Nanomedicine – emerging area of nanobiotechnology research

In 1959, Nobel Laureate Richard Feynman predicted the emergence of a new science called nanotechnology, a branch of science that deals with structures of 1 to 100 nm in scale. Nanobiotechnology is the convergence of engineering and molecular biology that is leading to development at the atomic, molecular or macromolecular size range to create and use structures, devices and systems that have novel properties. The true promise of nanotechnology lies in the ability to manipulate materials on the same unimaginably small scale used by nature. Nanomedicine is a cutting-edge area of research that combines the concepts of nanotechnology and medicine and it provides new hopes for research in both areas. The early genesis of the concept of nanomedicine sprang from the visionary idea that tiny nanorobots and related machines could be designed, manufactured and introduced into the human body to perform cellular repairs at the molecular level[1]. Now nanomedicine has emerged as a large subject area and includes nanoparticles that act as biological mimetics (e.g. functionalized carbon nanotubes), 'nanomachines' (e.g. those made from interchangeable DNA parts and DNA scaffolds such as octahedron and stick cube), nanofibres and polymeric nanoconstructs as biomaterials (e.g. molecular self-assembly and nanofibres of peptides and peptide-amphiphiles for tissue engineering, shape-memory polymers as molecular switches, nanoporous membranes), and nanoscale microfabrication-based devices (e.g. silicon microchips for drug release and micromachined hollow needles and two-dimensional needle arrays from single-crystal silicon), sensors and laboratory diagnostics[2] (e.g. detection of single cells, metabolites or ions). The applications of nanotechnology in bioimaging and detection, drug delivery, drug discovery and new drug therapies have declared war on cancer and other dreadful diseases. Molecular imaging techniques can be used as useful adjuncts in the development of nanomedicine and in personalizing treatment of patients[3]. In the near future, selective targetting for cellular delivery systems will overcome the chief limitations and side effects of systemic drug therapy. Through individualized therapy and personalized prevention, the scourge of many dreadful diseases will hopefully be a thing of the past to future generations.

Scientists working in the area of nanoscience strongly believe that the merger of nanoscience and biotechnology will undoubtedly transform the foundations of disease diagnosis, treatment and prevention in the future. Recent literature focuses on the potential of nanomedicine, including the development of nanoparticles for diagnostic and screening purposes, DNA sequencing using nanopores, manufacture of drug delivery systems and single-virus detection[4], and in the emergence of nanoneurosurgery[5].

National Science Foundation (NSF), USA estimated that nanotechnology will become a US $1 trillion industry by 2015, and much of this economic effort will be directed towards healthcare and cancer therapy sectors[6]. To make this estimate a reality, extensive collaborations among physicians, engineers, molecular biologists, material scientists, chemists and researchers from supporting disciplines from around the world are needed, which is easier said than done. Nanotechnology is here to stay, to provide opportunities for developing new materials and methods that will enhance our ability to develop faster, more reliable and more sensitive analytical systems[7]. Such is the future of 'nanomedicine' that it promises to consign current technologies to obsolescence.

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Interlinking of rivers

Rajamani *et al.*[1] have presented a new hypothesis which states that implementation of interlinking of rivers (ILR), the incorrect but more commonly used name for 'trans-basin sharing of water', would change the quantity and pattern of freshwater flow into the Bay of Bengal (BoB). This would set-off a chain of events that would adversely affect the monsoon rainfall and would also convert the BoB into a producer of CO_2 and N_2O. The hypothesis suffers from at least five major flaws, and the manner of its presentation also raises some questions, as explained below.

(1) The cause and effect relationship that Rajamani *et al.* have tried to establish between freshwater flow into the BoB and monsoons, is only a conjecture. Many of the steps in their reasoning are offered as axioms, to be accepted without question. It is pertinent to note that the quantity of return flow to the BoB, or the thickness of the less-saline layer in the BoB, are not included as parameters in the monsoon prediction model adopted by the IMD/DST, and the present thinking does not accept them as parameters of any consequence.

Of course, Rajamani *et al.* are within their rights to propose a new theory on monsoons; that is how science progresses. But those who propose a new hypothesis, are also required to provide evidence in its support. It would be best if they provide a conclusive proof supporting the new thinking. The minimum requirement is to provide sufficient evidence, enough for the scientific community to take the new idea seriously, and subject it to further examination. As of now, Rajamani *et al.* have not provided even this minimum evidence.

(2) The conjecture proposed by them is entirely qualitative. No attempt has been made to suggest, even as a rough estimate, what quantity of reduction in flow to the BoB would affect the monsoons by what quantum. Even if the descriptive cause and effect relationship as suggested by them is valid, it is of interest in the context of ILR only if the quantitative impact is significant.

(3) Rajamani *et al.* have completely missed or ignored the point that it is not the trans-basin transfer of water, but interception of water for human use, that alters the pattern of return flow to the oceans; and it is the consumptive use of water that reduces the quantity of return flow. Such interception and use takes place even without the ILR. If a certain quantity of, say, Mahanadi water was intercepted for human use, then seen from the perspective of the BoB, it makes no difference whatsoever whether it was used within Mahanadi basin, or whether it was first transferred to Godavari/Cauvery/Pennar/or any other basin and used there. [There are some other differences between use of water within the basin, and its transfer to another basin. But this is not a general discussion on ILR. This is only a rejoinder to the specific issue of change in the outflow to ocean, raised by Rajamani *et al.*]

Quantity of water required by the year 2050 has been estimated differently by different analysts, but typically the estimates are around 1200 bcm. And it is estimated that without ILR, it will be possible to use about 1122 bcm of water, 690 bcm from surface sources, and 432 bcm from groundwater sources. The additional use due to ILR is expected to be 200 bcm at the most. Now, if changes in the pattern and quantity of return flow to the oceans significantly affect the monsoon, then Rajamani *et al.* should be voicing their concern about interception and use of water, with or without ILR. Limiting their concern only to ILR use exposes an inconsistency in their thinking that they need to explain.

(4) Rajamani *et al.* have missed another important fact, that of all the links only the Sarda–Sabarmati link proposes transfer of BoB-destined water to the Arabian Sea. In case of all the other links that originate in the basins that drain into the BoB, the recipient basin also drains into the BoB, e.g. the unused component of the water transferred from Brahmaputra to Mahanadi, or from Mahanadi to Godavari, or Godavari to Cauvery, will still return to the BoB. On the other hand, there are several links – Pamba–Achikovil–Vaipar link, Bedti–Varda link, and Netravati–Hemavati link – that transfer some Arabian Sea-destined water to the BoB.

(5) Let us for a moment accept that there will be a change in the monsoon if some of the water that was reaching the BoB at its northern periphery, through Brahmaputra and Ganga, was to reach the BoB at its southwesterly periphery, through Mahanadi, Godavari, etc. But a change does not necessarily mean a change for the worse. It can as well be a change for the better. Without a quantitative relationship between the quantity, and spatial and temporal distribution of freshwater over the BoB *vis-à-vis* quantity and spatial and temporal distribution of monsoon rainfall, the underlying tone of the report that the change will be for the worse, is uncalled for.

In addition to these five flaws there are two other aspects that raise a question on the entire exercise.

It is not understood why water resources engineers were kept out of the Bangalore meeting. The errors (3) and (4) above would have been easily avoided if a representative from water resources engineering was present.

It is not understood why they have gone public with only a descriptive argument, without any analysis. Rajamani *et al.* have themselves inserted many disclaimers in their report, that their arguments are based on simplistic interpretation of presently available data; that they need to understand whether any long-term trend could result if river flow is gradually reduced; and these issues cannot be answered with their present understanding, etc.

The use of water has already crossed 600 bcm, which is more than three times the maximum additional use possible through ILR. In many of the basins that empty into the BoB, water use has reached almost its full potential. What impact has it had on monsoons? Rajamani *et al.* could have examined this first.

At present only one link, the Ken–Betwa link, has been taken up for preparation of DPR (only preparation of DPR, not construction). And no other link has reached even the DPR stage. ILR is not something that can be completed in secrecy over a weekend. It takes years to progress even from FR to DPR, and there was no 'risk' that ILR may be completed before Rajamani *et al.* complete their analysis. Then why were they in such a tearing hurry to broadcast the 'conclusions' without doing the analysis? This question also needs explanation.

The opposition to ILR has its basis more in romantic ideology than in hydrometeorology. What started in the mid-eighties as opposition to a few specific large dams, has now diversified into an opposition to all dams, barrages, canals, deep tube wells, irrigated agriculture in general, use of agro-chemicals, HYV seeds, GM crops, and of course the ILR – in short, opposition to any use of modern technology in India's quest of self-sufficiency in food production. Now only the very naïve believe that all thi s opposition is driven purely by a love for the environment. This needs to be mentioned, because the scientific community needs to be aware of the existence of trans-scientific dimensions of opposition to ILR.

Activists opposed to ILR were always keen to make out a case that ILR would affect the climate, as that would enable them to create a widespread scare, even internationalize the issue. Predictably, the activists lobby has conveniently ignored all the cautionary disclaimers in the report, and environmental glossies are quoting it as if it is the gospel truth, e.g. one of them has called the report 'A new study…'. Obviously, they either do not understand, or do not want to understand, the difference between a 'study' and a 'one-day brain-storming session'.

Reputed scientists and academicians need to appreciate that the controversy that has been raked up over the ILR issue has much wider dimensions than just science, and one needs to be careful, lest they become an unwitting partner to something they would have never agreed to, had they been familiar with the complete canvass of the ILR issue.

It would be appropriate if the Indian Academy of Sciences, Bangalore arranges another discussion on this, with a wider participation, including water resources engineers and hydrologists.

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