

Science Last Fortnight

Comprehending Kosi

Understanding sedimentation

The river Kosi, draining through the highlands of Tibet and Nepal and debouching into the plains of north Bihar, is considered one of the most dynamic rivers in the world due to its rapid migration and very large sediment flux. Understanding the sediment dynamics of the Kosi has been a big challenge particularly in terms of its role in flood disaster management.

Researchers from the IIT Kanpur, the IIT Gandhinagar and the International Centre for Integrated Mountain Development, Nepal, decided to study the Kosi's sediment dynamics. A recent report¹ from IIT Kanpur and the International Centre for Integrated Mountain Development, Nepal reveals that a sediment load of 100 million tonnes is generated on average each year at Chatara in Nepal, where all seven upstream tributaries of the Kosi meet. That implies a sediment load of as much as 1915 tonnes per square kilometre a year.

Another related work² by the same group and IIT Gandhinagar assessed sediment connectivity in the upper Kosi basin. The researchers used the hydrologically corrected digital elevation model of 90 m resolution from the Shuttle Radar Topography Mission to understand the terrain and interactions between hill slopes and channels.

They used a land-use and land-cover map of 30 m resolution. The generated connectivity maps of each sub-basin indicated that the sediment flux in the different sub-basins is strongly related to structural connectivity. The sediment load and dynamics are mostly controlled by variable slope distribution and land use and land cover. 'Tributaries in the basin's western part have high stream power because of high slope variability and high rainfall. So they contribute higher sediment flux', says the lead researcher, Rajiv Sinha, IIT Kanpur.

The researchers compared the connectivity maps with available hydrological and suspended sediment load data from the upper Kosi basin and

found good agreement with their model. The Dudh Kosi, Tama Kosi, and Bhote Kosi are amongst the most dynamic sub-basins with overall high sediment connectivity, say the researchers.

These studies emphasise that an integrated assessment of land-cover changes, erosion and sedimentation, at the transboundary level, is required. This will provide a better understanding of the cause-and-effect relationship between different processes and, for the Kosi, help design sustainable strategies for sediment and flood management.

Such connectivity models can be used in other physically inaccessible drainage basins to manage, plan, predict and assess disasters.

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²DOI: 10.1016/j.jhydrol.2018.12.051

Fe for Fish Culture

Labeo rohita

Rohu, *Labeo rohita*, is popular, the world over. From the Gangetic plains, the fish has travelled around the globe, not merely as food, but also as starter for aquaculture. However, quite often, the expected amounts of Rohu cannot be harvested merely because aqua farmers do not pay attention to the nutritional needs of this omnivorous fish.



Image: via Wikimedia Commons

Iron, for example, is an essential nutrient for *Labeo rohita*. But how much? What is the best method to feed Fe to the fish? Recently, Mukhtar A. Khan and Mohammad Musharraf from the Fish Nutrition Research Laboratory, Aligarh Muslim University reported their attempts to answer these questions.

To optimise iron supplements in *Labeo rohita* feed, they undertook a series of experiments. Twenty fish were randomly allocated per tank. The tanks were provided with a continuous water flow-through system. The team maintained the water at 26 to 28°C with dissolved oxygen varying from 6.2 to 7.3 mg per litre.

The researchers used ferrous sulphate heptahydrate as iron source and maintained different iron levels in the water – from 0.03 and 0.08 mg per litre. Rohu is known to absorb iron through the gills.

Fish feed in tanks that did not contain iron sulphate the team supplemented iron sulphate in feed. Unconsumed feed was collected from each tank by siphoning after every feeding, dried and weighed to obtain a correct estimate of feed consumed.

Both the experimental groups and the controls were kept in a photo-periodic cycle of 12 h light and 12 h dark.

After eight weeks, the researchers found that tissue iron concentration, haematological parameters and iron concentration in the serum increased significantly in fish in tanks with iron sulphate in water as well in those that received an iron supplemented diet. And antioxidant activities improved.

The dietary iron supplementation maximised the growth of *Labeo rohita* fingerlings. Though Rohu can absorb iron from water through their gills, it is better to provide it as a part of the diet, instead of as iron sulphate in water, say the researchers.

Rohu needs about 200 mg of iron per kilogram of fish feed, say the researchers. That is one sixth of the amount that Tilapia, another important aquaculture fish needs.

Rohu attains the marketable size of one kilogram within one year. Because of good consumer demand, there is an immediate application for these research results.

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No Tillage, No Transplanting Increasing rice yield

Farmers are going to love this. Tillage and transplanting are the most laborious activities in rice production. Now, scientists are telling farmers to stop these activities to improve productivity.

Tillage breaks up soil aggregates, exposes organic carbon in the soil to oxidation. Along with reduction in organic carbon, the productivity of the soil reduces. So many research groups in different parts of the world have been experimenting with no tillage, growing different crops.

Now, the Indian Agricultural Research Institute, New Delhi, the Indian Institute of Pulses Research, Kanpur, the International Rice Research Institute, the Philippines, the South Asian Regional offices of the International Maize and Wheat Improvement Center and the Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj have come together to report their six-year study on rice-wheat and rice-winter maize crops. They conducted the study in the ICAR-Research Complex for Eastern Region, Patna, from 2009 to 2015.

They experimented with and compared different combinations: conventional tillage and zero tillage, conventional puddled transplanting of rice and direct seeding of rice, manually broadcasted wheat after tilling and direct seeding of wheat, maize sown manually by dibbling and direct seeding of maize, and complete residue removal and leaving behind one third of the crop in the fields.

They analysed the values of different soil parameters at surface soil depth – till 20 centimetres. And then again, at the end of six years. They found that the stabilisation of added carbon in soil was the highest with zero tillage and direct seeding of rice followed by zero tillage for wheat or maize. The soil available phosphorous increased substantially. Nitrogen, potassium and zinc available in the soil also improved remarkably. Among all combinations tried, rice grain yield proved highest in zero tillage, direct seeding.

Even a single wet tillage (puddling) operation could result in substantial

loss of soil organic content, say the scientists. The soil microbial and biochemical environment of zero tillage soils is less oxidative than that under conventional tillage. Decomposing crop residue releases polysaccharide compounds that act as a cementing agent to form macro-aggregates. Thus, the effect of crop residues on soil available nutrients tends to add up and, over time, even the clay/silt in the soil gets a fair share of carbon – the most stable form of soil organic carbon.

Progressive farmers will gladly take to these practices, because labour input can be reduced substantially.

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Quantum Dots in Food Safety Tetracycline and aluminium in milk

Tetracyclines are broad-spectrum antibiotics widely used in veterinary medicine against a large range of microorganisms – aerobic, anaerobic, Gram-positive and Gram-negative bacteria and protozoa. Abundant use leaves residues in milk at unsafe concentrations. The residues cause allergic reactions and stained teeth.

Another toxic contaminant of milk is aluminium. Its ions can cause Alzheimer's, Parkinson's diseases and amyotrophic lateral sclerosis.

Now, researchers from the IIT, Rupnagar and the National Autonomous University of Mexico report a single technique to test milk for both tetracyclines and aluminium.



Santeri Viinamäki via Wikimedia Commons

The technique needed neither high-end liquid chromatography, capillary electrophoresis nor any sophisticated pretreatment methods. It employed carbon dots derived from tetracycline as sensor for aluminium ions and vice-versa, using a spectro-fluorometric technique.

The specialty of this technique is that it can detect the target by enhancing fluorescence intensity.

'You shine 365 nanometres of light. And it fluoresces at 480', says Pandiyan Thangarasu, National Autonomous University of Mexico.

The researchers first studied the detection of tetracycline with different cations. There was a clear distinction in fluorescence to detect aluminium using tetracycline.

Then the team examined milk samples as well as other biological samples mixed with known concentrations of tetracycline and aluminium.

'Other cations – iron or magnesium – don't interfere in the test', adds Narinder Singh, IIT Rupnagar.

The limit of detection for tetracycline was found to be 0.00022 mM with 94% accuracy.

The team then checked whether aluminium in living cells can be detected with this method. They chose *Saccharomyces cerevisiae* and *Debaryomyces* spp for their experiments. Using tetracycline carbon dots, they found that the limit of detection went as low as up to 0.00050 mM at similar accuracy with laser scanning confocal microscopy.

This technique has implications for food safety as it can be employed to determine toxic aluminium ions or tetracycline in milk products. Evidently, it will also be used in many labs to detect aluminium ions in biological samples.

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Aquatic Fungal Biodiversity From plant leaf litter

Aquatic ecosystems are known as hot-spots of biodiversity. Research shows that microbes follow a latitudinal diversity gradient – increasing richness in species from the poles to the tropics. And plate tectonics, we have learned, play a role in governing the global distribution of plants and animals. But we still lack perspective on microbial diversity and its bio-geographic history. How do these factors impact present-day microbial species distributions in freshwaters?

Last fortnight, S. Seena from the University of Coimbra, Portugal in

collaboration with other researchers across the globe reported their investigations into the fungal diversity and communities in leaf litter from streams.

The team selected nineteen streams across five continents, to gather the necessary geographic information and environmental characteristics of the streams. And they compared environmental parameters such as mean annual temperatures of air and water and rainfall data with latitudinal changes.



Image: Public domain, Pxhere

The researchers used linear regression to determine the relationship between rarefied fungal richness, physicochemical, environmental parameters and latitude. Fungal richness was lowest at latitudinal extremes and peaked at mid-latitude regions. This tendency was insensitive to the altitude, and the physicochemical and environmental characteristics of the stream sites.

When the team analysed the relationship of litter-associated fungi across the globe with stream water temperature, they found that fungal communities showed specific thermal preferences, independent of biogeographic realms. The results clearly indicated that temperature plays a key role in determining the occurrence of litter-associated fungi in streams and in maintaining their composition.

In the leaf litter samples from the streams, the researchers unravelled a relationship between physicochemical characteristics and concentrations of dissolved micronutrients. Dissolved oxygen increases along the latitudinal gradient. There were no latitudinal patterns in concentrations of phosphate or nitrate.

The team performed litter colonisation experiments during the dry season

in the tropics and during autumn in temperate and sub-arctic streams. They used leaves of *Alnus glutinosa*, black alder, since it has high-quality leaves and is widespread in Holarctic and Neotropical regions.

The researchers also randomly collected ten leaf discs and extracted DNA without sterilising the leaves. They determined the initial fungal composition on the litter with DNA sequencing. The raw sequences from the leaves before exposure to the stream and after retrieval of the leaves were analysed using bioinformatics. The team could now look at the patterns in fungal community structure across stream locations.

They found that the initial fungal community from the samples yielded 1311 operational taxonomic units. About 80% of aquatic fungi were dominated by Ascomycota. The team noted that fungal classes from the streams varied with location and water temperature.

The relative abundance of the taxonomic units was unique to single locations and some 30% identified were moderately endemic. The relative abundance of this endemic fungal taxon did not vary with geography. However, the taxon was more abundant in the Neotropics. *Lemonnier aquatica* was the most widespread species, occurring in 8 of the 19 locations studied.

Understanding the global distribution and diversity patterns of aquatic fungi will help us predict ecosystem responses to global changes. Identifying the role of environmental drivers and ecosystem types in response to species survival is critical, says Seena, lead author.

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Red Mud Pollution

Amelioration by friendly fungus

India has high bauxite reserves. Enough to satisfy our demand for aluminium. The industry that extracts aluminium from bauxite, however, has earned itself a bad name. The Central Pollution Control Board lists it among the 17 most polluting industries.

Red mud, a by-product of bauxite processing, is the main cause for the

pollution. It is highly alkaline, saline and contains heavy metals. It contaminates groundwater and air, raising public health concerns. How can we overcome the problem?



Image: Ra Boe via Wikimedia Commons

M. Sudhakara Reddy from the Thapar Institute for Engineering and Technology, Patiala collaborated with researchers from the Yeungnam University, Republic of Korea, to report a method.

Red mud from the bauxite processing industry does not have adequate carbon and fertiliser content. Yet some plants thrive even in such toxic conditions.

Previous research had shown the usefulness of mycorrhiza, a soil fungus, in supporting plant growth in such soils.

The researchers decided to check whether *Trichoderma*, a soil filamentous fungus, known for its plant growth promoting properties like mycorrhiza, can alleviate the problem.

They took soil samples from the red mud flooded rhizosphere of plants growing there. And cultured *Trichoderma* species isolated from the samples.

When they tested the ability of the isolates to grow in alkali-sodic agar medium, five distinct isolates came out with flying colours.

The team compared their properties and found an alkali and metal tolerant *Trichoderma* species from the red mud flooded rhizosphere of Bermuda grass to be the best. They analysed the rDNA sequence of this *Trichoderma* isolate through BLAST search and phylogenetic analysis which showed 99–100% similarity with *Trichoderma asperellum*. They also assessed the plant growth promoting traits of the isolate.

They observed significantly higher amounts of an enzyme that helps reduce ethylene stress and promotes plant growth in this isolate than in the other isolates.

Will the fungus strain from Bermuda grass rhizosphere be useful to promote plant growth and to establish vegetation in red mud contaminated sites?

The team collected red mud samples from a disposal pond of the National Aluminium Company Limited, Odisha. They oven dried the samples and sieved them to carry out chemical analysis.

The researchers observed a significant reduction in the pH and electrical conductivity of red mud due to the action of the isolate.

The isolate also had an effective phosphate solubilising mechanism under alkaline-saline stress which reduces the use of fertilisers in red mud, say the researchers,

The researchers demonstrated that red mud leachate with the isolate improved the growth of sorghum-sudangrass seedlings and increased their biomass and chlorophyll content.

The *T. asperellum* isolate from Bermuda grass rhizosphere can be used alone or in combination with inorganic and organic amendments to remediate red mud contaminated sites for reforestation.

Will the bauxite processing industries act on these findings to reduce the harm done to the environment?

That is a question that scientists can't solve.

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Dye-sensitised Solar Cells

With better photoanodes

Dye-sensitised solar cells are cheaper and easier to make than silicon-based solar cells. Most dye sensitised solar cells use titanium dioxide as anode because it has high thermal stability, a favourable band gap and is low-cost. However, the efficiency of these anodes is only 10% at the most. How can we enhance the photoelectric conversion of dye-sensitised solar cells?

Recently, scientists from the Avinashilingam Institute, Coimbatore and the Madurai Kamaraj University collaborated with scientists in the US and Finland to suggest combining nanostructures of titania.

The scientists prepared three types of titanium dioxide nanostructures – nanospheres with nanoparticles, microspheres with nanoparticles and stone-like structured nanoparticles using a simple one-step reflux method. They confirmed the structures with X-ray diffraction and electron microscopy.

The team then used these titanium dioxide nanostructures in combinations as photoanodes for a dye sensitised solar cell. They report that nanospheres with nanoparticles had the lowest charge transfer resistance. The nanospheres provided optimum surface area for dye loading and acted as light scattering centres. This led to greater absorption of light and, hence, to greater release of electrons. The nanoparticles improved the transfer of electrons. The dye-sensitised solar cells could now function even under diffused light.

This work might be beneficial to the industries to produce better solar cells that are within the reach of the poor.

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What Ails Alienists?

Interns at risk?

Doctors are more at a risk for suicide than the general public. And psychiatrists are at greater risk. In psychiatry, interns are most at risk.

Interns are under greater stress as they have to prove their competence. They are also usually at an age where many life changes take place. This can be worrying, considering that the profession is a service provider. But what are the actual facts?

Amit Malik, psychiatrist-founder of Innerhouse, Mumbai, worked with researchers from across the world to see what can ail resident alienists and what can be done to alleviate working conditions. To do so, they looked at an international sample of psychiatric residents: 1980 from 22 countries.

The team conducted an online survey using an established depression risk questionnaire, the Patient Health Questionnaire-9, to assess rates of depression, suicide ideation and suicide attempts in fully qualified psychiatrists undergoing specialist training.

The researchers took into account age, gender, relationship status, parenthood, psychiatry as career choice, as well as years of training, and postgraduate education other than training. Weekly working hours, daily rest and weekly clinical supervision were also included.

They screened the residents for reported depression and used the Suicide Ideation and Behaviour Questionnaire to assess suicidality.

Out of 1980, most were females in their early thirties, married or in a relationship and without children. Half of them were doing some postgraduate education other than psychiatry training. Most of them were under regular clinical supervision but some did not have any. They worked some 54 h per week, between workplace and work at home. Most got adequate rest: 11 h continuous rest a day, a day off each week and a 20 min rest break every 6 h – as recommended by the European Work Time Directive.

The team found that total weekly working hours, no supervision in clinical work, being single, and being female rank high for being at risk.

The researchers recommend that interns take up other postgraduate courses simultaneously as such engagement appears to be beneficial. They also advise the establishments where the residents are trained to offer such professional counselling and to take the initiative in facilitating the social life of single female interns.

The research can be usefully extended to the rest of the medical fraternity and even to other professions. After all, a healthy service provider provides better service.

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Reports by: Nihar Ranjan Sahoo, Ravi Mishra, P. Ramesh, P. K. Udham, Pudi Venkatesu, Pavithra Nayak, V. Subashini, J. Akash and Gita Madhu

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scienceandmediaworkshops@gmail.com