Science Last Fortnight

Pharmaceutical Pollution
Nationwide monitoring

The pollution of aquatic bodies by pharmaceuticals and personal care products is increasing worldwide. Many have reported such pollution in specific rivers and surface water bodies. However, a nationwide monitoring is usually not undertaken.

But now a team led by Keerti Guruge from NIAH-NARD Japan and Prasun Goswami from ESSO-NIOT, India in collaboration with researchers from Japan and Sri Lanka report how pharmaceuticals and personal care products are polluting Sri Lankan aquatic systems. Based on rainfall, in May 2013, they collected surface water samples from various aquatic environments in three zones: wet, dry and intermediate.

For the investigation, the team targeted 72 chemicals representing a wide variety of pharmaceutical and personal care products. This is the first study where so many chemical products were included. New compounds, scarcely reported earlier, were detected in Sri Lankan water bodies.

Out of 72 compounds, the team detected 41 compounds in the water bodies. Thirty-eight were omnipresent. The highest concentration was of sulfamethoxazole in a rural ornamental fish farm in the wet zone.

The second highest concentration was N,N-diethyl-meta-toluamide, a mosquito repellent, in a rural pond in the dry zone. This is a popular tourist destination and the use of insect repellents by the tourists could explain the high concentrations.

The third highest concentration was the antibiotic clarithromycin in an urban waste canal in the wet zone.

The highest concentration of antiepileptic drugs such as phenytoin and carbamazepine was found in urban waste canals from municipal wastewater sources. To mitigate such an ecological risk, all it takes is an adequate number of municipal sewage treatment plants, say the researchers.

The team compared the concentrations of the compounds in Sri Lanka with what was found in other countries. They found no relation between the concentrations and the development status of the countries.

Hierarchical cluster analysis and nonparametric multidimensional scaling to find spatial variability and similarity of sampling locations highlighted a cluster of urban lakes and rivers that showed variable concentrations of pollutants from densely populated areas. Another cluster, urban wastewater canals, showed high concentrations of many compounds from hospitals and municipalities. The contamination signatures in the third cluster of dry and intermediate sites differed from those in the wet zone.

A rural river in the wet zone with low level contamination and an ornamental fish culture pond, with very high levels of antibiotics, were distinctive clusters.

The team also investigated the environmental risks of the compounds to the most sensitive aquatic species. Nineteen pharmaceuticals pose risk to aquatic organisms. The levels of six antibiotics in Sri Lankan surface waters are conducive to the emergence of many diverse antibiotic resistant genes or strains of bacteria, say the researchers.

The team suggests implementing regulations for the sensible use of pharmaceuticals in aquaculture and animal industries.

Such nationwide surveys and monitoring of water resources need to be undertaken in India too. But for such a large country, it would require large networking of collaborative efforts.

Biomagnification of Plastic
What goes around comes around

Of over 300 million tonnes of plastic produced every year, at least 8 million tonnes are thrown into oceans. About 80% of all debris, from surface waters to deep-sea sediments, is plastic. Over time, plastic disintegrates into small fragments and enters the marine food chain because marine animals mistake the fragments for food. The accumulation clogs the digestive system of marine animals.

Recently, researchers from the University of Chittagong, and the Shahjalal University, Bangladesh with the support of the UNESCO/IOC subcommission for the western Pacific provided the first account of the presence of microplastics in fish in the northern Bay of Bengal. The team selected three commercial marine fishes from Bangladesh: white Bombay-duck, pink Bombay-duck and gold-stripe sardine.

For isolating plastic from the gastrointestinal tract, they dissected five fish from each species and pooled their gut for the hydrogen peroxide-based digestion of soft tissue. They separated plastic particles left behind, using saline filtration. Using Fluorescent Transform Infra-Red Spectrometry, the researchers confirmed the identity of the plastic particles: polyethylene terephthalate and polyamides.

'Our study shows that fish in the northern Bay of Bengal are not free from microplastic pollution', says Subrata, Shahjalal University, Bangladesh.

Microscopic observation showed the presence of irregular fibres, fragments, angular and round shaped microplastics ranging from <0.5 to 5 millimetres. The team observed that smaller sized particles were high in sardines, and larger sized ones dominated in Bombay-duck. This, the scientists say is because sardines feed on small plankton while Bombay-duck feeds on shrimps and small fishes. On an average, each gram of the intestinal tract had at least one microplastic particle.

There is a positive correlation between the microplastics and gastrointestinal tract weight. 'Species with more weight are likely to contain more microplastics', says M. S. Hossain, University of Chittagong, Bangladesh.

So when we are buying fish, we are also paying for a part of the plastic that we threw out earlier. The production, sale and consumption of plastic need to be regulated to reduce the problem.

Vehicular Pollution Signals
A role for castor and datura

Vehicle traffic is one of the biggest sources of air pollution. The pollution stress can be assessed by biomonitoring plants on the roadside. But which are the best plant species for the purpose?

Last fortnight, researchers from the Government College Women University, Faisalabad and the University of Lahore, Pakistan in collaboration with the Lanzhou University and the Zhejiang University, China investigated the responsiveness of two such bio-monitoring plants.

The team selected two different heavy traffic roads in Pakistan. They selected two biomonitoring plants – *Ricinus communis* (castor) and *Datura alba* L. Both are fast-growing plants and available abundantly along roadsides and wastelands in urban areas.

Ricinus communis. Image: Vinayraj

The researchers compared the responses of these two plant species under the same set of environmental conditions in general and roadside conditions. They examined the biochemical, physiological and defence system response in both plants.

When the team checked the soils, they found more carbon, nitrogen and heavy metal concentrations along both roads than there was in plants kept indoors.

Plants on the roadside, especially datura, had lower chlorophyll levels. The rate of photosynthesis was also lower in datura than in castor oil plants. So *Datura alba* can be used as a bioindicator for roadside pollution, say the researchers.

In both plant species, free amino acids and total antioxidant activity increased. Castor showed higher concentrations of free amino acids and antioxidant activity than *Datura alba*. Since castor oil plants appeared more resilient to pollution, the scientists conclude that it could be used as a phytoremediator at polluted sites along roads.

Datura alba. Image: Philstone

For monitoring roadside pollution, conventional methods requiring sophisticated and expensive instruments prove costlier than using roadside plants. Datura as bioindicator and castor as phytoremediator is an effective strategy to monitor and address vehicular pollution. Since these plants grow easily, they can be promoted for roadside greening, says Noreen Khalid, Government College Women University, Pakistan.

Corrosion-resistant Steel
Chitosan carbon quantum dots

Muhamed Ashraf and Keerthana from the ICAR Central Institute of Fisheries Technology, Kochi have been suggesting new techniques to overcome the problem of the biofouling of nets for some years now. Now they have come up with a technique to make boats corrosion resistant. Even the steel recommended for boat-building, carbon steel BIS2062, slowly corrodes in response to the various ions in seawater.

The team was examining the use of graphene quantum dots for protecting boats when they came up with the idea of using carbon quantum dots from chitosan for corrosion resistance. Chitosan is the second most abundant biopolymer derived from chitin.

The team dissolved chitosan in dilute acetic acid and heated it in a hydrothermal reactor. They optimised the process for synthesising the nanodots: increase the temperature at the rate of about 4°C per minute to reach 220°C, keep it steady at that temperature for about 5 hours and filter the resultant solution. And you get a brownish yellow solution with an acidic pH which contains the nanodots.

The carbon quantum dots from chitosan were quasi-spherical with a diameter of 18 nanometres and were composed of multiple layers, the researchers found. They tested the nanodots for inhibition of the oxidation reduction reaction of iron oxide. 'The carbon dots compete with chloride ions to incorporate the surface iron oxide to generate a passive layer. This enhances corrosion resistance', says Keerthana.

The team coated carbon steel BIS2062 with different concentrations of the nanodots and found that a uniform coat formed over steel. They tested the coated steel for corrosion using sodium chloride solution as the electrolyte and platinum as counter electrode. The steel panel coated with 0.05% carbon dots performed best.

'The electron clouds of the carbon dots inhibited the attack of microbial organisms', says Ashraf.

Thus it seems that chitosan from marine organisms, when transformed to carbon quantum dots, can be used to cover boat and ship hulls to make them survive longer in the sea.

Type-1 Diabetes Mellitus?
Grapes, red wine help stem cells

Type 1 diabetes mellitus is caused by pancreatic damage that results in reduced insulin secretion. The major treatment options for type 1 diabetes mellitus are life-long insulin administration and pancreatic tissue transplantation. Recent research on stem cell-based therapy also shows

potential in the treatment of pancreatic damage. But high glucose in the pancreatic environment remains a challenge for stem cells during transplantation.

Recently, Vijaya V. Padma, from the Bharathiar University, Coimbatore in collaboration with researchers from different institutes of Taiwan reported that stem cells preconditioned with resveratrol can be used to overcome the problem. They took four groups of rats – rats with streptozotocin-induced diabetes, diabetic rats with stem cell transplantation, diabetic rats with resveratrol preconditioned stem cells and untreated ones as control.

Streptozotocin treatment increased pancreatic damage in experimental rats. The researchers also found increased TGF-β expression proportional to fibrosis and collagen deposition in pancreatic tissue. Stem cell transplantation reduced the pathology, leading to decreased serum glucose levels. With resveratrol preconditioned stem cells the results were better than when stem cells alone were used. Resveratrol-preconditioned stem cells show better capability for pancreatic tissue regeneration because of enhanced stem cell viability under high glucose conditions, say the researchers.

Image: Snapware via pexels

Resveratrol is a polyphenolic compound found in grapes and red wine. Besides improving stem cell therapy for type 1 diabetes mellitus, it has been reported to show antioxidant, cardioprotective, anti-cancerous and anti-aging effects by different research groups.

Multilevel Inverters
Multiple DC to stepped-up AC

Inverters are used in electric vehicles, solar farms and UPS power systems to convert DC voltage to AC. When there are multiple DC voltage sources, we need multilevel inverters to produce stepped-up output with low distortion. For example, in solar farms, they convert multiple DC collected by each panel into a combined higher AC voltage. However, voltage stress, especially when the output needs to be boosted, and unbalancing are major challenges which call for increasing the number of components in multilevel inverters, and hence their costs and size. The unreliability of inverters remains a bottleneck in sustaining the optimum productivity of solar farms.

Last fortnight, a team of researchers from the Kalinga Institute of Industrial Technology, Odisha and the Indian Institute of Technology, Dhanbad reported a solution. During the examination of the problem, they realised that switched capacitor converters are important to provide near sinusoidal output voltage waveform – the capacitors perform as alternative DC power supplies. So they started with a basic unit structure with switched capacitor converters. They designed the basic unit using one DC power supply, two capacitor circuits, each with unidirectional switches, and a charging circuit with a switch and a diode.

The basic unit boosted input voltage by three times to produce output. Voltage stress that can cause breakdown across insulation in the circuit, was also low, say the researchers.

By combining several basic units, the researchers proposed a general structure for a switched capacitor converter. The proposed converter structure, with n charging and $2n$ capacitor circuits, produced 3^n output voltage levels. This type of inverter has a lower number of switches, capacitors and diodes and showed lower stress voltage than the structures reported earlier.

The researchers also developed a structure for a cross-switched multilevel inverter using the proposed switched capacitor converters. They analysed the multilevel inverter in symmetric and asymmetric DC source configurations. The inverter in symmetric configuration having two capacitor converters produced 13 output voltage levels with lower stress voltage and a lower number of DC sources, switches, drivers and diodes.

The same symmetric configuration when additionally attached to two capacitor circuits on each side of the DC input produced 37 output voltage levels.

The inverter in asymmetric configuration with three capacitor converters – 23 switches and 3 DC sources – produced 103 voltage levels. The asymmetric configuration structure is good for large output voltage generation, using a lower number of DC sources, say the researchers.

They conducted experimental studies on laboratory prototypes and confirmed the operation and performance of the proposed 13 level and 37 level symmetric inverter structures.

The proposed multilevel inverter structure is more cost-effective and has lower stress voltage than the structures reported earlier, says Tapas Roy, Kalinga Institute of Industrial Technology. The new topology of the structure improves the output quality of inverters and can increase the efficiency of solar power installations, and industrial and domestic applications.

Bridge Resilience
Experimental modelling

The only bridge connecting the Kutch region of India to the rest of the nation, the *Surajbari* or window to the sun, broke down in the Bhuj earthquake of 2001. Slow ageing of bridges leads to disasters all too often. Can simulation and computer modelling help us predict the failure of bridges?

B. Sharanbaswa Vishwanath and Swagata Banerjee from IITB, Mumbai

have been exploring the resilience of aging bridges for some time now. They realised that corrosion is the main reason for a reduction of steel area, and the degradation of bond strength between concrete and steel bars. If we assume a uniform rate of corrosion, Fick's second law of diffusion can be used to model the initiation. Under different levels of corrosion modelled by this method, the team plotted fragility curves to understand how the corroded bridge would behave in seismic activity.

The researchers took a life-cycle oriented approach to model bridge resilience. The resilience of a bridge to a seismic event is a function that integrates losses incurred due to earthquakes and bridge function recovery. These depend on the structural design and construction features of the bridge under consideration. So the researchers took a bridge in Washington where the relevant features are well documented, to anchor their theoretical construct for the life cycle of a bridge. The initiation of corrosion starts 15 years after construction and after 25 years, the vulnerability to damage increased rapidly. The researchers also found that the uncertainty of their results increased along with the intensity of ground motion.

Unlike the factors related to the bridge, the factors related to seismicity are unknown and, therefore, unpredictable. So the researchers had to resort to a probabilistic estimation of damageability due to seismic events in bridge life cycle. They also examined the potential losses and costs of recovery to estimate vulnerability and post-disaster preparedness. The monetary value for the post-disaster repair related to bridge structural loss. But there are also indirect losses: traffic delay, business interruption, income loss and relocation expenses.

The losses, they found, have a linear relationship with vulnerability if the damages are small. However, when the damage is higher, the losses are much more than expected from a linear relation.

The researchers then examined the recovery process – removing debris, sealing minor cracks, patching concrete to restore the functionality of bridges. The recovery, they found, has a sigmoidal function. Interestingly, regular maintenance can improve the resilience of the bridge to a level that is even higher than what is expected of the bridge when it is new and can even extend its life cycle. That is a message that decision makers need to keep in mind when giving contracts for building bridges.

Assessing Labour Productivity
Using human parameter index

There are various measurements, such as heart rate and calorie counts, to evaluate the physical efficiency of manual workers at construction sites. We know these factors influence labour productivity. But how do we collectively assess labour productivity directly using human physical parameters?

Image: Jim Carter via Wikimedia Commons

Last fortnight, D. Karthik and C. B. K. Rao, from the National Institute of Technology, Warangal reported developing a comprehensive human parameter index which correlates with labour productivity. They chose seventeen healthy workers from three different crews with the help of a supervisor at a building construction site. Three of the workers were females. The age range was 18–52 years.

The team calculated the body mass index of the workers as per WHO guidelines. They introduced a new measure for upper body muscle strength to characterize muscle strength along with an existing hand grip muscle strength measure.

The study was carried out for 3 to 4 months. During this period, the researchers ensured there was no disturbance in work due to weather conditions or delay in supply of raw materials. The researchers also measured the workers' muscle strength before, during and after work with easy-to-use digital instruments such as a hand grip dynamometer, and a handgrip isometric metric trainer.

They also video recorded the workers, when the activities were at peak. From the video footage, they calculated the labour productivity of the workers in terms of number of square feet built in 30 minutes.

Their analysis showed that middle-aged workers as well as workers within the normal range of body mass index are more productive than workers in the upper and lower categories of both age and body mass index. Where age and body mass index are similar, the higher the measure of muscular strength, the better the labour productivity.

By statistically combining all separate measures, the researchers developed a quantitative parameter index indicating the overall physical efficiency of a worker. They found that the index value positively correlated with labour productivity.

The results of the study cannot be generalized since the sample is limited. If large scale studies confirm the findings, this new method of assessing labour productivity in construction work in terms of human parameters may also be extended to other labour-intensive tasks to predict the productivity of labour force.

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