Invisible pollution

The total global water resource comprises 94% salt water (oceans and sea), 2% ice (polar ice caps and glaciers) and only 4% freshwater. Out of this total (4%) freshwater, only 1.5% is available in rivers, lakes, streams, etc. and the balance 98.5% of total freshwater is groundwater. With freshwater bodies of surface water being polluted at an alarming pace and due to increasing demand for freshwater for diverse activities of the ever-growing population, groundwater resource, which was once believed to be pristine and protected, is more under potential threat than ever before.

Let us look at the breakup of global water consumption: 75% of the world's freshwater is being used for agriculture, 20% by the industries and 5% for domestic purposes. Major portion of freshwater that is consumed by agricultural sector re-enters the hydrosphere through rivers and lakes and ultimately find its way into groundwater aquifer system through hydraulically connected surface water-bodies that are highly contaminated.

We do not have comprehensive database on the status of contaminated sites and groundwater pollution in our country. Groundwater pollution in Tamil Nadu's Pallal basin (due to indiscriminate disposal of tannery waste water), organic pollution of groundwater near Mysore, Karnataka (due to distillery waste water), recent contamination of water at Bichhri village, Rajasthan are only a few examples to quote. Arsenic contamination in the Ganges aquifer system of West Bengal and Bangladesh is presumed to be the manifestation of over-exploited groundwater resources.

Indiscriminate land-based disposal of hazardous waste, application of pesticides, unlined and poorly maintained surface impoundments, poorly constructed septic tanks, infiltration of domestic sewage from unsewered areas, underground storage tanks of petroleum and gasoline products and chemical spills are all potential sources of groundwater pollution. If preventive and corrective action is not initiated immediately, many of our groundwater aquifers will get contaminated and result in serious water resource crisis and pose a public health risk.

There are some demonstrated technologies which are promising for cleaning-up contaminated aquifers. New technologies that are evolving include soil vapour extraction, *in situ* bioremediation, bioventing, air sparging, *in situ* thermal desorption, soil flushing, *in situ* reactive barriers, etc. Inaccessibility and inherent complexity of subsurface system, impracticable time scales required for the clean-up, complex technologies and ultimately the cost, pose formidable challenges for effective and efficient practical implementation of these technologies. If any aquifer is once contaminated, it will be extremely difficult if not impossible to treat and remediate, especially for a country like India.

The action plan for groundwater protection has to be based on:

- Detailed characterization and preparation of baseline database for the entire country's groundwater system.
- Classification of aquifer systems with respect to quantity, quality, utility as well as present and projected pollution status.
- Surveillance and monitoring of groundwater system for pollution by federal and state regulating agencies through a permanently established and well-designed system of monitoring network on a continuous basis.
- Establishing the network of interactive information system among the state and federal regulating agencies, research institutes and local monitoring cells.

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More Bradmans

I enjoyed reading the piece 'The Bradman class' (*Curr. Sci.*, 2001, **80**, 717–718). J. D. Watson and F. H. C. Crick were, however, not so classified. Among the 20th century scientists, they deserve that class. Pauling had proposed a model of DNA (published in *Proc. Natl. Acad. Sci. USA*) before the Watson and Crick paper in *Nature* in 1953. According to him, the bases stick out. That did not solve anything. Chargaff found A is equal to T and G is equal to C, but he did not know what it meant. It was Watson and Crick who proposed that: (1) bases stick inside and pair by H-bonding, A with T and G with C; hence G = C and A = T; (2) for replication, the two strands unzip and act as templates for synthesis of two new strands; (3) the two strands are antiparallel which helps in H-bonding of A–T and G–C; (4) the sequence of bases is unique for each gene and codes for a specific protein; and (5) a change in a base causes a mutation.

All these are original and outstanding interpretations of the limited data that were available at the time. Watson and Crick were certainly the ones who made biology, physics and chemistry join hands. Without their elucidation of the DNA structure, there would not have been a gene revolution so early in the 20th century. What is remarkable is the amount of information that they could draw out by proposing a simple model of DNA. If the five conclusions mentioned above

had been made at different points of time, their impact would not have been as great as that made by the 1953 *Nature* paper. For example, Chargaff's data of G = C and A = T hardly made an impact on biologists, as he did not interpret the data. He did, however, express his annoyance for not sharing the Nobel prize.

I would, therefore, raise both Watson and Crick to the 'Bradman class' for their far-reaching interpretation of the limited data and for their insight into the DNA molecule which made possible the understanding of 'information flow in living organisms', the genetic code, genetic engineering and all the rest. It is praiseworthy that they continue to contribute to science at such high gear even after half a century.

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Academic leadership and the ailing state of Indian science

Indian institutions have not produced even one Nobel prize winner since independence, despite proliferation of very many universities and a large number of national research institutes. Concerns regarding the decline in academic and scientific quality in India have also been voiced recently. R. Kalshian[1], referring to the decline in quality of research in India states that, 'In the entire history of CSIR, only three out of over 20,000 papers published by its scientists have been cited more than 100 times against a world average of one out of every 250'. This may constrain people to infer that the functioning of the national research institutes is far from being satisfactory, since there is an asymmetrical relationship between the funding and their performances. This may be possible because in the post-independence period the high priests of academic and scientific organizations, instead of confronting the political bosses to defend quality and truth like Asutosh Mukherjee and others of pre-independence period, have become the messengers of political bosses and behave like chameleons depending on the political bosses. P. V. Indiresan, former Director of IIT, Madras has vividly compared the happenings of the pre- and post-independence period and has said[1], 'As a Vice-Chancellor Asutosh Mukherjee could straight away make Raman the Palit Professor in Calcutta University . . . Those days Vice-Chancellors were 10 feet tall. These days, their counterparts are pygmies. How did that happen?'.

These 'pygmies', devoid of adequate academic quality and integrity, in their capacity as Vice-Chancellor/Director tend to be scavengers of quality and settle for second raters and third raters. In the process merit and quality are sacrificed and the entire generation suffers. As a result, academicians with courage, integrity, conviction and originality are becoming casualities of the system justifying Gresham's law, i.e. bad money drives away good money out of circulation.

If India has to make a mark it is necessary to preserve, protect and defend quality in human capital. This cannot be assured without ensuring the quality of the Vice-Chancellors/Directors because they play a vital role in ensuring/damaging the quality of the institutions which serve as gold mines of human quality.

In the absence of an objective assessment of quality, judgments are mostly subjective and prejudiced and result in the selection of Vice-Chancellors of poor calibre, in spite of an elaborate procedure involving the University Grants Commission, Chancellor and the Syndicate vicariously. A similar situation holds true for research institutes. A corrupt and incompetent bureaucracy further contributes immensely to the said selection. Clearly, an objective assessment of quality through citation counts – the acid test of quality – has become mandatory[2], in addition to other prevailing criteria for the selection of Vice-Chancellors, Directors and other personnel for top academic positions. Only men of quality can preserve, protect and defend quality. As a result quality will breed merit and merit will no longer be a casualty and a glorious India can be assured.

1. Kalshian, R., *Outlook*, 23 October 2000, pp. 56–66.
2. Basa, D. K., *Curr. Sci.*, 2000, **79**, 1042–1043.

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Need for reforms in Indian National Science Academy

I was delighted to read the column 'News in brief' in *Current Science* (2001, **80**, 726) regarding the reforms and restructuring of Indian National Science Academy (INSA), proposed by Goverdhan Mehta, the President of INSA. As a matter of fact, restructuring of INSA has been long overdue in view of the changing scenario at the global level. INSA has been acting more or less like an exclusive 'White man's club' in India. It is one of the most prestigious science academies in the country. Unfortunately, after the independence, university academia have found less and less representation in its elected fellows compared with the scientists from institutes like TIFR and IISc. It may be considered as an index of decline in quality of research produced by our universities.

The President of INSA deserves all praise for introducing innovative ideas for the election of INSA fellows. Due recognition will be given to scientists working in inter-disciplinary areas of research by creating a separate sectional committee to consider their nominations. I know many physicists working in border-line or cross-border disciplines being ignored year after year, as there was no

slot for them in INSA. It is a well-known fact that the discipline of molecular biology was created due to the pioneering efforts of physicists, both experimental and theoretical. There is an overlap of basic science, applied science and technology in all disciplines and due weightage must be given for inter-disciplinary research.

INSA plans to involve itself in popularization and promotion of science education at all levels. A beginning has been made at the school level by recommending new curriculum in science subjects to the NCERT. INSA is also involved in promotion of history and philosophy of science (Virk, H. S., *Curr. Sci*., 2000, **79**, 1514). In fact, it is the only organization doing its bit in this inter-disciplinary area. It is my earnest desire that INSA should recognize the contribution of scientists engaged in promotion of science education in India by electing them as its fellows. To cite an example: B. L. Saraf (formerly of Rajasthan University, Jaipur) at the Institute for Laboratory Education, Indore had involved himself in promotion of physics-laboratory education in the country for the last 30 years and has achieved tremendous success, but INSA never bothered to elect him a fellow.

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Jyotir-vigyan

P. Balaram's editorial in *Current Science* (2000, **79**, 1139) drew my attention to the UGC proposal of introducing Vedic Astrology in Universities, though it was not clear whether this subject was to be included in the science faculty. A news report says that Patna University plans to create a Vedic Astrology Department, that will not be in the science faculty. If this course is not a part of science faculty, the campaign by scientists against it is misplaced. K. N. Ganeshaiah (*Curr. Sci*., **80**, 2001, 719–720) has quite convincingly refuted Balaram's alarmist editorial. Media reports show how a serious matter pertaining to knowledge is being scandalized by the so-called eminent scientists from premier institutions (see *The Hindu*, 19 April 2001 and *Hindustan Times*, 25 April 2001). A statement is quoted ending with 'astrological charlatans', but then science philosopher Paul Feyerabend made the statement 'Leading intellectuals with their zeal for objectivity. . . are criminals, not the liberators of mankind', and 'Scientists are every bit the equal of ancient myth-tellers, troubadours and court jesters' (*Sci. Am.*, May 1993, p. 36). A letter from IUCAA, Pune claims that the UGC move will take us backwards to medieval times. Even if we accept this claim, do they have any evidence to prove that modern society is more enlightened than the medieval one? Ganeshaiah observes that these scientists reject any idea originating from Hindu heritage, but cite erroneous views of Greek philosophers (though he is unnecessarily apologetic using the word Hindu). In contrast, Misner and Wheeler cite the Indian Vedas to have propounded the ideas related to 'physics is geometry' (*Ann. Phys*., 1957, p. 535–536). Why is it so? I think the main reason is that most of the leading scientists in India are imitators of West, lack original thoughts, and they neither understand philosophy of science nor ancient Indian wisdom. Media is obsessed with the eminent people, and in this case, Narlikar spearheading the crusade against 'Vedic astrology' has become the authority on this.

In his recent interview (*Times of India*, 3 May 2001), Narlikar has misinterpreted Vigyan as science. Vigyan is an ancient word and translating it as 'science' and then objecting to 'jyotir-vigyan' shows either lack of understanding or ill intention. He says that no astrologer could predict any event with certainty. If no physicist can prove an established law, does that invalidate the physical law or show the incompetence of the physicists? Reading the interview, it becomes clear that 'jyotir-vigyan' for Narlikar means 'what the stars foretell'/horoscopes, which are a few of its applications only.

Returning to science, Narlikar says that, 'There are no controlled tests to prove astrological predictions right'. Is there any such test for cosmological models? Is cosmology science? Why does he believe in the steady state theory disproved by 'observational evidence as defined by science establishment?' Big-bang cosmology and early universe scenario do not differ from mythological stories, yet scientists continue demanding huge funds for their so-called scientific predictions combining cosmology with high energy physics. The standard model of particle physics has as many as 19 or 20 (!) adjustable parameters; 'The history of super-symmetry' is exceptional. In the past, virtually all major conceptual breakthroughs have occurred because physicists were trying to understand some established aspect of nature. In contrast, the discovery of super-symmetry in the early 1970s was a purely intellectual achievement, driven by the logic of theoretical development rather than by the pressure of existing data' (see *CERN Courier*, March 2001, p. 19); there is no testable prediction of super string theory – a pure speculation. There are many eminent scientists in the premier institutions working on such speculations made by western scientists; real science is being strained, and meagre public resources are being misused for such fantasies. Today big science is suppressing new ideas. If the tyranny of the orthodox science establishment is not challenged, we are sure to enter the age of darkness. Narlikar and crusaders against jyotir-vigyan would do well to address the problems on philosophy, methods and limitations of science rather than indulging in misleading propaganda diverting public attention from their failures.

Finally a remark on the UGC move: I do not think that either the HRD Minister or the UGC Chairman also understands 'jyotir-vigyan'. In an article I read that 'exporting this knowledge' also figures in UGC circular. It may be true because now-a-days there is a brand of Indian heritage that is aimed at being marketed for 'dollars', and why not! NRIs have proved marketability of 'yoga', 'ayurveda', etc! The real danger to 'jyotir-vigyan' is from such people, not from Narlikar & Co.

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Astrology and science

The UGC has certainly stirred a hornets' nest by its ridiculous decision to promote courses in astrology and palmistry. It does not require a great deal of common sense to know why the UGC was bulldozed into this decision, which is a giant leap backwards for science in this country. Astrology is not a religion, it is a subject that comes cloaked in the garb of pseudo-science, purporting to make definitive predictions on human affairs based on planetary conjunctions. Khushwant Singh, in his column 'Sweet and Sour' mentions numerous examples of astrological predictions made by 'eminent' astrologers which fell flat. Let us erase words like 'Rahukala', 'Yamagandkala' and 'Gulikakala' and all the mumbo-jumbo of astrological and vaastu vocabulary from our lexicon. This is not meant to belittle the role of spirituality and even the most rational scientist believes that spirituality and science can co-exist and complement each other. Jayant V. Narlikar has been the most vocal and has written to the UGC Chairman expressing the deep anxiety of the scientific community against this retrograde step. What was most distressing was that his and Balaram's (editorial *Curr. Sci*., 2000, **79**, 1139 was the first to expose the grand designs of the UGC) have been lone voices among the 10-lakh strong scientific community in this country. There has not been any protest from the Indian Science Congress which organizes a yearly Kumbhmela inaugurated by the Prime Minister. And what about the other science organizations in the country and the academies. Why do they have to toe the UGC line? Let scientific thinking and a rational bent of mind prevail. Didn't Tagore himself say in his great poem *Where the mind is without fear*: 'Where the clear stream of reason has not lost its way into the dreary desert sand of dead habit, Into that heaven of freedom, my Father, let my country awake'. Let us fight to prevent our academic institutions from becoming a haven for 'sadhus and sanyasis', who will soon join the academic stream as teachers, flaunting their degree in astrology, witchcraft and palmistry. My good friend Ganeshaiah, himself one of the finest evolutionary biologists in this country, indirectly endorsed the decision of the UGC in a recent letter in this journal (2001, **80**, 719–720). His argument being (and I must confess a strong one) that we should not discard an initiative like this just because it is a pseudo-science, but give it time *to kill itself* if it does not have the strength to stand alongside the well-grounded science stream. Good logic, but let me ask him a simple question. If he was giving a talk on say 'Long-term strategies for bio-conservation of medicinal plants in the BR hills: Vision for 2020' and an astrologer scientist (say with a Ph D in Jyothir Vigyan from Banaras or Osmania University; yes Osmania University too has taken the bait, i.e. funding for a full-fledged department with positions, contingency funds etc.) said that according to planetary predictions, long-term studies would be an exercise in futility, because the world would end soon as we are in *Kaliyuga*, what would be his response? Let me guess. He would say, 'My dear sir, keep your Jyothir Vigyan degree to yourself. We scientists will always plan for research not just 20 years from now, but even 100 years from now. That's how we are trained to think, with logic and reasoning'.

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Diagenetic rare earth phosphates

The article by A. V. Sankaran on diagenitic rare earth phosphates (*Curr. Sci*., 2001, **80**, 818–820) is very informative and can be used for dating Proterozoic metasedimentary formation, where there are records of these minerals. This information can be applied in Rajasthan where there is lack of geochronological data in Proterozoic metasedimentary formation of Aravalli Supergroup.

There is one additional information which the author has missed. The oldest records of early crust is 4.2 b.y. recorded from Mount Narryers and Jack Hills, Western Australia[1,2] and not 4.03 which the author has mentioned in the article. This information has been gathered from detrital zircons derived from quartzites occurring in above-mentioned localities. This is the only evidence to probe in the era of Hadaean.

1. Amelin, Yuri, Lee, Der-chuen, Haliday, Alex, N. and Pidgeon, Robert, T., *Nature*, 1999, **199**, 252–255.
2. Mass, R., Kinner, P. D., Williams, T. R., Froude, D. O. and Compston, W., *Geochim. Cosmochim. Acta*, 1992, **56**, 1281–1300.

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Response:

The 4.2 b.y. zircon from Mt. Narryer and Jack Hills, W. Australia, pointed out by Vivek Laul represents the mineral-age and not the age of the host rocks–quartzites and conglomerates, which are much younger. In fact, still older zircons dated 4.4 b.y. have also been reported last year from the same locality[1]. Zircons in these rocks are detrital in origin, derived from an earlier crust, probably a granite, which like many of the early-formed crusts, must have had brief geological existence. Unlike these transient early crustal rocks, the Canadian occurrence of 4.03-b.y.-old zircons, quoted in my article (*Curr. Sci*., 2001, **80**, 818–

820), represents the age of the rocks–metatonalites and metagranodiorites, in which the zircons had crystallized as typical accessory mineral. These meta-igneous rocks are the only ones, so far discovered, to have survived till today and hence constitute the *Oldest preserved crust*. In the absence of the parent rocks, the 4.2–4.4 b.y. zircons from W. Australia only confirm that crustal development was active within half-billion years of formation of the earth and that a few of these early-formed crusts must have remained stable for some time to be weathered and the zircons deposited elsewhere.

1. Report on the Annual Meeting of Geological Society of America, *Science*, 2000, **290**, 2239–2242.

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NEWS

Nuclear power statistics for 2000*

A total of 438 nuclear power plants were operating around the world at the end of 2000, according to data reported to the Power Reactor Information System at the International Atomic Energy Agency (IAEA). The plants had a total net installed capacity of 351 GW(e). Also during the year 2000, six nuclear power plants representing 3056 MW(e) net electric

Table 1. Nuclear power reactors in operation and under construction during 2000

	Reactors in operation		Reactors under construction		Nuclear electricity Supplied in 1999		Total operating experience	
Country	No. of units	Net capacity MW(e)	No. of units	Net capacity MW(e)	TW(e)-h	% of total	Year	Month
Argentina	2	935	1	692	5.73	7.26	44	7
Armenia	1	376			1.84	33.00	33	3
Belgium	7	5712			45.40	56.75	170	7
Brazil	2	1855			5.55	1.45	19	3
Bulgaria	6	3538			18.18	45.00*	113	2
Canada	14	9998			68.68	11.80	433	2
China	3	2167	8	6420	16.00	1.19	23	5
Czech Rep.	5	2569	1	912	13.59	18.50	58	9
Finland	4	2656			21.06	32.15	87	4
France	59	63073			395.00	76.40	1169	2
Germany	19	21122			159.60	30.57	591	1
Hungary	4	1755			14.72	42.19	62	2
India	14	2503			14.21	3.14	181	5
Iran			2	2111				
Japan	53	43491	3	3190	304.87	33.82	962	8
Korea, Rep. of	16	12990	4	3820	103.50	40.74	169	2
Lithuania	2	2370			8.40	73.68	30	6
Mexico	2	1360			7.92	3.86	17	11
Netherlands	1	449			3.70	4.00	56	0
Pakistan	2	425			1.08	1.65	29	10
Romania	1	650	1	650	5.05	10.86	4	6
Russia	29	19843	3	2825	119.65	14.95	671	6
South Africa	2	1800			12.99	6.58*	32	3
Slovak Rep.	6	2408	2	776	16.49	53.43	85	0
Slovenia	1	676			4.54	37.38	19	3
Spain	9	7512			59.30	27.63	192	2
Sweden	11	9432			54.80	39.00	278	1
Switzerland	5	3192			23.54	38.18*	128	10
UK	35	12968			78.30	21.94	1238	4
Ukraine	13	11207	4	3800	72.40	47.28	240	10
USA	104	97411			753.90*	19.83	2559	8
Total	438	351327	31	27756	2447.53		9819	11

Note: Asterisk is estimate.
The total includes the following data in Taiwan, China: 6 units, 4884 MW(e) in operation; 2 units, 2560 MW(e) under construction; 37 TW(e)-h of nuclear electricity generation, representing 23.64% of the total electricity generated there; 116 years 1 month of total operating experience.
One reactor was shut down, Chernobyl 3, in Ukraine in 2000.