

Science Last Fortnight

Carbon Budget in the Sundarbans *Reducing uncertainty*

The concentration of carbon dioxide in the atmosphere has increased from 277 ppm in the pre-industrial era to about 400 ppm in recent years. Accurate estimates of natural carbon sequestration will lead to a better understanding of the carbon cycle and help us formulate appropriate policies.

Mangroves are carbon-rich ecosystems with high carbon burial rates within soils. However, there are very few detailed carbon budgets available for the Sundarbans mangrove forests. Yet mangroves which are not studied are also included in global budgets. This data upscaling creates uncertainties in the estimates produced.

Raghab Ray from the University of Calcutta and collaborators from Germany tackled the problem of improving the accuracy of the global carbon data inventory. They collected water and sediment samples to analyse dissolved organic and inorganic carbon, as well as particulate organic carbon. And estimated carbon export from the Sundarbans into the Bay of Bengal.



Image: via Wikimedia Commons

The team puts the export rate of dissolved organic carbon at approximately 20% of the mangrove carbon export worldwide. However, particulate organic carbon is only 2%, and dissolved inorganic carbon 4%, of the total mangrove export of carbon.

According to the researchers, the mangroves are a major source of carbon transported from the Sundarbans into the Bay of Bengal, amounting to 7.3 teragrams of carbon per year. These estimates from the Sundar-

bans exceed the 'missing carbon' of previous budget estimates.

The report presents empirical data on carbon export from the Indian Sundarbans mangrove to the Bay of Bengal. The approach used was rigorous and the results obtained improve the global carbon data inventory and reduce uncertainties in global carbon budget estimations, say the researchers.

Sci. Total Environ., **621**: 535–547

Side-effects of Pharmaceutical Use *Contamination of the Yamuna*

India is the third largest producer of pharmaceuticals and exports 56% of total drugs produced. The remaining 44% are consumed by Indians. Though important for health and disease control, pharmaceuticals pose serious environmental side-effects when released into water.

Last fortnight, researchers from the Indian Institute of Technology, Delhi in collaboration with the National Mission for Clean Ganga assessed the ecotoxicological risk of various active pharmaceutical compounds in the Yamuna. They collected water from the river at six different locations where sewage and industrial discharge enter the Yamuna and assessed the levels of nine commonly used drugs – aspirin, paracetamol, ranitidine, ibuprofen, diclofenac, caffeine, carbamazepine, codeine and diazepam. These represent widely used analgesic, anti-inflammatory, antipyretic, antiepileptic, anticonvulsants and muscle relaxant drugs as well as stimulating agents.

The researchers found substantial amounts of these drugs in their samples. The study revealed that these compounds are released into the Yamuna from sewage treatment plants.

During the monsoon, the levels of these compounds were lower in river water due to dilution by rain water. But there were substantial amounts of the compounds in summer. Although the researchers did not find signs of acute toxicity on aquatic life,

these compounds may have long-term effects. Not only on aquatic life, but animals, and humans as well, since the Yamuna is the major source of drinking water and irrigation in the region.

Risk assessment of toxicity is largely measured by mortality. So the current tests may not be adequate to assess the side effects of these compounds on growth and fertility. Moreover, the interaction of multiple drugs may pose a greater risk. The current single-compound assessment methods fail to address this issue.

Earlier studies had pointed out the emergence of antibiotic-resistant bacteria due to exposure to antibiotics in river water. The present study extends the problem to the issue of emerging toxicity due to an array of other commonly used pharmaceuticals.

Rivers are lifelines for any civilisation. There is a need to prevent overloading them with drugs. Sewage must be efficiently treated to remove pharmaceutical contaminants before discharge into rivers.

Ecotoxicol. Environ. Saf., **150**: 297–304

Toxic Chemicals in E-waste *Dangerous to the environment*

E-waste recycling poses risks for the environment and for health. Environmental pollutants, such as polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and dibenzofurans, are released during the recycling process. Toxic chemicals which impact humans accumulate as elements in the environment.

Most e-waste recycling processes in India are carried out by the informal sector which does not follow the necessary safety measures. And there are not enough studies in India to evaluate the environmental and health impacts of the recycling of electronic waste by the informal sector.

Recently, Paromita Chakraborty and team from the SRM Institute of Science and Technology, Tamil Nadu, in collaboration with scientists

from the US, France and Japan investigated the problem¹. They chose Chennai, Mumbai, New Delhi and Kolkata for the study. The sites were classified into three categories: dismantling, shredding or grinding and metal recovery.

The team collected soil samples from these sites and determined the amounts of polychlorinated biphenyl, polychlorinated dibenzo-p-dioxin and dibenzofuran using gas chromatography and high-resolution gas chromatography. Their results show that these toxic chemicals are substantially higher in the soils at metal recovery sites in Indian cities.

The scientists used the positive matrix factorisation model developed by the Environment Protection Agency of the US to derive information about pollution sources. And they found that burning of electrical wires for copper extraction increased polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and dibenzofurans levels in the soils.

The researchers suggest periodic monitoring and evaluation of persistent pollutants at e-waste recycling sites after the implementation of the new law which was recently introduced by the Government of India to regulate e-waste recycling industries².

¹Sci. Total Environ., 621: 930–938

²<http://meity.gov.in/esdm/e-waste>

Edible Coating on Guava For better shelf life

Raw or processed guava, *Psidium guajava*, is popular worldwide. India is top producer, exporting the fruit and its products to several countries. However, guavas continue to ripen after harvest, shortening shelf life to a few days at ambient temperatures. Under cold storage, guava shows signs of chilling injuries. This poses a major challenge for traders and exporters.

Edible coatings are known to reduce transpiration and weight loss in fruits. And essential oils have been shown to enhance this property. Besides, essential oils also act as antimicrobials. S. B. Murmu and H. N. Mishra from the Indian Institute of

Technology, Kharagpur, decided to follow this thread. Last fortnight, they reported the results of using a coating of Arabic gum and sodium caseinate along with essential oils.



Image: Wikimedia Commons

Both gum arabic and sodium caseinate form edible films. Combining them leads to intermolecular interactions that will lead to stronger films, reasoned the scientists. They used two different essential oils: cinnamon and lemon grass.

They analysed the effects of different proportions of Arabic gum and sodium caseinate with lemon grass oil and cinnamon oil as base. The team applied five different coating formulations using uncoated fruits as control. They thus identified two formulations that prolonged shelf life – one combining cinnamon essential oil with gum arabic and sodium caseinate, and the other, using cheaper lemongrass oil instead. The scientists say that the guava treated with these preparations extended shelf life up to 40 days versus the 7 days of uncoated samples.

The coating resulted in lower activity of polyphenol oxidase and peroxidase – enzymes responsible for browning and flavour loss. The antioxidant effect of the essential oils increased the radical scavenging activity in the coated samples. What is more, the coating seemed to retain comparatively high levels of ascorbic acid, phenols and flavonoids, leading to slower ripening of guava.

With this simple procedure that uses inexpensive substrates to delay the rapid postharvest ripening, the scientists are confident that their formulations will benefit guava traders and exporters. The method might

also work on other similar fruits, they say.

Food Chem., 245: 820–828

Oligosaccharides Inhibit Tumours Promoting apoptosis in cancer cells

Polysaccharides – polymers made of sugars – are now attracting attention for their biological significance. Plant-based dietary pectins, especially, have been shown to impede cancer growth and progression. One of the plants where polysaccharide content has been well researched is *Decalepis hamiltonii* or swallow root. The plant is endemic to South India, where it is used to make pickles and confectionary. Traditionally, it is known for its gastroprotective and bactericidal properties.



Image: Vinayaraj via Wikimedia Commons

Scientists from the CSIR-CFTRI, Mysuru now report that a smaller oligosaccharide of the swallow root has anticancer effects. Having established galectin-3 inhibition activity for the whole polysaccharide in their previous work, they now address the bioavailability and accessibility of the oligosaccharide.

After multiple extraction steps, the team isolated the swallow root oligosaccharide fraction. From mass spectroscopy results, they estimated that the oligosaccharide had a molecular size of 831 Da, close to the cell division inhibitors, used in chemotherapy.

Using gas liquid chromatography, they identified arabinose as a major component along with rhamnose and galactose. They deduced the structure to have core type I rhamnogalacturonan units by nuclear magnetic resonance and Fourier transform infrared spectra.

Next they evaluated the antiproliferative and apoptotic activity of the

whole polysaccharide and oligosaccharide using mouse melanoma cells. They found that the swallow root oligosaccharide modulates the well-studied cancer promoting proteins, galectin-3 and survivin, under *in vitro* conditions.

By varying the concentration of the swallow root oligosaccharide, they found a dose dependent inhibition of cell proliferation comparable with a known anticancer drug. The cells incubated with swallow root oligosaccharide and polysaccharide displayed a condensed nuclei characteristic of an apoptotic body substantiating their role in mediating apoptosis.

Using RT-PCR experiments, they found a reduction in the mRNA levels of galectin-3 and survivin. They confirmed down regulation in protein levels also. These proteins inhibit programmed cell death or apoptosis and their silencing is perhaps responsible for halting tumour progression, say the scientists.

The team proposes the use of oligosaccharide rather than the whole polysaccharide to enhance bioavailability. Further studies will help make the most out of this dietary polysaccharide based nutraceutical for cancer therapy.

Carbohydr. Polym., **186**: 402–410

Determining Neurotransmitters An efficient analytical method

Neurotransmitters, chemical messengers between neurons, modulate various biological and immunological processes, as well as behaviour. Neurotransmitters are involved in conditions as simple as stress and as complex as schizophrenia, Parkinson's and Alzheimer's diseases. The levels of these chemical messengers can be used as indicators of disease onset in the central nervous system. However, there is no efficient diagnostic method available for the simultaneous determination of these messengers in a biological matrix.

Devendra Patel and collaborators from the CSIR-Indian Institute of Toxicological Research, Lucknow and the Academy of Scientific and Innovative Research, Lucknow, now report devising an efficient method

for the extraction and measurement of neurotransmitters. The team developed a modified dispersive liquid-liquid extraction method using a nontoxic eco-friendly ionic liquid, 1-butyl-3-methylimidazolium hexafluorophosphate, as extraction solvent in place of a toxic chlorinated solvent. To improve the extraction efficiency they used ultrasonic waves. Then they quantified the neurotransmitters in the extracted samples using liquid chromatography-mass spectrometry.

The method is sensitive enough to detect the presence of neurotransmitters as low as $0.021 \mu\text{g l}^{-1}$, $0.028 \mu\text{g l}^{-1}$ and $0.025 \mu\text{g l}^{-1}$ in extracted samples of brain, plasma and cell respectively.

The method can extract and detect 15 neurotransmitters simultaneously in one go even if they are present only in traces in the biological matrix. It needs less than 3 ml of plasma, or brain or cell homogenate for analysis.

The technique developed by the team from Lucknow is environment friendly. It can be developed as a diagnostic kit for the quantitative determination of neurotransmitters in complex biological matrices.

Anal. Chim. Acta, **1005**: 43–53

Mild Steel becomes Strong Resists corrosion and UV rays

Low-carbon steel, or mild steel, has many applications in engineering projects, as it is malleable and ductile. Since it is cheap and easily available, industries use it as construction material. Besides buildings and bridges, it is used in marine applications such as rigs and pipelines. Mining, automobiles and power plants also use mild steel. Thus, protecting these mild steel applications against corrosion has enormous importance to global economy.

Organic coatings used to prevent corrosion of mild steel are usually adhering films or membranes made from either natural or synthetic organic compounds such as polymers, oligomers, monomers, or a mixture of these. But long exposure to UV radiation causes significant degradation to the coated surface by discolouration of dyes and pigments, weathering,

loss of gloss and change in mechanical properties.



Image: Wikimedia Commons

Recently, a team of researchers led by K. Anver Basha from the C. Abdul Hakeem College, Tamil Nadu reported developing a polymer hybrid coating on mild steel to overcome the problem. They incorporated zinc oxide nanoparticles into a selected polymer matrix to prepare the preventive coating against both ultraviolet radiation and corrosion. Zinc oxide is a wide-band gap semiconductor. The electronic properties of the metal oxide are precisely controllable. And its nanoparticles are used to prevent corrosion reactions at the metal-coating interface.

The researchers first synthesised the rod-shaped zinc oxide nanoparticles from zinc acetate and sodium hydroxide and modified those with oleic acid as a preparation for creating the hybrid coating.

Poly (pyridine-4-yl) methyl methacrylate was chosen as it is an electroactive polymer, capable of storing a large quantity of charge at the interface, forming a passive layer on a metal. It was copolymerised with *n*-butyl methacrylate, which exhibits better adhesive property and enhances solubility. The coating was then prepared from this polymer hybrid and zinc oxide nanoparticles in a tetrahydrofuran solvent.

The scientists coated the polymer hybrid on mild steel surface using the spin coating technique. The X-ray diffraction and Fourier-transform infrared spectra of the coated substrate showed good compatibility between the polymer hybrid and the nanocomposites. The team also report that the addition of zinc oxide nanocomposites enhanced the thermal stability of the polymer hybrid.

From the study of electrochemical parameters, they report that the coating decreased the pores of the polymer and provided a better barrier, blocking the access of charged particles to the steel surface. The surface analysis proved that the coating was uniform and has good adherent property.

UV absorption and transmission studies revealed that the coating on the steel substrate was homogeneous and the UV absorption was below 350 nm wavelengths, which was good for the UV screening effect.

The researchers tested the corrosion resistance of the coating in a sodium chloride solution, which demonstrated that the nanocomposite is effective as an anticorrosive coating with UV blocking property in aggressive conditions.

The polymer-hybrid coating has excellent potential in paint technology, as UV blocking and anticorrosive material for mild steel, say the researchers.

J. Appl. Polym. Sci., **135**(16): 46175

Electrode for Supercapacitor

A supercapacitor is a high capacitance storage device used to store huge amounts of electrical charge. Traditionally batteries are used for the purpose. The quick charging/discharging efficiency makes supercapacitors a strong competitor to batteries for application in future technologies. Additionally, supercapacitors are less toxic and have a long life time. The major challenge, however, is their high cost of production and low specific energy.

Priyanka Londhe from the Savitribai Phule Pune University, in collaboration with scientists from the Korea University and the University of Buffalo has now developed an electrode material for supercapacitors which is simple, electrochemically stable and superior in performance. 'I was working on nanoparticles for solar cells and this is my first foray into supercapacitors', says Priyanka. 'But my experience with nanoparticles came in handy'.

They fabricated nanoparticles of inorganic metal oxide of zinc on graphene and used the ZnO/graphene composite as the electrode. Compared to other methods for preparing such composites, this one is simple, low-cost and showed improved performance.

ZnO shows remarkable reversible redox reaction but long-term use leads to fast decay and agglomeration, resulting in poor conductivity. Graphene, just one atom thick, is extremely porous and acts as an ion sponge. However, graphene fails to exhibit high capacitance due to restacking of graphene sheets. The scientists combined the synergistic properties of both and produced a composite with reduced particle agglomeration, less restacking and improved capacitance. The nanostructure of the material further enhanced the surface to volume ratio and, thus, increased electrochemically active sites for charge transfer.

Conventionally, the synthesis of electrodes is a multistep process, relatively expensive and uses binders

which become residual impurities and reduce the desirable properties of active materials. The team used electro-spray deposition under ambient temperature to create a uniform coating with low material consumption. They used nickel foil as base to create a binder-free electrode.

The team prepared a coin cell using two electrodes and used a sodium sulphate solution as electrolyte to test the properties of the supercapacitor. The long term cycling performance test showed that even after 1000 cycles, 90% capacitance was retained by the electrodes. The tests also confirmed that the diffusion of ions from electrolyte to electrode occurred readily, indicating efficient charge transfer with low resistance.

The electro-spray deposition-based binder-free ZnO/graphene composite electrodes are easy to make, cost effective and show high capacitive performance compared to existing composite electrodes. ZnO nanoparticle-graphene electrodes will prove to be promising candidates for future supercapacitor technology, hopes the team.

J. Alloys Comp., **741**: 781–791

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