

Science Last Fortnight

Arsenic Contamination in Wheat *Risk of cancer*

Arsenic poisoning leads to lung, bladder, kidney and skin cancer in extreme cases. We now know that rice cultivated in arsenic-contaminated soils takes up arsenic. And eating such rice leads to arsenic toxicity. Though wheat also accumulates arsenic, it has not received the same attention.

Debapriya Mondal was concerned. The food habits of large populations have shifted from rice to chapatis and other wheat-based products. And due to ease in transportation, wheat can now reach even remote villages. So, Debapriya and a team of researchers in Patna undertook a case study in arsenic-affected areas in Bihar.



Image via pxfuel

The team collected wheat samples – both flour and grains – from 77 households across 19 villages, along with the socio-economic background of the households.

'From the survey we found that, while 78% of the population consume rice daily, 99% have wheat-based food products daily', says Sidharth Suman, A.N. College, Patna.

The wheat samples collected were analysed for the amount of arsenic present. The team found that arsenic contamination was about twice the amount previously recorded in the area.

'Wheat is an important source of various minerals. We found that the arsenic concentration is negatively correlated to manganese, but positively correlated with magnesium. Further studies will help us better understand how arsenic contamina-

tion reduces wheat's nutritional value', says Pushpa Kumari Sharma, A.N. College, Patna.

The team also used a probabilistic model to identify the risk of cancer, based on the amount of arsenic contamination in wheat. The model predicted increased cancer risk as a result of consuming contaminated wheat. The risk was, however, lower in females than in males.

It is important to take steps to control heavy metal contamination, because wheat products are not restricted to any area. Due to ease of transport and large-scale consumption of wheat-based products, a much larger population might be at risk.

Regular checking and data collection of such heavy metals in food is required to keep arsenicosis from becoming a public health problem even in areas where groundwater used for drinking or irrigation and soils are not contaminated with arsenic.

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Plastic Debris *Kerala coastal zone*

January 1, 2019. The Government of Tamil Nadu bans single use plastics. This New Year, the Government of Kerala followed suit. Other state governments will soon join the ranks. But has public awareness of the issue increased?

Recently, R. S. Robin and colleagues from the National Centre for Sustainable Coastal Management, Chennai collected samples from nine coastal districts in Kerala based on criteria such as urbanisation, tourism, fishing and shipping.

They looked at the characteristics, abundance and distribution of the samples and quantified the presence of microplastics in marine fish, beach sediments and coastal waters. To identify the types of microplastics present, the samples were examined under a stereo microscope with a digital camera. Fourier transform infrared spectroscopy with attenuated total reflectance identified the chemical composition of the microplastics.

The researchers used quality controls to avoid contaminating the samples and to ensure the quality of the results obtained. They found that Thottappally had the highest abundance of microplastics. Water discharge from the catchment areas of the Pamba, Achancoil and Manimala rivers to the Alappuzha coast flow through the Thottappally Spillway. This could be why there is a higher concentration of microplastics.

Thaikadappuram beach in the Kannur district had the least amount of microplastics. The area has relatively low population density and almost no major industries.

The researchers say that about 21 per cent of sampled fish had ingested microplastics. They highlighted the quantity of microplastics at various coastal areas of Kerala using a map.

'Micro-plastics could be the source of marine metal intoxication affecting marine and marine dependent ecosystems', says R. Ramesh, National Centre for Sustainable Coastal Management, Chennai.

Banning plastic is perhaps only the first step. Identifying and curbing plastic pollution may also need to be taken up.

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White Passion Flower *Pacifying ulcerative colitis?*

White passion flower, *Passiflora subpeltata*, grown as an ornamental plant, is rich in polyphenols. So, it has antioxidant, anti-inflammatory and hepato-protective properties. The species is also known for analgesic, antipyretic and antimicrobial effects. Tribals in the Western Ghats traditionally include it in their diet to reduce pain and inflammation. Could the plant offer hope for gastric ulcer?

Parimelazhagan Thangaraj from the Bharathiar University, Coimbatore, in collaboration with Saravanan Shanmugam and researchers in Brazil, recently revealed 15 polyphenolic compounds in the flower. Now they

report investigating its intestinal anti-inflammatory activity.



Image: Wikimedia Commons

They used both rats and mice for their experiments, randomly dividing them into five groups of six each for an experiment that lasted 11 days.

The first group served as control. The second group, treated with indomethacin on days 8 and 9 to induce ulceration, served as negative control.

The researchers treated the third group with indomethacin for two days along with prednisolone for 4 days starting from day 8. For the fourth and fifth group, acetone extracts of *P. subpeltata* leaves were given. And on days 8 and 9, the experimental animals were also given indomethacin to induce ulceration in the stomach.

On day 12, the animals were dissected to evaluate the gastrointestinal tract. The researchers found that the leaf extract at a dose of 400 milligrams per kilogram exhibited strong therapeutic effects. There was a significant reduction in inflammation in animals treated with the plant extracts and in those that were treated with prednisolone.

The researchers found that the plant extract also helped the rodents gain body weight. The weight of the intestinal segments had also increased.

The team evaluated the diseases induced in the experimental rats based on haematological properties, enzymatic antioxidants, macroscopic and microscopic characteristics.

They also found that the plant extract reduced neutrophil infiltration, inhibited myeloperoxidase assay enzyme levels and controlled the levels of expression of enzymatic antioxidants – superoxide dismutase, catalase enzyme, lipid peroxidase, etc.

Anti-inflammatory activity was significantly increased with the suppression of nitric oxide activity and tumour necrosis factor levels.

'The data suggests a synergistic effect of the plant extract for pharmacological properties', says Saravanan Shanmugam, Federal University of Sergipe, Brazil.

'Further clinical studies will evaluate the leaf's effects as alternative and/or additive therapy to manage ulcerative colitis', says Narendra Narain. 'It may even help prevent IBD'.

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Osteogenesis in Bone Fractures

Symphytum is safe and effective

Symphytum, a homeopathic medicine, is reported to help heal blunt injuries, bruises, fractures, dislocated joints, damaged muscles and tendons. It is often recommended for consolidating bone fractures and to accelerate bone mineralization. The homeopathic remedy contains highly diluted extract of the roots of *Symphytum officinale*, the comfrey plant. But research has not yet examined how these orthobiological properties operate.

A. Khurana, from the Central Council for Research in Homeopathy, was curious: could the homeopathic remedy stand up to research? He got together with Sudip Sen and other researchers from AIIMS Delhi to determine if homeopathic doses of the plant root could help mesenchymal stem cells differentiate into osteoblasts – bone cells. Mesenchymal stem cells are multipotent cells that migrate to the site of a bone injury such as a fracture and differentiate into osteoblasts.

B. Garg at the Department of Orthopedics at AIIMS, New Delhi collected bone marrow samples from 15 patients who had undergone bone grafting procedures. They isolated mesenchymal stem cells using flow cytometry.

To make the homeopathic medicine, the roots are powdered and phytochemicals are extracted with ethanol. The liquid is strained and the extract is filtered. This forms the

mother tincture potency of *Symphytum officinale*. Higher potencies are prepared by diluting the mother tincture.

The team evaluated homeopathic *Symphytum*'s cytotoxicity. Though the plant root extract is toxic, the homeopathic potencies used, they found, are not toxic.

Then they induced osteogenic differentiation in mesenchymal stem cells with β -glycerophosphate, ascorbic acid and dexamethasone over 2 weeks. They added different homeopathic doses of *Symphytum* to the basic differentiation medium and measured the efficiency differentiation of mesenchymal stem cells into osteoblasts using flow cytometry as well as by evaluating the expression of osteocalcin and alkaline phosphatase activity.

They also evaluated gene expression analyses for osteoblast markers in differentiated osteoblasts using Q-PCR. Gene expression analysis showed increased expression of genes involved in osteogenesis when *Symphytum*, especially the mother tincture, is added to basic differentiation medium.

'Our findings suggest that the homeopathic dose, especially the mother tincture, of *Symphytum officinale* has the potential to enhance osteogenesis,' says J. Jingar, AIIMS, Delhi

'The morphological findings at the molecular level demonstrate the osteogenic potential of *Symphytum officinale* in its homeopathic form,' says S. Agrawal, Department of Biochemistry, AIIMS, Delhi.

'*Symphytum officinale* mother tincture can be an economical and efficacious alternative to existing therapies to treat bone non-union and complicated fractures', insists B. Garg, AIIMS.

'But we need more studies to demonstrate the overall effect of *Symphytum officinale*,' adds D. Dey, his colleague.

There have been attempts by scientists to downgrade homeopathy since the methodologies used in the discipline differ from those used in mainstream medicine. Now, homeopathic researchers are bridging the

chasm between the disciplines using the methodologies of modern science.

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Indian Coral Tree *Corralling depression*

To control depression, we use selective serotonin reuptake inhibitors. However, side effects include coma, seizures, cardiac toxicity and sexual dysfunction. In pregnancy, the drugs affect the embryo. Moreover, discontinuing these drugs abruptly is dangerous because of withdrawal symptoms.



Image: Kai Yan via flickr

Erythrina variegata is used by South Indian traditional healers to treat mental illness. Stress is relieved by the tree's shade, say Sanskrit texts. And, in rodents, the stem bark extract is anxiolytic, reports research. Research appears to confirm that the Indian coral tree can be used for neuromuscular blocking, as smooth muscle relaxant, and as central nervous system depressant. But how does it really work?

Brijesh Sukumaran and Jeanette Martins from the Narsee Monjee Institute of Management Studies, Mumbai recently reported researching the action of the ethanolic extract of the plant bark in animal models of depression.

The duo subjected mice to the forced swim test, a model to assess behavioural despair in rodents. The animals are deemed depressed when they stop swimming or make only small limb movements.

The researchers divided the mice into six groups. Group 1 was control. To Group 2, they gave escitalopram, a selective serotonin reuptake inhibitor. Groups 3–6 were treated with *E. variegata* bark extract at different doses.

The forced swim test was done an hour after a single dose of either saline or escitalopram or the plant bark extract was administered. The researchers found significant reduction in immobility time periods when the extract was used as adjunct with escitalopram.

Compared to when escitalopram was used alone, the team found that when the extract was used in conjunction, there was significant inhibition of monoamine oxidase A and B activities.

Monoamine oxidases are implicated in depression and are the point for action of most first-generation antidepressants.

The team also tested the extract on the chronic depression model created by using relatively minor and unanticipated irritants that lead to an inability to experience pleasure in some. In this case, it consisted of six different kinds of stressors – tail pinch, cold water swim, food deprivation, water deprivation, cage tilting and soiled cages. The mice were exposed to one type each day for a period of three weeks.

Every day, the rodents were given escitalopram or the extract and the forced swim test was performed on day 21 of the stress study, one hour after oral administration.

The researchers divided the mice into seven groups of five each. Group 1 served as the non-stress control group. Group 2 was a stress control group. Groups 3 and 4 were administered different doses of escitalopram and groups 5–7 were treated with a combination of escitalopram and varying concentrations of the extract.

The mice in groups 2–7 were subjected to the chronic unpredictable mild stress paradigm over a period of three weeks.

After three weeks, the forced swim test was performed for all the groups. Then brain samples were collected and monoamine oxidase-A and -B activities were evaluated. These enzymes were seen to be more inhibited in animals treated with the plant extract in combination with escitalopram, than in those treated with escitalopram alone.

'The antidepressant mechanism could be via the inhibition of monoamine oxidase-A and monoamine oxidase-B activities', conjectures Jeanette, NMIMS, Mumbai.

'The presence of specific phyto-compounds in the extract could also be exerting a synergistic antidepressant action', adds Brijesh.

The extract can potentially serve as adjunct to selective serotonin reuptake inhibitors to decrease drug doses in clinical practice, to reduce the drug toxicity profile.

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Enzyme Stability *Curry leaf extract and nanoparticles*

Enzymes have high demand in the food, beverage and pharmaceutical industries. These bio-catalysts help increase chemical reaction rates. However, at high temperatures, these protein catalysts are not stable. And, once used, they are also difficult to recover and reuse.

Recently, Sathyanarayana N. Gummadi and team from IIT Madras along with Matheswaran Manickam from the National Institute of Technology, Tiruchirappalli reported improving enzyme stability by modifying them with nanoparticles.

They selected xylose reductase, an enzyme that reduces xylose to xylitol, a low calorie, anti-cariogenic natural sweetener. Xylitol has many applications in the food and pharmaceutical industries.

The team took magnetite nanoparticles and used L-cysteine amine as a functionalising agent and activated the complex with glutaraldehyde.

The cysteine-functionalised magnetite nanoparticles were prepared by simple precipitation using the extract of curry leaf, *Murraya koenigii*.

Then the team treated the xylose reductase with this nanoparticle and continuously mixed the product in a centrifuge for five hours and collected the supernatant and pellet of xylose reductase-bound nanoparticles.

The team estimated the protein content in the supernatant and the pellet. They found that the enzyme and nanoparticle ratio of 1 : 5 is efficient for best immobilization.

The team also examined the concentration of nanoparticles, enzymes and cross-linking time.

When they compared the activities of free and immobilized xylose reductase, using a spectrophotometer, they found that the immobilized enzymes had higher binding affinity towards the substrates than the free enzymes.

The team also reported eighty-five per cent residual activity of immobilized xylose reductase was retained after five hours.

The free enzyme and the immobilized enzyme exhibited a similar half-life.

'But, since immobilised enzymes have higher binding affinity, the process is more efficient', says Harshiny Muthukumar, IIT Madras.

For industrial and biological applications, enzyme–nanoparticle bioconjugates have advantages over free enzymes.

'The nanoparticles make it easy to separate the enzymes from the reaction mixtures', adds Shwethashree Malla, her colleague.

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Tackling Terror

Decoding network dynamics

Every now and then we hear of terror attacks. We usually relate it with religion and politics. The degree and spread seems on the rise. Anti-terrorism squads deal with the problem. However, can research decode how attacks operate and help predict them?

S. S. Husain and his colleagues from Jawaharlal Nehru University examined the dynamics. They took data from 1970 to 2016 from the Global Terrorism Database – a list of 170 thousand with 135 attributes such as location, time, source, target...

They created a graphical network connecting source and target where the thickness of connecting lines was proportional to the impact and frequency of attack. They then used another algorithm, a Disparity filter, to identify existing heterogeneity and correlations and weights based on chosen cut-off parameters. Thus,

they created the backbone of the network.

The terror network grows differently at different places. The backbone structure confirmed an exponential rise in incidence. It also identified active sources.

They found that frequent recurrence of star-like structure of hubs and vulnerable motifs is due to a single source operating at multiple targets. Using the backbone structure, they identified the Muttahida Qami Movement, Tehrik-i-Taliban Pakistan, Islamic State, Laskhar-e-Jhangvi and Baloch Liberation Front.

'Local circumstances play a key role in framing anti-terrorism policies', says Husain.

'Network analysis can provide useful insights for framing preventive measures', adds Anirban Chakraborti.

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Science to Sustainability

Indian Higher Educational Institutions

1991. M. C. Mehta, a renowned advocate in the field of environmental law, requested the Supreme Court to make environmental studies compulsory in Indian schools and colleges. The objective was to educate children about the environment such that they understand their right to a healthy and clean environment as well as abide by their fundamental duty of protecting and improving the environment. Following a long battle, in 2004, Environmental Studies became mandatory in schools and colleges. Around the same time, the world had started exploring and setting goals for sustainable development, where political, socio-economic and environmental aspects form three pillars.



Image via Wikimedia Commons

It is time for higher education institutions, who train professionals in various fields of developmental activities – Engineering, Law, Architecture,

Design, etc. to move from teaching only basic environment-related concepts to a holistic concept of sustainable development. But how do we incorporate sustainable development in education?

Priya Priyadarshini and P. C. Abhilash from the Institute of Environment & Sustainable Development, BHU, Varanasi have now come up with a detailed framework. They advocate the infusion and diffusion models to incorporate sustainability in curriculum.

In the infusion model, sustainable development is introduced into the curriculum such that students get a holistic view. The diffusion model incorporates various concepts of sustainable development in already existing courses. All these topics can be taught through lectures, experiential learning, field visits, activities, and case studies to bring in the importance of the practical applications of this course.

The team also suggests a timeline and responsibilities of different ministries such as MHRD, NITI Aayog and the UGC to incorporate Sustainability Studies into the curriculum of Higher Education Institutions.

'Integrating concepts of sustainable development in courses is a sure way to propel India's trajectory for achieving UN-Sustainable Development Goals 2030', argues Priya, BHU.

'Education is a way of building ethics in professionals. Including sustainability studies will help build the right ethos in the political and socio-economic activities of the young,' says Abhilash, her colleague.

Do we wait till somebody goes to the Supreme Court before any action is taken as was the case with environment studies, we wonder.

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