rage 228 km upstream of Delhi and diverted into two great canal systems known as the Western and Eastern Yamuna canals. Only during high floods does some flow escape out of the basin. This too is proposed to be stored and put to use by construction of three storages, Kishau, Lakhwar-Vyasi and Renuka, with a combined live storage capacity of about 2 BCM. The storages will enable additional utilization of 2 BCM, bringing the total utilization from surface sources to about 11 BCM, more than five times the total live storage capacity.

Another example. In the Ganga up to Haridwar there is only one storage, the Tehri dam, which has been completed only two years ago (in 2005). But the Upper Ganga canal system taking off from Bhimgoda barrage near Haridwar has been irrigating almost one million ha for more than 100 years, without any storage. Likewise, any number of more examples can be given from other basins. Upper Yamuna and Ganga were deliberately chosen as examples because these are practically 'no storage' basins, and yet have a large surface-water utilization. Moreover, this utilization is there for all to see, without the need for any data. The point is – a significant part of the surface-water utilization comes from non-storage schemes, and Garg and Hassan have completely ignored that.

Thus, it seems that the Garg and Hassan estimate of 668 BCM as the total utilizable water resource is way off the mark and on the lower side; because they have equated utilizable surface resource with live storage capacity in a basin, completely ignoring the non-storage utilization. Therefore, one may relax and start breathing normally again, as the water shortage scenario they have painted is incorrect.

Concluding their paper, Garg and Hassan have pointed out that theirs is only a quantitative analysis, which assumes that all the available water will be of acceptable quality. This is indeed the most crucial aspect of water resources planning. Many analysts have pointed out that agriculture is already supporting as many livelihoods as it possibly can; land holdings are reducing in size with every generation and this is the main reason for rural poverty, as it is not possible to support a family with land holding as small as 1 ha. As the population continues to increase, it is necessary to reduce the pressure on agriculture as a means of livelihood and provide more employment opportunities in the industrial sector.

Thus, a massive increase in industrialization, and with that a massive increase in urbanization, is inevitable. But the performance of the Indian industry in effluent treatment – particularly the small-scale industries – is most unsatisfactory. Likewise, the performance of the urban local bodies in sewage treatment is also nothing to be proud of. It is not impossible that there will be water in the rivers and in the aquifers, but its quality will be so bad that it will be of no use.

Garg and Hassan have recommended that all possible storage works be completed on priority basis. Temporal skew in precipitation and river flow is smoothened out by storing the water in reservoirs and aquifers. As the climate change accentuates the skew, storages will become even more important than what they are as of now. Just as temporal skew in precipitation is smoothened out by storages, spatial skew is smoothened out by transferring the water from where it is available to where its availability is less. That is what inter-linking of rivers is all about. Thus, storages and interlinking are two major actions that are necessary to deal with the temporal skew and spatial skew respectively. To implement these to the fullest extent, it would be necessary to overcome the dogmatic opposition to river valley projects by 'renowned water experts'.

1. Garg, N. K. and Hassan, Q., *Curr. Sci.*, 2007, **93**, 932–941.

CHETAN PANDIT

National Water Academy,
Central Water Commission,
Government of India,
Sinhagad Road,
Khadakwasla R.S.,
Pune 411 024, India
e-mail: cmpandit@nic.in

Garg and Hassan reply:

Considering the complexity of the problem and in order to compare the estimates, we have adopted a similar methodology[1] for the estimation of water utilization as that of the NCA – comprising storages plus river diversions (the regenerated groundwater flows into the rivers due to recharge from natural precipitation) and groundwater recharge due to water use. After analysing the previous studies it was found that the CWC had also adopted the same methodology and directly adopted the figures of the utilizable surface water from the NCA (table 3 of the paper[1]) – comparison of utilizable flows of identical basins) without going into the assumptions, etc. The CWC estimated the utilizable water resources as 690 BCM from surface water plus 418.54 BCM (CGWB assessment 1983–84) from groundwater (table 1 of the paper[1]) to approximate the total utilizable water resources as 1110 BCM. It has also been shown by us[1] that the utilizable surface water of 690 BCM was the sum of the live storage of 240 BCM (after deducting losses) and 450 BCM (the regenerated groundwater flows into the rivers due to recharge from the natural precipitation during the non-monsoon period for river diversions, following NCA). Since 418.54 BCM was estimated as the new updated figure of total groundwater recharge (corresponding to 800 BCM (450 (natural) + 350 (irrigation recharge)) of NCA), the CWC should have subtracted 450 BCM from 690 BCM before adding it to 418.54 BCM, and therefore overestimated the water utilization. Thus, data from the NCA were juxtaposed on the data from the CGWB assessment (1983–84) without going into the assumptions by the CWC and has been clearly shown[1]. All the subsequent reports like NCIWRDP or National Water Policy of India, have taken the value of 690 BCM as utilizable surface water from the CWC and therefore are matching within tolerable limits.

The NCA report categorically states: 'In the absence of comprehensive observations and data compilation the figures in the chart represent only broad magnitudes and should be treated merely as indicative and not definitive'. Therefore, it was necessary to incorporate the significantly reduced updated value of the replenishable groundwater resources of CGWB and unlike the CWC, we have corrected the estimate of the utilizable flows with the new estimate of 432 BCM (the sum of the natural recharge and the additional recharge from canal irrigation system) of the CGWB (1995)[1]. Unlike the NCA, the CGWB kept the entire replenishable groundwater to be utilized through pumping, except for a provision of around 36 BCM to the river to main-

tain river ecology. Unlike the CWC, we have corrected the estimate of the utilizable flows with the new estimate of the CGWB (1995) (keeping no flows for non-monsoon river diversions) and 385 BCM from storage (including identified future storage projects) along with the additional return flows (following NCIWRDP (1999) approach) on full development[1] and estimated the utilizable water resources as 668 BCM. CGWB (2006) has again re-confirmed its earlier estimate of 432 BCM, as it is now updated marginally to 433 BCM.

The foregoing clarifications clearly show that unlike the CWC, there is no mixing up of data on the utilizable groundwater resources by us. The water-use balance in 1997–98 of 629 BCM has already been discussed by us[1] and would not be repeated here. The estimation of 1123 BCM has also not been calculated as stated by the authors of the correspondences, but as a sum of 690 BCM (surface water) + 433 BCM (groundwater). It is assumed that all the storage figures of the CWC are at 75% dependability, although the total replenishable groundwater estimates are for normal rainfall. The reduction on account of silting is not considered and it is also assumed that all the water, including the return flows is of acceptable quality. The water utilization may increase through non-conventional methods and may be tried with proper assessments.

The monsoon river diversions were also not considered by the CWC and therefore, it is not discussed by us[1] in order to compare estimates with similar methodology. Also, we could not obtain data on monsoon diversions, generating from around 100 h of rainfall, to meet the irrigation demands without storages at 75% dependability.

The illustrative examples of Pandit certainly seem to be wrong. Historically, it was the low flows that were diverted either from the Ganga or Yamuna rivers with the help of temporary or permanent structures called as weirs, and the dropping shutters on the weirs remain dropped during the monsoon season to pass the monsoon floods. The policy was also limited to extensive irrigation. It is only recently (around 1990) that the weirs were remodelled as barrages to maintain the pond levels during the monsoons and to divert some flows depending upon the matching of the monsoon flows with the irrigation demands. If the regenerated groundwater flows into the river are not available, then the diversion structures may not be suitable for the assured irrigation and may not be economically viable.

The river diversion data, as claimed by Pandit on the utilizable river diversions, is of the order of 70% of the mean flow. If one takes it seriously, it would mean that the utilizable river diversions alone would be of the order of 1308 BCM (0.70∗1869 (mean annual flow)) without any storage. The total utilization would be of the order of 2125 BCM (1308 (river diversion) + 385 (surface storages) + 432 (groundwater)). The 20% return flows would make the utilizable flows to 2550 BCM. The utilization can be further increased by considering non-conventional methods like transferring 250 BCM by inter-basin transfer and 36 BCM by artificial groundwater recharge. It would lead to a total utilization of the order of 2893 BCM, more than normal breathing space even with no population control!

The foregoing discussions and table 3 of our article[1] conclusively prove that the CWC had also adopted the same methodology as that of the NCA and directly adopted the figures of the utilizable surface water from the NCA, but data from the NCA were juxtaposed on the data from the CGWB assessment (1983–84), without going into the assumptions by the CWC. We have also used the same methodology as that of the CWC, but have corrected the mistake of the CWC in our calculations. There is an overestimation of the utilizable water resources of India ranging from 66 to 88%, as analysed in the article[1].

1. Garg, N. K. and Hassan, Q., *Curr. Sci.*, 2007, **93**, 932–941.

N. K. GARG[1,*]
Q. HASSAN[2]

[1]*Department of Civil Engineering, Indian Institute of Technology, New Delhi 110 016, India*
[2]*Department of Civil Engineering, Jamia Millia Islamia, New Delhi 110 025, India*
**e-mail: nkgarg123@yahoo.com*

MEETING REPORT

METALLO 2007*

A four-day international conference on the theme of metals and alloys, METALLO 2007, was organized to discuss the past, present and future of metals and alloys and their applications in diverse engineering fields. The conference showcased the latest global trends in metals and alloys research, education and industry. In particular, the latest developments, strategies and material requirements for a range of applications in various sectors were highlighted, e.g. in construction, automotive, aerospace, railways, space, nuclear, defence, chemical, petrochemical, biomedical and process industries. The target audience included academicians, engineers, scientists, young researchers and policy makers drawn globally from the industry, R&D and education sectors. The conference honoured T. R. Anantharaman, whose eightieth birthday was being celebrated in 2007. A citation of honour was read out for Anantharaman during the inaugural function.

Different aspects of research related to production of metals and alloys, structure and properties of metallic alloys at nanoscale as well as various diverse applications were discussed by 31 invited speakers. The workshop was attended by close to 250 delegates from USA, Canada, UK, Australia, Germany as well as various Indian institutions. Besides invited talks, the meeting had a poster presentation by active researchers, including senior Ph D students. Altogether 25 posters were presented under 11 different sessions with those on microstructural and phase evolution, mechanical properties, powder metallurgy and sintering, nanomaterials, corrosion and oxidation and modelling on 8 December, and sessions on material processing, application and process overview, characterization, steels and intermetallics and electronic materials on 9 December.

T. Ramasami (Secretary, Department of Science and Technology, New Delhi) delivered the inaugural lecture on 'An insight into the world of metals and alloys'. He emphasized the important role that metals and alloys would play in the coming years for India's overall development.

On 8 December 2007 there were four speakers in the first session of the conference, entitled 'Metals and alloys: Fundamentals and applications'. The first talk was delivered by Reiner Kirchheim (Institut für Materialphysik, Univeristy of Goettingen, Germany) on 'A new way of describing the interaction of solute atoms and defects'. He presented a coherent method which could explain segregation of solutes at interfaces. The results of the presented treatment were compared with those stemming from experiments, statistical mechanics or computer simulations. It was explained how various phenomena and models, like solid solution softening, hydrogen-enhanced local plasticity, brittleness of hydrides, and superabundant vacancies could be interpreted on the basis of thermodynamics as caused by changing the defect energy by solute segregation. This was followed by a lecture by P. Rama Rao (International Advanced Research Centre for Power Metallurgy and New Materials (ARCI), Hyderabad) on 'Low stress creep of zirconium and its alloys, zircaloy 2 and Zr-2.5Nb', in which he highlighted the importance of microstructural control on properties. In particular, he discussed the low stress creep behaviour of zirconium, zircloy-2 and Zr-2.5Nb alloy. Zircaloy-2 has 1.5 wt% Sn as a major alloying element along with Fe, Ni and Cr, each around 0.1 wt%. The microstructural changes observed during low stress creep leading to significantly enhanced creep rates for the $\alpha + \beta_2$ structure were rationalized in terms of the relative stability of the β_1 and β_2 phases. P. Ramachandra Rao (ARCI, Hyderabad) delivered an interesting lecture on 'Biomimetic synthesis of materials', in which he mentioned that several interesting practical applications of engineering materials were developed using clues from nature. Rao's talk briefly summarized some of the observations made and results obtained by his collaborator (Arvind Sinha) at NML, Jamshedpur. Subhash Mahajan (Arizona State University, USA) enlightened the audience on 'Physical metallurgy in microelectronics: Past, present and future' by providing examples to show the impact of physical metallurgy in the past, present and future development of electronic materials. Mahajan illustrated the respective roles using the following examples: zone refining, metal–semiconductor interactions, phase separation and atomic ordering in mixed group III nitrides and growth of low-dimensional structures.

In the first poster session, there were a total of 62 posters dealing with five themes: microstructural and phase evolution, mechanical properties, powder metallurgy and sintering, nanomaterials, corrosion and oxidation and modelling.

There were four talks in the final session of the day. S. Ranganathan (Indian Institute of Science, Bangalore) in his lecture on 'The shape and growth of metallic grains', discussed the interplay between static and dynamic structures in terms of geometry. Among various theories of the grain shape and grain growth, he also reviewed von Neumann law for grain growth in two dimensions and the recent extension to growth in three dimensions by MacPherson and Srolovitz. Peter W. Voorhees (Northwestern University, Evanston, USA) explained a single-order parameter model that accounts for all five degrees of freedom that determine the grain boundary energy and a multiorder parameter model for grain growth, using experimentally measured 3D grain structures in his lecture entitled 'The topology and morphology of interfaces: From phase separation to grain growth'. The talk concluded with a discussion of the factors controlling the interfacial morphology and topology found in various materials. This was followed by talks of Chandra S. Pande (Naval Research Laboratory, Washington) on 'Recent developments in grain boundary migration and grain growth' and of Srikumar Banerjee (Bhabha Atomic Research Centre (BARC), Mumbai) on the theme

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