established a small factory in the industrial suburbs of Bengaluru for manufacturing instruments for measuring wind speed and solar energy. She hoped that instruments produced in her factory would help to measure solar fluxes and wind patterns in different regions of the country and which in turn would help to develop solar and wind energy.

Let us end this brief write-up by quoting Abha Sur to highlight the fact that Anna Mani did not consider that it was a disadvantage being a woman in pursuing science. Abha Sur wrote: "Anna Mani had a very matter-of-fact view of her life and achievements. She saw nothing unusual in her pursuing physics in an era where it was possible to count all women physicists in India on one's fingertips. She made light of the difficulties and discriminations she encountered as a woman scientist and was disdainful of victim politics. She actively resisted coercive gender identities which limited women's potential as well as posited different intellectual capabilities in men and women. It is no surprise that Anna Mani is a success story which few women (or men) could aspire. She transcended the delimited culture spaces available to her. She not only created her own laboratory but a whole workshop, a mini factory of her own."

She died on 16 August 2001 at Thiruvananthapuram.

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(The article is a popular presentation of the important points of the life and work of Anna Mani available in the existing literature. The idea is to inspire the younger generation to know more about Anna Mani. The author has given the sources consulted for writing this article. All the sources on the Internet have not been individually listed. The author is grateful to all those authors whose works have contributed to writing this article. The sources of the photographs/illustrations are duly acknowledged.)

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Ramanujan's legacy:
Another cryptic clue of Ramanujan solved

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Researchers have finally solved the cryptic mathematical puzzle of Srinivasa Ramanujan. In 1920, Ramanujan wrote a letter to G.H. Hardy outlining several new mathematical functions that had never been heard of before, together with a theory about how they worked. These mathematical functions baffled mathematicians for more than 90 years. But new findings , presented at a conference at the University of Florida during 5-7 November 2012, reportedly show that Ramanujan was right.

Srinivasa Ramanujan

One of the Plenary Speakers during the conference, Ken Ono of Emory University, United States, told the audience that they had finally solved the problems from Ramanujan's last mysterious letter. Prof Ono referred to the problem mentioned in Ramanujan's last letter to Prof Hardy which had been open a challenge to the mathematicians for 90 years. .Ramanujan's legacy, it turns out, is much more important than anything anyone would have guessed when Ramanujan died. 'We proved that Ramanujan was right,' Prof Ono said in his speech, 'no one was talking about the black holes back in the 1920s when Ramanujan first came up with the mock modular forms, and yet, his work may unlock secrets about them.'

Mock theta functions

Ramanujan listed 17 examples of functions that he called mock theta functions. He also listed several other examples of the function in his notebook. Ramanujan used the term "theta function" for what today would be called a modular form. Ramanujan conjectured that his mock modular forms corresponded to the ordinary modular forms earlier identified by Carl Jacobi, and that both would wind up with similar outputs for roots of 1. Nobody at the time understood what Ramanujan was talking about.

Ramanujan's 'simple' pattern

It seems to be an easy problem to find out all possible that a number can be created by adding together other numbers. However, the solution to this leads to a greater understanding of 'partition numbers', a cryptic phrase Ramanujan used to describe sequences.

A partition of a number is any combination of integers that adds up to that number. For example, 4 = 3+1 = 2+2 = 2+1+1 = 1+1+1+1, so the partition number of 4 is 5; i.e. p(4) = 5. It sounds simple. The partition number of 10 is 42, while 100 has more than 190 million partitions! So a function for calculating partition numbers was needed.

Ramanujan was the first mathematician to seriously investigate the properties of this function. He sought a formula for p(n), one which describes the phenomenal rate of growth suggested by the table below:

n	p(n)
0	1
1	1
2	2
3	3
4	5
5	7
.	
.	
50	204226
.	
.	
200	3972999029388
.	
.	
1000	24061467864032622473692149727991

If we arrange p(n) of first 30 numbers (i.e. 0 to 29) in five column form, we get the following table:

1	1	2	3	5
7	11	15	22	30
42	56	77	101	135
176	231	297	385	490
627	792	1002	1255	1575
1958	2436	3010	3718	4565

The striking feature of this table is that every entry in the last column is a multiple of 5.

Ramanujan's approximate formula, developed in 1918, helped him spot that numbers ending in 4 or 9 have a partition number divisible by 5. He proved for every non-negative integer n, that $p(5n + 4) \equiv 0 \pmod 5$.

Ramanujan found similar rules for partition numbers divisible by 7 and 11. Without offering a proof, he wrote that these numbers had 'simple properties' possessed by no other numbers. Later, similar rules were ound for the divisibility of other partition numbers. Therefore no one knew whether Ramanujan's words had a deeper significance.

Ramanujan's work on p(n) inspired research of modular forms. Theory of partitions has historically served as a "testing ground" for some of the deepest developments in the theory of modular forms.

Ramanujan's last letter to Hardy

On 12 January, 1920, just three months before his death, Ramanujan wrote his last letter to Hardy. Ramanujan said in this letter:

"I am extremely sorry for not writing you a single letter up to now. I discovered very interesting functions recently which I call 'Mock' ϑ-functions. Unlike the 'False' ϑ-functions (studied partially by Prof. Rogers in his interesting paper) - they enter into mathematics as beautifully as the ordinary theta functions. I am sending you with this letter some examples."

This letter contained 17 examples. Most of the surviving text of the letter, which included roughly 4 typewritten pages, consisted of explicit formulas for these 17 strange formal power series.

Ramanujan even divided these examples into groups based on their 'order', a term he never defined. Despite these formidable

Mathematics of Planet Earth – 2013

Mathematics is an integral part of our life. We encounter mathematics in our everyday life in different forms. It also plays a predominant role in the overall development of society. An understanding and appreciation of mathematics is therefore an essential life skill. While it aids in solving many real life problems, it also enriches us to develop a logical thinking process.

Mathematics is not about a monotonous and complex collection of techniques for measuring, counting and accounting. Mathematics is also not about remembering complex rules to solve problems in the examination. Mathematics is to develop our logical ability to question, investigate, and explore solutions to many real life problems. Mathematics is perhaps the only tool that helps us in developing and refining such aptitudes.

With this motivation, the international mathematical community brought forward the idea of Mathematics of Planet Earth (MPE) – 2013. More than a hundred scientific societies, universities, research institutes and organisations all over the world have come together to dedicate 2013 as the year of Mathematics of Planet Earth. During this year an attempt will be made to explore the mathematical framework in Nature and to see how mathematics with the help of other disciplines can provide solutions that will help us to face the challenging problems on the planet Earth, like the problem arising out of a growing population competing for limited global resources, the dramatic changes in climate, environmental issues, etc.

The ideas generated and the initiatives planned during MPE-2013 are likely to make an impact on society in such a way that a new generation of researchers will be motivated to explore mathematics involved in solving scientific problems related to sustainability of planet Earth. These efforts may provide opportunities for exploring mathematics with interdisciplinary approaches in the context of evolution of planet Earth and its development.

challenges, a few mathematicians such as G. E. Andrews, L. Dragonette, A. Selberg, and Watson investigated Ramanujan's mock theta functions .

Despite the absence of a theory, or much less, just a simple useful definition of a mock theta function, these few early works bolstered the belief that Ramanujan had discovered something important.

Watson, in his own words: *"Ramanujan's discovery of the mock theta functions makes it obvious that his skill and ingenuity did not desert him at the oncoming of his untimely end. As much as any of his earlier works, the mock theta functions are an achievement suffient to cause his name to be held in lasting remembrance. To his students such discoveries will be a source of delight and wonder until the time shall come when we too shall make our journey to that Garden of Proserpine (a.k.a. Persephone)".*

These 17 examples, together with five examples of mock theta from Ramanujan's notebook have been related to a number of subjects including Lie theory, Modular forms, and Polymer chemistry. Despite this flurry of activity, the essence of Ramanujan's theory remained a mystery. The puzzle of his last letter to Hardy, thanks to the 'lost notebook', had morphed into the enigmatic web of Ramanujan's 22 mock theta functions. This strongly suggested the existence of a theory, and it also demanded a solution.

A new beginning

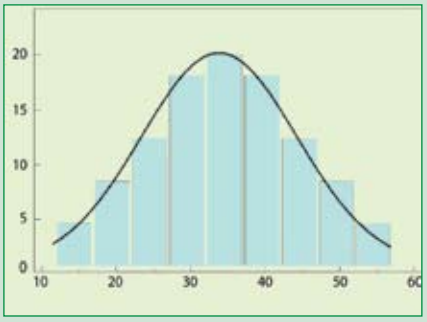
As Ken Ono said, "… Although Ramanujan's last works provided the first examples of such forms, his untimely death and the enigmatic nature of his writings resulted in a great mystery. We will never know how he came up with the mock theta functions. We certainly cannot pretend to know what he fully intended to do with them. However, it is clear that he understood that the mock theta functions would go on to play important roles in number theory."

Ramanujan's mock theta functions or mock modular forms is not only an important tool in analytic number theory, it is applied in several other areas of mathematics like, topological invariants analysis, Lie superalgebras —to name a few.

Ramanujan died before he could prove his theorem. But more than 90 years later, Ono and his team have proved that these functions indeed mimicked modular forms, but don't share their defining characteristics, such as super-symmetry. The expansion of mock modular forms helps physicists computing the entropy or level of disorder of black holes.

International Year of Statistics – 2013

The year 2013 will also be celebrated as International Year of Statistics. More than 1,400 organisations in 111 countries are joining hands for a worldwide initiative that will highlight the contributions of statistics in finding solutions to global challenges. The goal of this awareness campaign is to Increase public understanding of the impact of statistics on all aspects of society and nurturing statistics as a profession.



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Water and Biodiversity: Two sides of the same coin

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Water is our most valuable natural resource. It is essential to all basic human needs, including food, drinking water, sanitation, health, energy, and shelter. Its proper management is the most pressing challenge of all. Without water we have no society, no economy, no culture, and no life. Although water is a global issue, the problems and solutions are often highly localised. Our natural environment supplies clean drinking water. Biodiversity supplements the ability of the environment to do this. The Convention on Biological Diversity (CBD) promotes the restoration and maintenance of biologically diverse ecosystems as a way of improving access to clean drinking water and as a means to eradicate poverty by using the services that healthy watersheds and freshwater ecosystems provide naturally. Human needs and environmental needs are often uneven against each other in a false dichotomy; protecting the interests of one side often harms the interests of the other. But in the case of drinking water, human and environmental interests are clearly aligned. Holistic water management is essential if the world is to achieve sustainable development.

The present focus is on only one, although important, dimension of water: its use by humans for drinking. The linkages between water, biological diversity and development/poverty alleviation aims at raising awareness of sustainable approaches to managing drinking water, which have been tested globally. It also demonstrates how biodiversity conservation can be used wisely to achieve development goals. Many of us never consider water's source. This luxury is unavailable to billions of the world's people, whose water circumstances lead to a daily struggle involving disease, death, hardship and social injustice; women and children are particularly affected. Lack of access to safe drinking water is a primary definer of poverty itself.

Drinking water and poverty reduction

Water that is fit to drink without risk of immediate or long-term harm is fundamental to human well-being. Without food we can survive for weeks, but without water, we can die of dehydration in as little as two days. Water is often scarce. Although roughly 71% of the Earth's surface is covered by water, most of it is saltwater and therefore unusable for drinking. Less than 2.5% of all of the Earth's water is fresh water of which nearly 1.5% is locked up in polar ice-caps and only a small fraction of it is available for human use. This fraction of useable water is also very unevenly distributed. About 2.8 billion people – more than 40% of the world's population – experience some form of water scarcity. Scarcity, as measured by available water per capita, is expected to worsen where the population is still growing significantly – in Sub-Saharan Africa, South Asia, West Asia and parts of South America. Over one billion people in the world lack access to safe water. Roughly two-million people die each year of diarrhoea caused by infectious water-borne diseases; roughly 70% (1.4 million) are children (World Water Assessment Programme 2009). In addition, up to 50% of malnutrition is related to repeated diarrhoea or intestinal infections as a result of unclean water, inadequate sanitation, or poor hygiene. Even malaria is related to poor water management – when water is scarce it is hoarded, providing the shallow stagnant breeding grounds necessary for mosquitoes to spread this deadly disease. Exposure to environmental health risks in early childhood leads to permanent growth faltering, lowered immunity, and increased mortality. Poor water quality, sanitation, hygiene, and inadequate water resource management account for half of the causative factors behind childhood and maternal underweight and hence stunted child growth (World Bank 2008).

Yet humans need only three-to-four litres of drinking water per day – not a significant source of stress on the environment. When we add amounts for other household activities (which vary considerably from tens of litres to more than several thousands of litres a day, depending on economic circumstances), it is substantial. Agriculture, industry, and energy generation are the biggest users of water – it can take up to 10,000 litres to produce a single hamburger, 1,500 to 4,500 litres to produce one litre of bio fuel, and as much as 230,000 litres to produce a tonne of steel. Agriculture alone accounts for 70% of water use worldwide. These amounts, and the stresses they represent on water resources, can be expected to mount in the coming years, particularly given that climate change is frightening on the horizon. Water is not just an issue facing the developing world – but the poorest communities certainly face the most pressing challenges and have the most limited capacity to act.

The Water Cycle

We cannot properly preserve our water resources without first understanding how water circulates through the environment. The water cycle refers to the movement of water on, above, and below the surface of the Earth as ice, liquid water, and water vapour. Water constantly moves over and under the ground, evaporates into the atmosphere, mostly through plants, and then recycles as rain or snow. It is the fundamental way in which the 0.027% of the Earth's fresh water continues to be available for all land-living things, including humans, for food production, industry, drinking water, the maintenance of healthy ecosystems, and a large number of other needs (World Wide Fund for Nature). The same fresh water that we depend on today has circulated in this way since water first appeared on this planet.

Water travels from the Earth's surface to the atmosphere as water vapour through evaporation from surface water and through transpiration. Transpiration is the movement of water through vegetation and soil, and it accounts for 62% of annual globally renewable fresh water. However, the presence of vegetation affects local rainfall patterns, and its large-scale removal can significantly change these patterns; in dry areas this can lead to desertification. The vapour accumulated

through these processes, together referred to as evapotranspiration, condenses to form clouds, which later returns to the Earth's surface through precipitation (rain, snow, hail, and sleet). And the cycle repeats (see Figure 1). Water that seeps underground becomes "groundwater"– the major source of drinking water for many people. In fact, the bulk of the world's liquid fresh water is actually groundwater. The hydrological cycle works relatively quickly above ground, but slowly beneath it. It can take months or years to recharge, and hence rehabilitate, surface waters, but groundwater recharge periods can be in the order of hundreds of years. As a result, groundwater, once degraded, can be extremely difficult – sometimes impossible – to cleanse and restore.

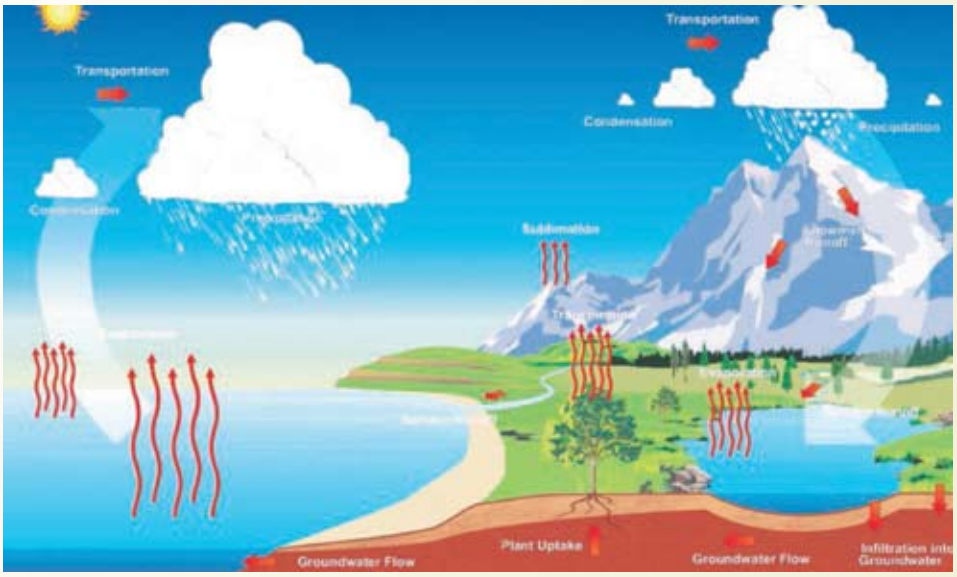

Figure 1: Schematic of the water cycle. (Source: US National Weather Service)

Role of Biodiversity

The term "biodiversity" refers to diversity of life forms – the variety of plants, animals, microorganisms and the ecosystems in which they occur. The vegetation and soil in the environment, in turn, drive the movement of water. Every glass of water we drink had travelled through a number of ecosystems, after which it is cleansed and made fit for human consumption. The undisturbed natural environment, with a few localised exceptions, provides water that is safe to drink in streams, lakes or wells. This supply of water is a "service" (benefit to humans) that the environment provides. Biodiversity is what underpins the ability of nature to provide this service by sustaining the continuous recycling of water, through the hydrological cycle. Forests, for example, influence the hydrological cycle by directly affecting rates of transpiration and evaporation and by influencing how water is routed and stored in a watershed.

Forest soils readily absorb and capture water and also sustain the quality of water: removing forests increases soil erosion, which not only reduces land productivity but also causes major water quality problems downstream.

Forests are clearly rich in "biodiversity," therefore many cities depend on biodiversity for their water. Plants, soils and animals not only sustain the hydrological cycle, they also play a significant role in purifying water. Wetland plants remove high levels of chemicals, such as phosphorous and nitrogen, preventing them from reaching drinking water; many wetland plants can also remove toxic substances, such as heavy metals, from water, accumulating them in their tissues at 100,000 times the concentration in the surrounding water

Poor availability of drinking water is in most cases a direct result of human behaviour. Therefore, where people face problems of poor drinking water supply, there are two general options to find the solution to the problem which are listed below:

Incorporating modern technology, such as water desalinisation or water treatment facilities, are often favoured by planners. These solutions are cost-prohibitive in many poor regions. These costs, in economic terms, reflect the value of the service the ecosystem originally provided before we degraded it.

Reviving ecosystem involves restoring the biodiversity that supports drinking-water provision. Not only is this holistic approach often more economical, it is more effective, as even wealthy nations are discovering.

In relation to drinking water – "biodiversity" is not just about the "conservation of species"; biodiversity maintains ecosystem functions and services that we need to sustain drinking water supplies; biodiversity is a resource to be used sustainably to achieve sustainable drinking water objectives.

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Ways to Win Over Chronic Myeloid Leukaemia

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Fighting the battle to prevail over chronic myeloid leukaemia is by no means an easy task. Still, if the patient holds his courage, and retains his will to live, helpful treatments exist which can rein in the disease. These are trying times, and family and friends must play an affirmative role to tide over the crisis. They must support him with their care, love and encouragement. The key to success lies in positivity.

Some people wrongly think of leukaemia as an infectious disease. This is far from truth. Leukaemia is in no way a communicable disease, and it cannot spread to anybody, be it the spouse, parents or children.

Others fear it to be a hereditary disease. That again is not true. Children or other members of the household do not run a greater risk of acquiring chronic myeloid leukaemia.

Gauging the severity of disease

When a person has cancer, people often wish to know which stage the disease is in. They believe this can give them a clue to its severity. The same question pops up with chronic myeloid leukaemia. People ask, "Doctor, which stage is the patient in? How bad does it look? Will he get better?"

Chronic myeloid leukaemia, however, cannot be categorised into stages. Rather, its aggressiveness can be measured by the phase the disease is in. The phase of chronic myeloid leukaemia is determined by measuring the proportion of diseased cells to healthy cells in the blood and bone marrow. When diseased cells are in a higher proportion, it implies that chronic myeloid leukaemia is at a more advanced stage. Some doctors, to simplify things, however, sometimes loosely call these phases as stage I, II and III.

Chronic phase

The chronic phase is the earliest phase and generally has the best response to treatment. Most of the patients are diagnosed in this phase. The disease may remain stable for years, there may not be many symptoms, and the patient may be able to pursue his vocation normally.

Accelerated phase

The accelerated phase is a transitional phase when the disease becomes more aggressive. This can sometimes be very rapid. In this phase, there are more blasts in the blood or marrow. The patient feels more weak and tired. He may also develop infection, fever and bleeding. The spleen enlarges and the patient may not respond well to treatment.

Blastic phase

The blastic phase is a severe, aggressive phase that can easily become life-threatening. The patient becomes very weak and often requires blood transfusion and hospitalisation.

Treatments and drugs

The goal of chronic myeloid leukaemia treatment is to eliminate the blood cells that contain the abnormal BCR-ABL gene that causes the overabundance of diseased blood cells. For most people, it is not possible to eliminate all diseased cells, but treatment can help achieve a long-term remission of the disease.

Targeted drugs (tyrosine kinase inhibitors)

Targeted drugs are designed to attack cancer by focussing on a specific aspect of cancer cells that allows them to grow and multiply. In chronic myeloid leukaemia, the target of these drugs is the protein produced by the BCR-ABL gene — tyrosine kinase. Targeted drugs that block the action of tyrosine kinase include Imatinib, Dasatinib and Nilotinib.

Targeted drugs are the initial treatment for most people diagnosed with chronic myeloid leukaemia. If the disease doesn't respond or becomes resistant to the first targeted drug, doctors may consider other targeted drugs or other treatments.

Side effects of these targeted drugs include swelling or puffiness of the skin, nausea, muscle cramps, rash, fatigue, diarrhoea, and skin rashes.

Doctors haven't determined a safe point at which people with chronic myeloid leukaemia can stop taking targeted drugs. For this reason, most people continue to take targeted drugs even when blood tests reveal a remission of chronic myeloid leukaemia.

Imatinib

Imatinib mesylate (Glivec) is the standard-of-care today for most people with chronic myeloid leukaemia. The usual dose is a single pill of 400 mg once a day. Most of the patients respond to this treatment extremely well. They also tolerate it very well. Such patients need to take this treatment for life, without any break. The dose must also not be tinkered with. Else, it reduces its efficacy. Some people may have difficulties, and, in that case, may benefit by splitting the daily dose into twice-a-day regime.

The efficacy of the therapy must also be monitored regularly. A thorough clinical examination, blood work (blood cell counts), and cytogenetic and molecular tests are necessary at periodic intervals. If the response is inadequate, the doctor may consider increasing the dose to 600 mg or 800 mg daily.

The cytogenetic tests are based on karyotyping – study of chromosomes. For this test, marrow is removed by suction from the hip bone under local anesthesia and subjected to culture. After a few days, the chromosomes are studied to look for Philadelphia chromosome. At least 20 cells are studied. Carried out at periodic

intervals, this test helps assess the patient's response. Majority of the patients show substantial decrease or total absence of the Philadelphia chromosome within a year or two of starting Imatinib therapy.

However, bone marrow tests are painful. To obviate their need, certain sophisticated techniques like fluorescence *in situ* hybridisation (FISH) and polymerase chain reaction (PCR) test have come to the fore. These tests are expensive, but can be performed on a regular blood sample and can help gauge the behaviour of the disease and its response to treatment.

Blood stem cell transplant

A blood stem cell transplant, also called a bone marrow transplant, offers the only chance for a definitive cure for chronic myeloid leukaemia. However, it is usually reserved for people who have not been helped by other treatments because blood stem cell transplants have risks and carry a high rate of serious complications.

During a blood stem cell transplant, high doses of chemotherapy drugs are used to kill the blood-forming cells in the bone marrow. Then blood stem cells from a donor or a patient's own cells that were previously collected and stored are infused into his bloodstream. The new cells form new, healthy blood cells to replace the diseased cells.

Chemotherapy

Chemotherapy drugs are typically combined with other treatments for chronic myeloid leukaemia. Often, chemotherapy treatment for chronic myeloid leukaemia is given as a tablet a person can take by mouth. Side effects of chemotherapy drugs depend on the drugs used.

Biological therapy

Biological therapies harness the body's immune system to help fight cancer. The biological drug interferon is a synthetic version of an immune system cell. Interferon may help reduce the growth of leukaemia cells. Interferon may be an option if other treatments don't work or if a patient can't take other drugs. Side effects of interferon include fatigue, fever, flu-like symptoms and weight loss.

Lifestyle and home remedies

For many people, chronic myeloid leukaemia is a chronic disease that they will live with for years. Many will continue treatment with Imatinib indefinitely. Some days, they may feel sick even if they don't look sick. And some days, they may just feel sick of having cancer. In these situations, certain self-care measures can help them adjust and cope with the illness. These include:

Taking active measures to beat stress

People with chronic myeloid leukaemia must plan stress-relieving activities to take their mind off their anxieties. They can try yoga, exercise and time with friends and family. Meditation, relaxation techniques like *yog nidra*, visual imagery, and laughter therapy can also work wonders.

Turn to family and friends for support

Stay connected to family and friends for support. It can be tough to talk about your diagnosis, and you'll likely get a range of reactions when you share the news. But talking about your diagnosis and passing along information about your cancer can help. So can the outpouring of practical help that often results.

Seeking emotional support from family, friends, and treating team

Ask for help if you're having trouble coping. The emotional toll of a chronic condition can be overwhelming. Talk to your family members or friends. Tell your doctor about your feelings. You may get a referral to a counsellor or other specialist with whom you can talk.

Connect with other cancer survivors

Consider joining a support group, either in your community or on the Internet. A support group of people with the same diagnosis can be a source of useful information, practical tips and encouragement.

Stick to the treatment

People will often recommend alternative therapies. Lest you get carried away, believe me, most of them are sham promoted by charlatans who have no idea of the disease. Chronic myeloid leukaemia often is a chronic disease and requires long-term treatments.

To help you cope with your cancer journey, stick to the basics:

Seek out a specialist

Ask your doctor about his or her experience in treating chronic myeloid leukaemia. If your doctor has little or no experience in this area, ask about having a consultation with a specialist. Most doctors aren't offended by this and may be willing to help arrange a consult.

Go to all of your medical appointments

People with chronic myeloid leukaemia often face frequent medical appointments, blood work and bone marrow exams. Appointments can bring anxiety because you may fear your cancer is no longer in remission or your condition has worsened. Expect some anxiety around the time of your appointments, but don't let that stop you from going to each one.

Talk to your doctor about your side effects

Powerful cancer medications can cause many side effects, but those side effects often can be managed with other medications or treatments. You don't necessarily have to tough them out.

Don't stop treatment on your own

If you develop unpleasant side effects, such as skin rashes or fatigue, don't simply quit your medication without consulting your health care professionals. Likewise, don't stop taking your medications if you feel better and think your disease may be gone. If you stop taking medication, your disease can quickly and unexpectedly return, even if you've been in remission.

Recent developments in science and technology

Biman Basu
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Gas cooled below absolute zero

Temperature is a measure of the motion or kinetic energy of particles in matter. Till recently, absolute zero or 0 kelvin (0 K or –273.15°C) was considered to be the theoretical lower limit of temperature where all motion stops. Absolute zero was first defined by Lord Kelvin back in the mid-1880s, as the lowest possible temperature state, where atoms stop moving. At absolute zero particles were thought to have zero energy. As such, nothing can be colder than absolute zero on the kelvin scale. Till now it has not been possible to achieve absolute zero in laboratory.

However, over the past several decades, scientists have discovered that there are exceptions to the rule and that at least theoretically, it should be possible for a system to produce conditions where temperatures fall lower than absolute zero. This is possible, they say, because the temperature of a system is generally considered to be the average energies of the particles in it. For example, when water is heated, the water molecules increase their kinetic energy over time and move faster and faster on average. Yet, the individual molecules possess different kinetic energies – from very slow to very fast. Low-energy states are more likely than high-energy states, i.e., only a few particles move really fast. In physics, this distribution is called the Boltzmann distribution.

But a situation can be created in which most of the particles exhibit higher energy levels, and just a few have lower energy, which leads to a reversal of the temperature signs, indicating temperatures below absolute zero. Such a situation can be described as 'inverted Boltzmann distribution'. According to Ulrich Schneider, a physicist at the University of Munich in Germany who led the research team, "The inverted Boltzmann distribution is the hallmark of negative absolute temperature, and this is what we have achieved."

Negative-temperature-system

The scientists have succeeded in forcing a gas to become colder than absolute zero. Using lasers and a magnetic field to manipulate an ultra-cold quantum gas made up of potassium atoms, they managed to coax the temperature of the gas to drop to a few billionths of a kelvin below absolute zero (*Science* 4 January 2013 doi: 10.1126/science.1227831). But, according to the scientists, in the quantum world, the gas is not colder than zero kelvin, but hotter. It is even hotter than at any positive temperature.

To comprehend the negative temperatures scientists have now devised, one might think of temperature as existing on a scale that is actually a loop, not linear. Positive temperatures make up one part of the loop, while negative temperatures make up the other part. When temperatures go either below zero or above infinity on the positive region of this scale, they end up in negative territory.

According to the researchers, these negative absolute temperatures have several apparently absurd consequences: although the atoms in the gas attract each other and give rise to a negative pressure, the gas does not collapse – a behaviour that is also postulated for dark energy in cosmology. One could create heat engines such as combustion engines with an efficiency of more than 100%. This does not mean, however, that the law of energy conservation is violated. Instead, the engine could not only absorb energy from the hotter medium, and thus do work, but, in contrast to the usual case, from a colder medium as well.

While the achievement is not likely to result in the creation of such systems for practical purposes, it does help better understand the principle of temperature, and may, some suggest, help explain other still mysterious phenomenon, such as why the universe is continuing to expand, despite the pull of gravity – which some have attributed to a force called dark energy.

Redefining the kilogram

The kilogram is the SI unit of mass, defined by the General Conference on Weights and Measures (CGPM) as equal to the mass of a cubic decimetre of water. The International Prototype Kilogram (IPK) is a small cylinder of platinum–iridium alloy, about 39 mm in both height and diameter. It is stored in a vault at the International Bureau of Weights and Measures in Sèvres, France. The IPK defines the fundamental unit of mass. Several copies of the IPK are held at laboratories around the world as mass standards. The Indian national standard of mass is copy number 57 of the international prototype kilogram supplied by the BIPM and kept at the National Physical Laboratory, New Delhi. It is a platinum-iridium cylinder whose mass is measured against the international prototype at BIPM. The NPL also maintains a group of transfer standard kilograms made of non-magnetic stainless steel and nickel-chromium alloy.

Although the IPK and its replicas are stored in filtered laboratory air at constant temperature and pressure (under two or more nested bell jars), there is no way to completely isolate them from air pollution and contamination stored in air, and no wonder, industrialisation and modern living have taken their toll on the platinum-based

weights and contaminants have built up on the surface. According to a 2011 report, the IPK had lost about 50 micrograms since it was cast in 1879. But according to a recent study by researchers at Newcastle University in the UK published in the January 2013 issue of the journal *Metrologia*, the IPK may have gained "tens of micrograms in mass from surface contamination".

Maintenance of a standard mass of 1 kilogram of the IPK is essential, as several other units of measurement is based on it. If the kilogram changes, so must the newton; if the newton changes, so must the joule. Unfortunately, the kilogram is not defined in terms of fundamental physical constants as are the other SI units. Ideally the seven base units within the SI (metre, kilogram, second, kelvin, ampere, mole and candela) should be stable over time and universally reproducible, which requires definitions based on fundamental constants of nature. The kilogram is the only unit still defined by a physical artefact.

In the meanwhile scientists have been trying to redefine the kilogram in terms of fundamental physical constants. One alternative suggested is to define the kilogram in terms of the Planck constant, *h*. As part of its 'electronic kilogram project', the National Institute of Standards and Technology (NIST) in USA have been carrying out experiments using the 'watt balance' and have rebuilt nearly the whole experimental apparatus to achieve this improvement. This device, through a few relatively recently-discovered effects, turns the mass of an object into charges racing around a circuit – one of the many forms of energy. It connects a kilogram mass with fundamental, repeatable natural phenomena. According to the researchers, even though the ultimate changes to the kilogram as we now know it may only be in the parts per million or even billion, the microelectronics industry deals in tiny distances and movements of charge. And these could be directly affected by any changes to the kilogram.

At its 24th meeting in October 2011, the General Conference on Weights and Measures (CGPM) agreed in principle that the kilogram should be redefined in terms of the Planck constant, but deferred a final decision until its next meeting, scheduled for 2014.

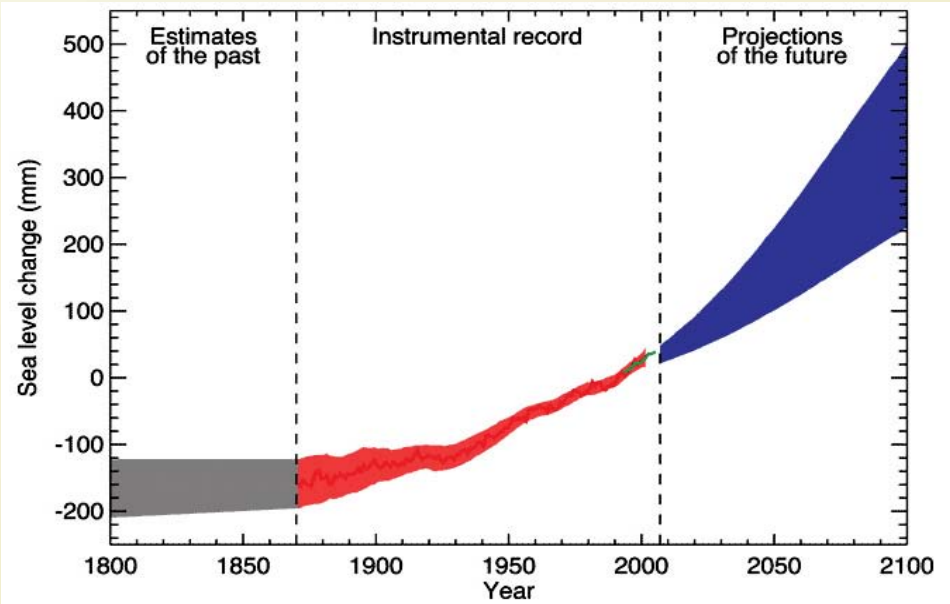
Prototype-kilogram

Future sea level rise may be much greater than estimated

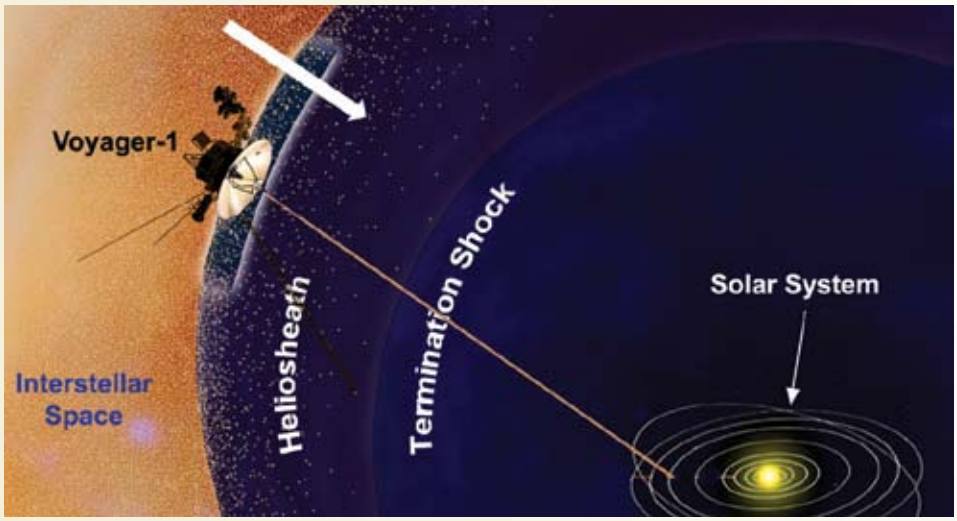
One of the frightening consequences of global warming is a rise in sea level. The Intergovernmental Panel on Climate Change (IPCC) had in its Fourth Assessment Report, which mentioned figures ranging from 18 cm to 59 cm for six possible scenarios. But according to a study by scientists Jonathan Bamber and Willy Aspinall of the University of Bristol, UK, published in the 6 January 2013 issue of *Nature Climate Change* (doi:10.1038/nclimate1778), future sea level rise due to the melting of the Greenland and Antarctic ice sheets could be substantially larger than estimated in the IPCC report.

The ice sheets covering Antarctica and Greenland are the largest potential source of future sea level rise – and they also possess the largest uncertainty over their future behaviour. The Antarctica and Greenland ice sheets contain about 99.5 per cent of Earth's glacier ice which would raise global sea level by some 63 m if it were to melt completely. The unpredictable behaviour of the ice sheets present some unique challenges for predicting their future response using conventional numerical modelling, as is done for weather forecasting. So, it is necessary to look for alternative approaches for predicting ice sheet melting.

The Bristol University researchers used a new approach by carefully soliciting and pooling expert judgements – what is known as 'structured expert elicitation (EE) together with an approach which mathematically pools experts' opinions, to assess the uncertainties in the future response of the ice sheets. EE is already used in a number of other scientific fields such as forecasting volcanic eruptions. Using the new approach, Bamber and Aspinall found that the sea level rise from the melting of ice sheets by 2100 could exceed 84 cm. When



Sea level rise (Credit: IPCC)



Voyager 1 at the edge of the solar system

combined with other sources of sea level rise, the rise could be greater than 100 cm by 2100, which is substantially larger than predicted by the IPCC report and would have deeply profound consequences for humankind. If it is indeed so, then many of the coastal cities around the world would be in danger of inundation.

The researchers also found that the scientists, as a group, were highly uncertain about the cause of the recent increase in ice sheet mass loss observed by satellites and equally unsure whether this was part of a long-term trend or due to short-term fluctuations in the climate system.

Solar system is bigger than thought

NASA's *Voyager*-1 spacecraft reached the edge of the solar system in December 2012 and made a surprising discovery, 35 years after its launch in 1977. The spacecraft is now about 18 billion kilometres from the Sun, which is 122 times the distances from the Earth to the Sun. NASA scientists had expected the spacecraft to reach the so-called heliopause, which marks the boundary between our solar system and outer space by this time. But instead of slipping away from the bubble of charged particles that encloses the Sun and its planetary system called heliosphere, *Voyager*-1 encountered something completely unexpected. It entered a new region at the edge of the solar system that scientists did not even know was there.

NASA scientists have described it as a "highway" of magnetic particles, shepherding *Voyager*-1 out into interstellar space. The *Voyager* team believes this region is where lines of magnetic particles from the solar system are meeting particles from interstellar space. They feel this new region at the far reaches of our solar system is the final area the spacecraft has to cross before reaching interstellar space.

According to NASA, the spacecraft is in a magnetic region unlike any seen before – about 10 times more intense than before the termination shock (the point where the solar wind begins to slow down to subsonic speed). The magnetic field data turned out to be the key to pinpointing when the spacecraft crossed the termination shock. The scientists expect these data will tell them when the spacecraft first reaches interstellar space.

Voyager-1 is powered by plutonium-238 and loses about 4 watts of power a year. By 2020, the science team will have to start turning off instruments in order to conserve power. It is expected to run out of power completely in 2025.

The twin *Voyager* craft – *Voyager*-2 was actually launched first, on 20 August 1977, followed by *Voyager*-1 on 5 September – were designed primarily to study the biggest planets in our solar system, Jupiter and Saturn. Taking advantage of a planetary alignment, they fulfilled that mission before pushing on to Uranus and Neptune, beaming back stunning images of the first two in 1979 and 1980, and the latter pair in 1986 and 1989. *Voyager*-2, which is on a different flight path, is a few billion kilometres closer to the Sun.

NASA has described *Voyager*-1 and its companion *Voyager*-2 as "the two most distant active representatives of humanity and its desire to explore".

Letters to editor

Ruchi Ram Sahni

The editorial 'Remembering Ruchi Ram Sahni' (*Dream 2047* November 2012) was really an eye opener. Sahni was a great contributor to science popularisation and his work could have helped solve many problems of civil society such as superstitions, Tantriks, etc. In my opinion, it is the negligence shown towards the science popularisation, which still puts a large section of our population to have faith on Tantriks, etc, who are making use of some science laws and related experiments to deceive the innocent masses. Ruchi Ram Sahni was at par with any frontier researcher because, spreading science among the masses for their fair and better living is at par with any scientific research, for it is the masses for whom any research is carried out.

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Informative magazine

Dreams 2047 is a magazine that provides information on complicated science topics in simple way which school students can easily understand. The article by Dr. Yatish Agarwal on 'Chronic myeloid leukaemia' (January 2013) was explained in a very simple manner, especially the information on Philadelphia Chromosome (BCR-ABL Gene). I would like to know more on this topic in the forthcoming issues. For example, what is bone marrow transplant? What is the revolutionary drug Imatnib?

Ashish Hegde,
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Bethora Industrial Estate, Bethora 403 409, Goa

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Articles of scientists

I am a research scholar doing PhD without a stipend, and I am preparing for clearing JRF-Exams like CSIR, ICMR, and ICAR. The article on 'Top 10 science stories of 2012' by Biman Basu (January 2013) helped me to recollect the scientific events of the year. But I also request you to publish articles of scientists

Shankar Pillai
sankarshankarpillai@gmail.com

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National Meet of Science Communicators in Indian Languages

A three-day National Meet of Science Communicators in Indian Languages was organised by Vigyan Prasar in collaboration with Vigyan Parishad, Prayag at Vigyan Parishad, Allahabad from 13th – 15th December, 2012. Science communicators from Punjab, Uttarakhand, Uttar Pradesh, Bihar, West Bengal, Assam, Meghalaya, Madhya Pradesh, Jharkhand, Maharashtra, Gujarat, Karnataka, Orissa, Goa, Andhra Pradesh, Tamil Nadu, and Kerala participated in the meet. Major organisations and individuals in different regions working in the field of science and technology communication were invited and representatives presented their work done by their organisations in regional languages.

The meet provided a platform to science communicators and scientists to share the challenges and the prospects of communicating science to the people at grass root level. Discussions took place on different aspects of science communication, means and modes of reaching out to people. The participants talked about the issue of popularising science, science writing, the language, the content, translation, terminologies and the various formats of delivering the information to the public.

The event was inaugurated by Prof. Krishna Bihari Pandey, VC, Chitrakoot University, along with the other dignitaries. The key note address on 'Tools of science communication' was delivered by Prof. Jayant Vishnu Narlikar, Emeritus Professor, IUCAA, Pune. Er Anuj Sinha, Former Director, VP, Dr Saroj Ghosh, Former DG, NCSM, Dr. R Gopichandran, Director, VP attended the inaugural session. Dr. Shiv Gopal Mishra of Vigyan Parishad welcomed all in his welcome address which was followed by opening remarks from Mrs Kinkini Dasgupta Misra, Scientist 'E', Vigyan Prasar.

In the session on 'National initiatives in science communication' chaired by Dr. Saroj Ghosh, speakers Er. Anuj Sinha, Dr Gauhar Raza, Chief Scientist, CSIR-NISCAIR and Dr R. Gopichandran, presented their views on the initiatives taken by the national level organisations like DST, NISCAIR, NCSM, VP in popularising science and the future of science communication in the country. They also discussed different strategies to be chalked out for inculcating scientific temper.

Other sessions deliberated on issues such as 'Science communication in Indian languages through electronic and print medium', 'Science communication through innovative science experiments and distance education,' 'Challenges in science writing, translation and terminology', and 'Science communication in Indian languages – Eastern, Southern, Western, Central, North-Eastern and Northern region'.

Padmavibhushan Prof Jayant Vishnu Narlikar delivering keynote address (sitting from L-R) Prof Shiv Gopal Mishra, Dr R Gopichandran, Er Anuj Sinha, Prof Krishna Bihari Pandey, Padmabhushan Dr Saroj Ghosh and Prof K K Bhutani

Scientists/Officials from State S & T Councils of Uttarakhand (Dr. Ashutosh Mishra), Manipur (Dr. L Minaketan Singh and Ch. Sarat Singh), Meghalaya (Shri. C. P. Syiem), Punjab (Dr. Neelam Gulati Sharma), Andhra Pradesh (Er Nagesh Kumar) and Gujarat (Dr. Narottam Sahoo), and representatives from major S & T organisations working towards science communication in the country, Dr R N Ray (BJGVS, Orissa), Dr. K K Mishra (Jan Shiksha Parishad, Allahabad), Prof. Sugra Chunawala (Homi Bhabha Centre for Science Education, Mumbai), Prof K Papputty and Mrs T K Meera Bai (Kerala Sasthra Sahitya Parishad), Dr Sumangala Mummigatti and Dr. Vasundhara Bhupati(Karnataka Rajya Vijnana Parishat), Dr B.K.Dwivedi (Bioved Research Institute, Allahabad), Shri Dhananjay Chopra (Institute of Professional Studies, Allahabad University), Dr Parul R Seth (National Centre for Science Communicators, Mumbai), Shri Abhijit Bardhan (Science Communicators' Forum, Kolkata), G. Sakthivel Murugan (Anna University), Mr Dinesh Gandhi (Regional Community Science Centre, Vadodara), Mr. Sailesh Gandhi (Rajkot Science Centre), Sri Ram Pandey from Science for Society, Patna, Dr. R G Rao, Goa Science Forum, Dr. Paramjit Singh of BGVS, Punjab highlighted the work being done in science popularisation by their respective organisations.

Dr C K Ghosh (NCIDE, IGNOU), talked about development of scientific temper using open and distance learning system. Dr. Arup Kr Misra, Assam Engineering College, Guwahati, talked about efforts in science communication being made in the North Eastern region by the states of that region. Shri Sanjay Pandey, Lucknow University talked about challenges of science journalism in print media. Dr T V Venkateshwaran, Scientist, VP talked about Science and Television Reflection in his presentation. Shri Rintu Nath, Scientist, VP, in his talk, put forward the challenges and opportunities in learning science through open ended innovative experiments. Mr Kapil Tripathi, Scientist D, VP talked about role of Vigyan Prasar in the development of scientific temper. Dr Amit Chakraborty, Former DDG, AIR gave a historical perspective of science popularisation, current scenario and role of electronic medium such TV and Radio.

Mrs Sandhya Jalal of Lucknow Doordarshan, Dr Shyamal Chakraborty, Mr Sudhir Pal and Mr Shyam Sunder Singh, Dr S. Kumar (Regional Science City Lucknow), Dr Krishna Nand Pandey (ICMR), Mr Manas Ranjan Mahapatra (National Book Trust), Dr Lalit Sharma (National Children's Science Congress) talked about

their organisational efforts. Dr Deoki Nandan, Former Scientist, BARC talked about the institutional efforts of science communication in Hindi in BARC.

A panel discussion, keeping in view of the recent protests and demonstrations against Nuclear Power Plant in the country, on 'Nuclear Energy and Science Communication' was held during the national meet. Role of science communicators in dissemination of evidence based scientific knowledge and removing mis-concepts on nuclear power were discussed among the science communicators in different languages and media representatives. Mr Nimish Kapoor, Scientist D, VP talked about the challenges of science communication on nuclear energy.

A mobile exhibition from Children Science Centre, Indore with exhibitions from National Science Centre, Lucknow, Bioved, Allahabad and Science City, Gujarat were also on display. Popular science books were kept on display and sale by Vigyan Prasar and Vigyan Parishad. Micro level hands-on experiments were demonstrated to the visiting students from different schools/ colleges and participants by Prof. S P Kamat and Dr Savia Torres of Goa University.

Prof K P Mishra, VC, Nehru Gram Bharati University, Allahabad, in valedictory session, focussed on the need of better communicating practices for science communicators on the current issues of development. Prof. Indira Chakravarty, Chief Advisor, CCDU, Govt. of West Bengal, in her valedictory address pointed out the role of science communicators in improving personal and environmental hygiene and water quality usage. Dr Krishna Mishra, Secretary NASI presented her views on the importance of science popularisation in the country.

During discussions many ideas emerged regarding the challenges and prospects of science communication in the country. Based upon the recommendations a 'Way Forward' was prepared for future strategies for popularising science and creating scientific temper in the society and presented by Mrs Kinkini Dasgupta Misra, Scientist E, VP. Mr Nimish Kapoor, Scientist D, VP gave vote of thanks to all delegates and guests. From Vigyan Prasar Mr Kapil Tripathi, Scientist D, Dr Bharat Bhushan, Scientist C, Mr Manish Mohan Gore, JSO, Mr Abhinav Gupta, Programme Officer, Mr Jitendra Singh and Mr Nitin Garg attended the national meet. Dr Deovrat Dwivedi, Executive Secretary, Vigyan Parishad Prayag and Mr Nimish Kapoor, VP anchored the various sessions of national meet.

(Report by: Kinkini Dasgupta Mishra and Abhinav Gupta) ■