

## Science Last Fortnight

### Triple Negative Breast Cancer Targets for combination therapy

Triple negative breast cancer is the most aggressive form of breast cancer prevalent in women under forty. Triple negative breast cancer is called thus because the cancer tissue lacks expression of oestrogen and progesterone receptors and access to human epidermal growth factor 2. Due to the absence of hormonal receptors, hormone therapy is not possible. And the cancer develops resistance against chemotherapy, rendering patients and clinicians helpless against this aggressive disease.

So Deepak Mittal from BBRC Bengaluru collaborated with Prahlad Raninga, Kum Kum Khanna and colleagues from Australia and Taiwan to work on triple negative breast cancer. The team noticed that the redox status of the cancer cells was different. They found that the cancer cells survive and thrive even under high oxidative stress. They evaluated the expression of antioxidant genes in patients using available databases. And they found a higher expression of thioredoxin reductase, a member of antioxidant gene families. Increased thioredoxin reductase keeps thioredoxin in the reduced form. The reduced form of thioredoxin is active against oxidative stress. This perhaps is why the cancer cells have a higher survival rate.

The scientists hypothesised that the inhibition of thioredoxin reductase can increase the oxidative stress of the cancer cells to toxic levels resulting in reduced tumour growth. They tested this using auranofin, a well-known thioredoxin reductase inhibitor, in the mouse model and found a reduction in tumour growth.

But there was no complete inhibition of tumour in their animal studies. So they evaluated the immunity status of the animals used in the study. They found a higher expression of programmed death ligand-1, a protein on the cell membrane. Though auranofin inhibits tumour

growth, it also increases the expression of programmed death ligand-1. This protein interacts with a protein on the surface of T cells and stops the initiation of programmed cell death or apoptosis of the cancer cells. Thus the cancer cell evades the immune surveillance.

The researchers therefore thought of using an antibody against the programmed death ligand-1 and tried a combination of the antibody and auranofin, the thioredoxin inhibitor.

Due to the synergistic effect of the two, they found very encouraging results. 'A combination of auranofin and anti PD-L1 antibody may prove a potential targeted therapy against triple negative breast cancer', says Prahlad Raninga, from Australia.

'However, this is an animal study. Further studies and human clinical trials are needed before the combination becomes available to patients', says Kum Kum Khanna, his colleague.

Programmed death ligand-1 is known to be overexpressed in many other cancers. So the results may have implications for the treatment of other cancers too.

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### Arsenic Mitigation in Rice Intermittent irrigation

Paddy cultivation requires a large volume of water. When rainwater is not available, farmers use groundwater to fill the field with up to 10 centimetres of water. In the Ganga Delta Plain, groundwater is highly contaminated with arsenic. Using contaminated groundwater over the last three decades has led to increasing arsenic load in the soil and accumulation in rice, a crop which is more vulnerable to arsenic accumulation than other crops because of the high mobility of arsenic in waterlogged conditions.

Sutapa Bose and her research team from the IISER Kolkata hypothesised that aerobic rice cultivation can help reduce the uptake of arsenic by rice plants.

From 2013 to 2016, the team conducted extensive field studies in the Nadia district of West Bengal where the paddy fields are highly loaded with arsenic. They selected 8 plots – 6 experimental and 2 controls. The control plots were irrigated with rainwater throughout the study period. In three experimental plots, they planted rice in raised beds within the field. The other three plots were conventional fields. They used intermittent flooding in the plots with raised beds whereas the conventional plots had continuous flooding.



Image: needpix.com

Every 20–25 days, they collected soil and rice plant samples randomly at different stages from the plots from planting to harvest and analysed the arsenic concentration in the soil and rice plants

Over the study period, the researchers found that the concentration of soil metals – arsenic, iron and manganese – in the contaminated plots increased owing to irrigation with contaminated groundwater. The control field irrigated with stored rainwater had safer limits of all metals and was arsenic-free.

The rate of arsenic accumulation was more or less the same in plots irrigated with groundwater. In the raised beds that had intermittent flooding, however, they noticed considerable reduction of soil arsenic. This is because rice root activity determines the absorption and uptake of metals from soil. The absorption ability of rice depends on soil aerobic conditions, crop variety and soil properties.

The team found that the bioavailability of arsenic in soil is reduced to below 15% in the intermittent flooded system whereas there was an increased level in the continuous flooded system – up to 20% every year. Intermittent flooding reduced physiological stress in the rice plants and paved the way for higher grain production and lower environmental risk.

Agricultural extension and research institutes can pilot this proposed method for ensuring food and nutritional security and getting higher yield.

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### Migrants and Locals Apportioning resources

Within the Indo-Burma biodiversity hotspot, there are three wetlands – Narathali, Rasik Beel and Rasomati. Staging and wintering areas for water birds migrating along the East Asian-Australasian Flyway. From October to March, every year, birds from afar flock here without visas or passports and join birds endemic to these wetlands.

After a field study of three consecutive migratory seasons, from 2012 to 2015, Asitava Chatterjee from the Kangsabati South Divisional Forests, Purulia recently teamed up with researchers from the Government College of Engineering and Leather Technology and the Jadavpur University, Kolkata to report species diversity and niche apportionment among water birds in these wetlands.



Image: Wikimedia Commons

Using field observations and transect walks for counting birds seen on land or water and measuring distances with a laser range finder and night vision binoculars with well-defined ranges and documenting conditions where the birds were found, they identified 27 species.

Thirteen were migrants, visiting only during winter.

Birds neither sow nor reap. So how do populations of different species get along with those of others? How do they resolve conflicts for food resources?

Some birds skim water with their beaks for food, some dip their head, some go down deeper and some even dive further into water. The researchers measured water depths from shore to shore, at one metre intervals, using a boat and a string marked in centimetres with a weight attached to it. Thus they could divide water bodies into shallow, medium and deep portions.

They also sampled vegetation in each area, including submerged vegetation, scooping samples out from the bottom. The team identified the foraging habitat and foraging technique of each species. There were nine distinct foraging habitats. Using information on foraging habitat, foraging technique, depth of water where the species foraged and type of food consumed, they clustered the species into five separate guilds: birds that forage in medium and shallow water and eat a variety of food, stalking waders, pecking waders, mud picking waders and divers.

'We considered nine different foraging habitats and nine different foraging techniques. These two dimensions should give us 81 potential combinations. But the water birds here used only 56 foraging combinations', says Shuvadip Adhikari.

'The birds in the first guild used 35 of these 56 combinations', adds Sudin Pal, his colleague. 'What we need to be careful about is the possibility of the generalist feeders encroaching on the niches of guilds with a narrower range.'

'Ecosystem health depends on community structure. In post hoc analysis, we found that the guild that contained generalist feeders was far removed from the guild that had very narrow niches', says Subhra Kumar Mukhopadhyay. These were divers who foraged in the deeper parts of the wetland.

Thus, though there are overlaps in feeding niches between birds in the

same guild, they manage to resolve conflicts without using weapons of mass destruction. Migrants and locals coexist during their winter break.

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### Elastin Wealth From tannery waste

During leather processing, only 15% of the raw hide is converted to leather. The remaining 85% is waste. Converting this waste into useful products is the key to a profitable leather industry and can lower the cost of leather goods for consumers. Researchers at the CSIR-Central Leather Research Institute, Chennai have taken a step in this direction.

Previous research had provided clues to extract glue, gelatin, protein flavour and reconstituted collagen from leather industry waste. Now, the scientists there came up with a method to extract another high value product from leather waste – elastin. While collagen provides strength, elastin is responsible for the elastic property of skin. Elastin is a high value product that has applications in cosmetic products including moisturisers and anti-aging creams.

The researchers collected raw hide trimming waste from the pilot tannery of the Institute. They washed it thoroughly with water, mixed it with alkaline solution and kept it under a shaker for seven days. Then, they autoclaved the mixture under high pressure and temperature and further filtered and centrifuged the supernatant. The result was a mixture of proteins and fats.

They removed the fats by solvent extraction using ethylene acetate to separate the protein. They ascertained the identity and character of the material obtained using UV-spectroscopy, FTIR, solid state NMR analysis and HPLC. Fast performance liquid chromatography confirmed the presence of aromatic amino acids – desmosine and isodesmosine – typical features of elastin. They observed the elastin under a scanning electron microscope. And were able to confirm its thermal stability – up to 215°C – using differential scanning calorimetry.

After confirming that the protein was indeed elastin, they tested its cytotoxicity and biocompatibility using human keratinocyte cells. The elastin extracted had no impurities that could hinder cell growth.

The finding that waste from the leather industry is good raw material for the pharmaceutical and cosmetic industry signals a potential for another step towards a circular economy.

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### **Indoor Air Pollution** *Affecting urban health*

The air you breathe in your home is often more dangerous than that outdoors, especially during winter because doors and windows are kept shut to keep out the cold. This can be a reason for headaches, frequent colds, respiratory problems, chronic cough, and eye and skin irritation.

Researchers from the IIT Bombay in collaboration with the Massachusetts Institute of Technology assessed the impact and sources of household air pollution across three low-income housing archetypes in Dharavi, the world's largest slum area and two nearby communities where current slum resettlement is taking place.

They analysed indoor air pollution levels and observed that indoor air pollution levels in these areas of Mumbai are nearly 12–40 times higher than the WHO recommended levels – less than 25 micrograms per cubic metre.

Higher indoor pollution occurred despite the use of low-pollution emitting LPG stoves in slum and resettlement areas. This was puzzling. But the researchers identified the problem: housing architecture.

During cooking, the doors of houses in both the resettlement colonies were closed for privacy. But one had architecture with the kitchen towards a central space, whereas the other had the opening towards the outside. So in one resettlement colony, the particulate matter concentration was highest in the kitchen and the foyer while in the other, the sleeping area had the highest particulate matter.

Exhaust fans, even when available, were not used during cooking, point out the researchers. Moreover, in some cases, windows were also blocked due to privacy concerns or by storage space. Pollutant decay analysis indicated that proper ventilation by opening windows improves air exchange rates and reduces indoor pollution.

Indoor air quality can be improved by implementing three main principles, say the researchers. The first is to limit indoor air pollution sources. Second, you could maximise outdoor airflow. And, lastly, you could employ a high-efficiency particulate air filtration system to purify outdoor air.

On average, urban people spend 80–90% of their time indoors and most of that in their homes. Indoor air pollution is linked to many fatal diseases such as heart problems, respiratory sickness, and even cancer. Indoor air pollution is described as the most significant environmental cause of death globally, with an estimated 1.5 million premature deaths in India alone according to the WHO report.

The Indian government's initiative of 'Housing for all by 2022' needs to consider housing architecture when constructing homes for those with low incomes, as a key to health. Public health players and people who wish to construct homes also need to consider the recommendations.

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### **Improving Solar Collectors** *Inserting porous blocks*

As the cleanest and most preferred form of non-conventional energy, solar energy plays an important role in resolving global energy consumption and climate change issues. Solar thermal systems are an economical way to use solar energy. Flat plate solar collectors have been used for water heating systems in the domestic and industrial sectors. However, solar collectors have high heat loss and low thermal efficiency.

Research has shown that, if the inner layer of the fluid channel is porous, the heat transfer between the collector and the fluid can be im-

proved. The empty spaces store thermal energy and enhance thermal conductivity. If, instead of coating the inner part of the channel with porous material, porous blocks are placed intermittently in the path of the circulating fluid, the efficiency is increased further due to the thermal mixing induced by the blocks. If the whole fluid channel is made porous, however, the increased resistance to flow decreases the efficiency of the flat plate collector.



Image: needpix.com

So what is the best configuration of porous metal blocks to be placed in the path of the circulating fluid? What height should these blocks be? What is the optimum permeability of the blocks?

Recently, K. Anirudh and S. Dhinakaran from IIT Indore reported tackling these problems. They carried out extensive two-dimensional numerical computations to understand the influence of the porous block numbers, arrangement, and thickness on flow patterns and the heat transfer performance of solar flat plate collectors filled with porous metal foam blocks.

The team inserted different numbers of porous metal foam blocks with uniform porosity and permeability, with different heights, into flat plate solar collectors in various permutations and combinations along the channel.

They found higher heat dissipation from the absorber plate with the intermittent placing of porous metal blocks than when a porous layer is coated on the inner lining or when the channel is filled with a porous medium.

The duo reports enhancement in heat transfer with an increasing number of permeable blocks. 'However, there is a penalty for increasing the



height of the blocks. The friction factor also increases. This, in turn, demands pumping power', says K. Anirudh.

'The heat transfer rate attains maximum value when the height of the porous blocks is more than sixty per cent of collector channel height. Particularly at eighty per cent of collector channel height', says S. Dhinakaran, his colleague.

Though heat transfer to the fluid is improved, resistance to flow increases. When the researchers studied the influence of the height of the porous blocks on the temperature at the outlet, they found that blocks with one-fifth the channel's dimension gave the best results.

Blocks near the outlet reduce thermal output. In fact, it is better not to have blocks close to the inlet or outlet, they found.

The efficiency of the flat plate solar thermal collectors used in water heating systems can be improved by more than a hundred per cent using porous metal foam. The study from IIT Indore has laid the foundations for optimising the factors involved. Solar collector manufacturing units in the country can now leverage on the study to improve the efficiency of their products.

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### **Sustainable Food Supply Chain** *Operational and resource efficiency*

India is the second largest producer of fruits in the world. But up to 30% of the fruits harvested by farmers are often wasted in the chain of supply from the farm to your dining table. It is not just the fruits that are wasted. The labour in cultivating, costs involved in fertilisers, pesticides, harvesting, packaging, transporting, etc. are also wasted in the process. In the light of rising populations, this is not sustainable.

Operational efficiency alone cannot make the supply chain sustainable. Sustainability is dependent on the efficient use of resources also. Recently, Ramesh Krishnan and K. Arshinder from IIT Madras in collabo-

ration with Renu Agarwal and Christopher Bajada from the Business School of the University of Technology, Sydney proposed a practical framework to combine operational and resource efficiency in the life cycle assessment of a sustainable food supply chain.

Surveying existing literature on themes relevant to environmental sustainability practices, such as operational efficiency in food supply chains, circular economy and life-cycle assessment of resources, the team noted that, though there are a number of studies assessing environmental impacts, literature on mitigation is rare. This is also the case with sustainability frameworks to transform the supply chain, based on life-cycle assessment.

So they developed a conceptual framework for efficient operation and optimum use of resources – a design for a sustainable food supply chain integrating operational improvements and recycling waste resources. But is the framework applicable to real life situations?

The researchers chose mango as case study since India is famous for its mangoes and mango pulp is exported in large quantities to the Arab countries and to Europe. They collected data about mango cultivation practices from farmers in the Salem and Krishnagiri districts of Tamil Nadu. Mango pulp processing and packaging industries in Krishnagiri provided another part of the data. The team had to rely on secondary sources for data related to the environmental impact of the packaging materials. With such data in hand they conducted life-cycle assessment in line with the ISO: 14040-2006 guideline, using SimaPro software, a tool for such analysis.

To find the potential causes of environmental impacts at all stages except consumption, the scientists described and defined the systems, boundaries and assumptions. Then they collected and discussed relevant data to explain the impacts.

They found that using steel at the packing stage and the absence of

optimization of transportation across all stages figured as major factors causing environmental impacts. According to the new framework, they identified potential causes at each stage and ranked them according to the strength of the environment impacts. Guided by literature, they redesigned the mango pulp supply chain to reduce the impact.

Finally, based on the results of this assessment, they came up with a framework that improves the sustainability of the mango pulp supply chain. Their design incorporated new practices in operations as well as resource recycling to improve economic, social and environmental sustainability.

For instance, using sensitivity analysis they showed that 10% reduction in transportation distance through network optimisation reduces 10% environmental impact from transportation.

The analysis has led to a number of recommendations for mango farmers, and managers of mango pulp industries to improve their bottom line.

The researchers acknowledge that the design is specific to the Tamil Nadu region where the study was conducted. However, redesigning the supply chain along the same lines can make the mango pulp industry elsewhere resource efficient and sustainable.

The design for the mango pulp industry cannot be used for other food industries because the data used will be different. However, the researchers say that the framework can be extended to other food products as well as to other agro-based sectors to make them sustainable.

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