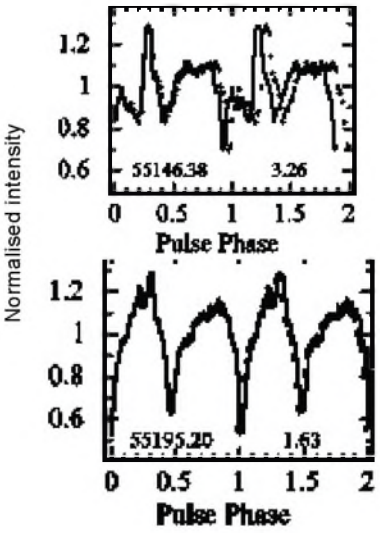
Science Last Fortnight

Curious Case of an X-ray Pulsar

When a neutron star starts accreting material from an optical companion star, it emits a powerful X-ray outburst. Some highly magnetized neutron stars show X-ray pulsations at their spin frequency. These objects are known as X-ray pulsars. The transient Be/X-ray binary pulsar, 2S 1417−624, is one such, discovered in 1978. From the late 90's, space-based observatories, such as the Rossi X-Ray Timing Explorer, have provided clues to its behaviour, allowing researchers to understand how matter behaves under extreme physical conditions close to these stellar corpses.

Researchers from the PRL, Ahmedabad in collaboration with a researcher from Denmark, examined the data from a strong X-ray outburst in 2009 when they observed something strange: a change in the pulse profiles of light coming out of the neutron star's magnetic poles. They found that the emission profile underwent a gradual shift from a dual-peaked pattern to a triple-peaked structure when the pulsar was emitting at its utmost. The observed pattern reverted as the outburst faded.



To explain these puzzling changes in the emission, the team conducted spectral analysis using phase-resolved spectroscopy, a technique that allows exploration of these distant objects as a function of spin frequency. The team realised that the changes in emission geometry are not related to obstacles such as accreting streams of outflow or accretion disk. This finding excited further research. The researchers found that this dead star was accreting close to critical luminosity when the transition occurred in the emission geometry. Below this specific luminosity, high energy photons from the magnetic poles of the neutron star emitted in a straight line, forming a pencil-beam pattern. When the luminosity increases, the presence of a strong shock closer to the surface alters emission geometry. This results in a different kind of emission pattern where the radiation beam fans out, perpendicular to the magnetic field.

This hypothesis was supported by the pulse-fraction, a measure of modulating signal from the pulsating star. When emissions are in the form of pencil beams, a strong pulse fraction is expected. An increase in the un-modulated component from fan-beam geometry distorts the pulsating signal. This explains the variation in pulse profiles in the form of multiple peaks, say the researchers.

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Mosquito Control

Fern extracts

Mosquitoes are vectors for malaria, filaria, Japanese encephalitis, dengue, chikungunya, zika ... The list continues to grow. For a tropical country like India, mosquitoes prove costly.

Many plant extracts have mosquito repellent and insecticidal properties. Chinnaperumal Kamaraj, from the Periyar University, and collaborators from other labs in Tamil Nadu, now suggest ferns, plants of very ancient lineage, for mosquito control.

They selected leaves from five species of ferns and extracted active compounds using methanol. The team prepared five doses and checked their larvicidal activity on *Aedes aegypti*, the dengue vector, and *Anopheles stephensi*, the malaria vector. The researchers found three species promising candidates for further investigation.

The gas chromatography–mass spectroscopy profiling of one species – *Actiniopteris radiate* – yielded seven active compounds. Five dominant compounds had known insecticidal activity.

Mosquito larvae lead an aquatic life. So, the team needed to test environmental safety. They exposed zebrafish embryos and brine shrimp cysts – accepted models for biosafety tests on higher order animals – to the extracts. The researchers found that the extracts do not harm non-target organisms.

The *A. radiata* extract is safer than synthetic pesticides. The researchers say that it is also commercially feasible.

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Diagnosing Malaria

Capacitive aptasensors

Malaria, caused by *Plasmodium falciparum*, can be fatal if not diagnosed in time. Most clinics, however, lack the basic infrastructure to diagnose the disease in early stages. Available methods require expensive equipment and expertise, or are poorly stable in hot and humid climates.

Recently, researchers from the IIT Guwahati, in collaboration with researchers in the UK, developed a simple diagnostic test for detecting *P. falciparum*. They used aptamers – single-stranded DNA oligonucleotides – that fit into the glutamate dehydrogenase protein of *P. falciparum*. Glutamate dehydrogenase is a robust biomarker of malaria in the blood serum of infected people.

The team tested a variety of random single-stranded DNA oligonucleotides from existing libraries. After about 17 cycles of selection, they identified a potential aptamer. They inserted the aptamer into *E. coli* using a vector and selected positive clones.

To attach the glutamate dehydrogenase-specific aptamer on a gold electrode surface, the researchers

created a chemical environment, where the aptamer would self-assemble on the surface of the electrode.

When the serum sample with falciparum glutamate dehydrogenase is applied on the electrode, the aptamer binds to glutamate dehydrogenase and generates a non-Faradaic electrochemical impedance spectroscopy signal.

The capacitive aptasensor could detect picomolar levels of the target antigen, while existing methods can detect only nanomolar levels. So, the test can detect the parasite even in asymptomatic malaria patients.

The test was very specific for the malaria parasite as human glutamate dehydrogenase and serum albumin proteins did not interfere with the functioning of the aptamer.

The test does not require any labelling compound and is, thus, suitable for use even in clinics with minimum infrastructure. The team hopes that the capacitance sensor will be scaled down to a handheld device.

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Breast Cancer Metabolomics

Metabolites as biomarkers

Cancer cells modify several metabolic pathways to meet increased energy requirements. Can the altered level of metabolites in cancer cells be correlated to the different stages of progression of the disease?

Last fortnight, scientists from the Indian Institute of Toxicology Research, the King George's Medical University and the SGPGIMS, Lucknow reported answers to the question.

They collected blood plasma samples from 72 breast cancer patients at the King George's Medical University. The patients were classified into early and late breast cancer, based on disease progression. Blood plasma was also collected from 50 age-matched healthy donors.

The team studied metabolites in the samples using NMR spectroscopy, a technique to identify and characterise molecules. They observed a significant difference in the levels of sixteen metabolites among the three groups. Lactate levels, for example, were higher in the plasma of early and late stage cancer patients than in healthy donors.

Next, the scientists used a predictive model to assess whether these metabolites could act as accurate diagnostic markers of breast cancer progression. According to the model, metabolites such as lactate, N-acetyl glucosamine, glutamate, glucose, lysine and hydroxybutyrate could be potential biomarkers to diagnose early and late stage breast cancer.

Repeating and reproducing these results can lead to technologies for faster and more accurate diagnosis of breast cancer and its progression.

DOI: 10.1016/j.jpba.2018.07.024

Pungency in Chillies

Answer hidden in genes

Bhut Jolokia, from the North-Eastern region of India, is a hybrid of *Capsicum Chinese* and *C. frutescens*. It has the world record as the hottest chilli, up to 850,000 Scoville Heat Units. The pungency is attributed to capsaicin. However, what codes for pungency in chilli genes?

Image: teacoffeespiceofindia.com

Last fortnight, Mayank Rai and team from the Central Agricultural University, Imphal investigated the phenotypic variations and allelic status of pungency genes in the *Capsicum* species.

The team compared two highly pungent germplasm varieties of Bhut Jolokia and Dalle Khursani with a non-pungent bell pepper variety. They found that plant height, stem pubescence and length of leaf blade differed among the chilli varieties.

Then, the team extracted genetic material from the two hot chilli varieties as well as from a chilli variety with no pungency. Using simple sequence repeat markers, they amplified genes of interest. The amplified products ranged between 100 and 260 base pair regions. The team analysed genetic similarities using clustering.

The team focussed on three key regulatory genes for pungency. After allele mining, they sequenced two genes for single nucleotide polymorphisms, and screened for variations. They found uniquely conserved haplotypes with base pair changes in both Dalle Khursani and Bhut Jolokia. There were eight single nucleotide polymorphisms in the intronic region of one of the pungent genes conserved in Dalle Khursani and two pungent reference sequences of *C. annuum.*

The report provides genetic information about the pungency of chillies. A step towards improving chilli species through genetic breeding and towards providing the famous Bhut Jolokia with geographical indication which it lacks, says Mayank Rai, Central Agricultural University, Imphal.

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Reusing Waste Heat

Generating electricity

Waste heat from automobiles and industrial units is an inefficient way of using fossil fuel. Now, a team of Indian scientists have found a way to use this thermal waste to produce electricity.

S. K. Panda and colleagues from the NIT, Rourkela designed a lab-scale experimental rig. They used bismuth telluride based thermoelectric generators that operate on the Seebeck effect: if a temperature gradient is maintained across a thermoelectric material, electricity is generated.

For simulating a heat source, they used a heat gun. The heated air was fed through a steel tube to a heat exchanger. The temperature of the inner wall of the heat exchanger was maintained at 200°C. The outer wall served as heat sink, continuously cooled using a fan. This created a temperature gradient across the walls. Between the interface of wall and sink, the researchers inserted an array of ten thermoelectric generators made of bismuth telluride. The temperature gradient across these generators created electromotive force, generating direct current.

The researchers observed that voltage increased with increase in temperature gradient. At a temperature difference of about 70°C, the setup could generate an average of 10.5 W. The scientists proposed a theoretical model for heat flow rate and voltage output, and validated its accuracy with experimental results.

Presently, reusing waste heat is high cost, requiring moving components, and sophisticated setups. Thermoelectric generators, on the contrary, do not have moving parts and have less wear and tear. They are smaller, slender and simpler to set up.

Upscaling this heat waste recovery prototype can mitigate the damaging effects of fossil fuel consumption.

DOI: 10.1002/er.4157

Human Urine as Fertiliser

India generates some 1–2.25 billion litres of urine every day. Urine, a rich source of essential plant nutrients – nitrogen, phosphorus and potassium – is used as liquid fertiliser in Sweden, the Netherlands, Mexico, Germany and China.

India is the second-biggest importer of urea in the world. Can human urine as liquid fertiliser minimise urea imports? So, urine banks were set up in the Nagpur district. Here, the urine was collected and treated to produce liquid fertiliser. But the idea did not catch on.

What stops us from using human urine as fertiliser? Socio-cultural attitudes or lack of knowledge? Researchers from the Vellore Institute of Technology, Vellore and Chennai campuses, in collaboration with researchers from Sweden, addressed the issue by conducting a survey at the VIT University, Vellore. Around 28,000 people – students, staff and faculty – were invited to respond to an online questionnaire. About 4.5% people responded.

The questionnaire dealt with perceptions of human urine as crop fertiliser, willingness to consume food grown using human urine and whether urine should be disposed of and never recycled.

Interestingly, though 55% considered it fertiliser, only 44% showed willingness to consume food grown using human urine, says Prithvi Simha, VIT University, Vellore campus.

We also found resistance against the concept – 32% of the respondents said that it should be disposed of and not recycled, says M. Ganeshapillai, his colleague from the Mathematics Department at the Chennai campus.

While 65% believed using human urine as crop fertiliser poses a health risk, the majority accepted that proper treatment can avoid risk.

The researchers found that there is willingness to use cow urine as fertiliser and to grow food using it. However, younger respondents were less positive about using cow or human urine as fertiliser.

The team noted that respondents from business or biosciences supported urine recycling. Contrastingly, respondents from the IT, computer sciences/engineering, and electronics sectors as well as those from language schools did not. However, gender, religion and caste did not affect acceptance. But no significant patterns were found.

'Appealing to environmental sensitivities is not enough for introducing environment-friendly technologies', says another team member. Targeted messages are needed to change attitudes.

Further research will help identify what information and agency can help improve acceptance of such technologies. For success, a larger demographic study is needed before introducing any technology, say the researchers.

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Minimising Post Harvest Losses

India is the world's largest producer of cereals, pulses and spices. But, in terms of post-harvest losses, India stands seventh. To feed an ever increasing population, India needs to address the issue.

Bhaskar Gardas, Rakesh Raut and Balkrishna Narkhede, researchers from Mumbai, now provide an analysis of factors responsible for post-harvest losses in the fruit and vegetable supply chain in India. They conducted a detailed literature review and sought expert opinions. They identified fifteen causal factors using a multi-criteria decision making tool, DEMATEL.

The major factor turned out to be poor packaging and storage facilities. This single factor influences all others. Inefficient product packaging leads to wastage of water, labour, fuel and electricity. Strengthening packaging facilities can, therefore, minimise losses, says the team.

Most farm product processing is manual. This is labour-intensive and time-consuming. Skill enhancement and automation will help reduce losses.

The team feels that lack of proper storage facilities and insufficient infrastructure are areas which need urgent attention. Incentives to stakeholders at each level of the supply chain can also reduce losses.

Supply chain members and decision-makers can benefit from the study. It provides a structured solution for reducing post-harvest losses and improving the performance of the supply chain.

DOI: 10.1016/j.jclepro.2018.07.153

Tea Powder Waste

For biogas production?

India is the largest consumer of tea. Small tea stalls mark the entire landscape of India. According to the Tea Board of India, the huge amounts of tea powder waste are of environmental concern. Scientists at the Anna University and the CSIR-CLRI, Chennai worked on the possibility of using this waste as co-substrate in biogas plants to increase biomethane production.

Amudha Thanarasu and colleagues tried tea powder waste as feedstock for anaerobic digestion. They used fruit, food and vegetable waste as main substrate and tea powder waste as co-substrate. For methanogenic bacterial inoculum, they collected sewage sludge from the Anna University sewage treatment plant and enriched it with micronutrients.

The team physicochemically characterised all the substrates. Fruit, food and vegetable waste mainly contains sugars and carbohydrates while tea powder waste is rich in protein. The scientists then experimented with dif-

ferent substrate concentration ratios on a wet weight basis. There were five batches of co-digestion reactors and three mono-digestion reactors. The experiments ran for 60 days at 37°C.

The researchers then analysed volatile fatty acids, carbon and nitrogen ratio, soluble chemical oxygen demand and total solids to monitor feed substrate use. The high nitrogenous content in tea powder waste increased microbial activity and helped convert biomass to methane. It also helped stabilise the pH.

The scientists used water displacement to analyse biomethane production in the reactors. They found that the reactor containing a feed ratio with double the quantity of tea powder waste as co-substrate gave maximum results. Using this substrate concentration ratio, they obtained more than half a litre of biomethane per day. They found that the methane produced was four times more than output from mono-substrate experiments. Based on the optimised values, the team estimated 153 kWh of energy production.

Biogas is a renewable energy source. It is an alternative to fossil fuel. India has the second largest number of biogas plants. National biogas and manure management programmes provide for the setting up of small family type biogas plants for rural and semi-urban households. A pilot scale study with tea powder waste is needed to establish the economic benefits.

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Eco-friendly Technologies

Roadblocks for industries

Small and medium enterprises and large scale industries are considered the backbone of the Indian economy. However, the manufacturing sector is responsible for degrading the environment. Therefore, it is necessary to shift from conventional manufacturing to eco-friendly technologies. Though such technologies can lead to financial gains and a better image, their adoption is limited. Now, Minhaj Ahemad and Dinesh Seth from Nagpur, in collaboration with Rakesh Shrivastava in Qatar, explore why.

Available literature did not provide details of factors that lead to the adopting of eco-friendly technologies in the Indian context. Do drivers of technology adoption differ between SMEs and large industries?

The researchers consulted experts from manufacturing industries, covering both SMEs and large industries. The experts included decision makers, senior managers, consultants and seasoned academicians. Based on interpretive structural modelling, the team found no autonomous driver. Both sectors had similar drivers: top management commitment, environmental regulation and stringent execution backed by legislation, product processes, packaging and a reduce–reuse–recycle strategy. Other contributing factors were awareness, education and training, as well as energy conservation and using alternative energy sources.

The researchers found that, for SMEs, monetary assistance is important while large industries prefer government collaboration. Quality was a major concern for SMEs. Large industries, on the other hand, seek employee involvement and commitment, post-training and empowerment. Large industries have more awareness about eco-friendly supply chains and display greater readiness to use them. Overall, for going eco-friendly, SMEs focused on strategic organisational transformation while large industries focused on cost reduction and market leadership.

Appropriate policy measures and strategic interventions can encourage SMEs and large scale industries to adopt environment-friendly technologies.

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Continuous Activity Recognition

Kinect connects movements

Automatically tracking behaviour from data captured by cameras or wearable devices is a trending topic in research. However, existing techniques only recognise isolated activities. Human activities are inherently continuous, with spatial and temporal transitions between various activity segments. Therefore, there is a need for a system to recognise continuous human activity.

Recently, scientists from the Roorkee and Bhubaneswar IITs developed a framework to recognise continuous human activity using Kinect – a line of motion sensing input devices. The line is based on webcam-style add-on peripherals. Users control and interact with their computer using gestures.

The scientists captured 3D skeleton trajectories of the positions of 20 joints. They grouped recorded sequences coarsely into two activity sequences, performed sitting and standing. Then, fine level activities in the segmented sequences were recognised. For both stages, the team used a Bidirectional Long Short-Term Memory Neural Network Classifier.

The team recorded thousands of continuous action sequences using a combination of 24 isolated human activities. Using the classifier, they achieved recognition rates of about 65%.

The scientists compared results for isolated activity recognition with those from existing approaches. The new approach was superior.

They suggest extending the work by combining sequence classifiers. Alternatives for sequence alignment along with different topologies of the neural network can also improve recognition.

The technology can, perhaps, help dementia patients overcome difficulties in day-to-day activities. It could connect them with remote caregivers who could quickly act when required.

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