of charged residues at the accessible surface, more hydrophobic and charged residues at the subunit interface, slightly more hydrogen bonds per residue in the overall structure and a reduced number of residues per monomer due to loop deletions.

Akihiko Yamagishi and coworkers (Tokyo Univ. of Pharmacy and Life Sciences) have developed a new way of designing thermostable mutant enzymes using phylogenetic tree. Mutant enzymes of 3-isopropylmalate dehydrogenase exhibited higher thermostability than the enzyme from *Sulfolobus tokodaii*. A similar observation was recorded with glycyl-transfer RNA synthetase from *T. thermophilus*. The investigators have concluded that these results support the hyperthermophilic common ancestor hypothesis.

Tairo Oshima and coworkers (Institute of Environmental Microbiology, Tokyo, Japan) demonstrated *T. thermophilus* to produce 16 different polyamines (PAs), including long, branched and standard PAs. Long PAs effectively stabilize nucleic acids. When genes encoding PA biosynthesizing enzymes were knocked out, the mutants failed to grow at elevated temperatures, and supplementing with PAs restored growth. Investigations using pure enzymes supported a new pathway for PA biosynthesis.

Daniel Prieur and coworkers (Univ. of Occidental Bretagne, Plouzane, France) reported isolation of barophilic *Thermococcus barophilus* and ionizing radiation-resistant *T. gammatolerans*. They have also isolated a virus (PAV1) from *Pyrococcus abyssi* that has a genome of 18098 bp with 24 ORFs.

Philip Hendry and coworkers (CSIRO Molecular and Health Technologies, Australia) have isolated *Sulfolobus* sp. JP2, that showed minor differences with *S. solfataricus* at the genomic level. Micro-array analysis suggested the expression of genes related to sulphur oxidation, electron transport and carbondioxide fixation. The strain was able to efficiently leach copper from chalcopyrite.

Radhey Gupta (McMaster Univ., Hamilton, Canada) presented work on the identification of many conserved signatures in widely distributed proteins that are unique to members of Aquificales that are not found in any other organisms. Further evidence was provided that Aquificales phylum is a late branching lineage within bacteria.

The conference also included 72 poster presentations on aspects such as diversity of thermophilic bacteria and archaea from various terrestrial and marine thermal environments, physiology and biochemistry, cloning and overexpression of thermostable proteins and enzymes, structure–function relationships of enzymes, biotechnological application of enzymes, genomics and proteomics, genetics and molecular biology. The conference gave ample opportunity to understand recent trends in research on thermophilic microorganisms, and investigations that are in progress all over the world on basic as well as applied aspects of thermophilic microbes.

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MEETING REPORT

Linking Indian rivers vs Bay of Bengal monsoon activity*

In a popular article on 'Interlinking rivers: Is it the solution?' (*The Hindu*, 26 August 2005), V. Rajamani brought out a possible consequence of the proposed interlinking of Indian rivers on the SW monsoon. The connection is that the run-off of Indian rivers to the Bay of Bengal (BOB) plays a critical role in the process of monsoon intensification by creating and sustaining a low-salinity layer on top of the BOB. The President of India, A. P. J. Abdul Kalam, as an advocate of the river-linking project showed keen interest in Rajamani's article, particularly to the link between run-off to the BOB and the SW monsoon. In view of the importance of the project, the interest of the scientist-President and the scientific importance of the problem, a one-day meeting of earth scientists interested in the air–sea–land interactions was arranged for a focused discussion on the following: If the proposed river linkages were to reduce the total annual run-off into the BOB or the rate at which run-off is released into it, then do river linkages have any significant consequence on the Indian monsoon rainfall? This report is an outcome of the discussion meeting and the opinion expressed is the prevailing and collective knowledge of the participants (listed at the end) on the issue.

Owing to its unique geographic location, the BOB receives large quantities of freshwater from both local precipitation and river discharge. The estimated freshwater influxes into the BOB from local precipitation and through river discharge are 4700 and 3000 km^3/yr respectively. Ganga, Brahmaputra, Mahanadi and Eirawaty are the major rivers that discharge in the head BOB. The loss due to evaporation is about 3600 km^3/yr. Thus, on an annual scale, freshwater input exceeds the loss due to evaporation substantially. This tends to make the water of the BOB relatively less saline compared to other oceans and the low salinity is confined to the top ~ 10–20 m layer. There is a strong seasonal dependence, as the major fraction of the freshwater comes during the summer monsoon period, i.e. during June–September. During this time, southwesterly winds tend to accumulate the freshwater in the head BOB and the salinity decreases further, resulting in the occurrence of a quasi-permanent, low salinity layer north of 17°N. Once the southwest monsoon ends (in October), water starts flowing southwards. Eventually, BOB water spreads out over the equatorial and south Indian Ocean and also over the east Arabian Sea.

Density of sea water increases with salinity. The low-salinity layer at the BOB, is therefore a layer of less dense water floating on denser water below as a stratified layer. This inhibits vertical mixing and even strong monsoonal winds have limited success in inducing vertical mixing. Most of

*A report on one-day meeting of earth scientists held at the premises of the Indian Academy of Sciences, Bangalore on 15 October 2005.

the solar energy is trapped in this top 10–20 m thick layer. Owing to high levels of humidity in the air over the BOB during monsoon, evaporative cooling is also small compared to other oceans at comparable wind speeds. Calculations as well as observations show that it only takes 4–5 clear-sky days for the surface temperature to increase by about 1°C over head BOB, whereas the corresponding time is about a month for other oceans, including the Arabian Sea. Response of monsoon cloud systems (convection) is a highly nonlinear function of sea surface temperature (SST). While convection nearly vanishes for SST < 28°C, it peaks around 29°C. When clouds form, solar insolation is cutoff, water cools mainly due to evaporation and observations show that the minimum SST reached during such periods is about 28°C over the BOB. But given a few days of clear-sky conditions, SST of BOB increases to a value where the probability of convection is high. Thus, the BOB manages to support a high convection despite frequent clouding.

Eventually, the excess input (4100 km^3) of freshwater is balanced by the outflow of low salinity (fresh) water from the BOB to the southeastern Arabian Sea and to the Indian Ocean. Experiments using an ocean General Circulation Model suggest that the impact on salinity is different between the two inputs of freshwater. Effect due to oceanic precipitation over the BOB tends to spread throughout the BOB and then into the eastern equatorial Indian Ocean. The river run-off, however, is confined largely to the coastal region and parts of head BOB during the monsoon period, and after October it flows along the east coast of India and around Sri Lanka into the southeastern Arabian Sea. Here it plays an important role in the warming of the Arabian Sea during the pre-monsoon months. Thus, the effects of river water input into the BOB are not just local, but spread out over a large area on an annual scale.

A thin layer of low saline water, therefore, plays a critical role in maintaining convection over the BOB. Therefore, reduced run-off, a certain consequence of linking rivers in India to increase residence time of water on land, could affect monsoon rainfall both in amount, duration and spatial distribution. However, we are not in a position at present to quantify the effects precisely. There are several issues here, including the present uncertainty over the actual amount of river discharge, amount of river discharge likely to be reduced due to river linking (it is not possible to stop the flow completely), its geographic location, etc. Another important aspect is the amount of freshwater needed in the top 10–20 m layer to inhibit vertical mixing. There are interannual variations in monsoon rainfall, and the BOB seems to be able to maintain its stable layer against these natural fluctuations. However, we need to understand if any long-term trend could result if river flow is gradually reduced. Some of these issues cannot be answered with our present understanding. Observational and numerical simulations are needed.

Stratification below the mixed layer also affects the chemical and biological processes in the Bay. It is worth noting here that because the low salinity layer in the BOB prevents vertical mixing, the Bay is not a source of CO_2 to the atmosphere. Removing this lid (by reducing the freshwater run-off) will lead to upwelling of cooler and nutrient-rich deeper water and the Bay also will become a source of CO_2 to the atmosphere, similar to the Arabian Sea. In addition, because of the nutrient supply from below, biological productivity is likely to increase in the Bay resulting in the development of oxygen minimum zone, as in the Arabian Sea. This will, in turn, cause denitrification that releases N_2O to the atmosphere, a more potent greenhouse gas than CO_2. Thus, in addition to its possible adverse effect on monsoon rainfall in India on a long term, river linkages may have the potential to accelerate global warming on a short term.

The benefits of the monsoon rainfall to the entire ecology of India as well as to the human-centric economy need no reiteration. The adverse effects of reduced run-off to the BOB because of river linkages also appear to be real. We note here that our arguments are based on simplistic interpretation of presently available data on SST, salinity and wind velocities over the BOB. A more accurate relation between the run-off input and monsoon phenomenon will require more and credible datasets on various ocean, atmosphere and land-based physico-chemical and biological parameters and modelling them for their interconnectedness.

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