River diversion schemes versus waste water recycling for Bangalore city*

The concern of Hegde and Subhash Chandra[1] about the environment and cost economics of river diversion schemes is commendable; however, given the limitations of the proposals recommended by the authors, the river diversion schemes could be inevitable for the reasons mentioned in this note. In addition, it is pertinent to look at the water problem from a river basin perspective where better options with long-term perspectives can be searched to manage the water crisis of Bangalore city.

Bangalore is flanked on either side of ridge-line of the Cauvery river basin and east-flowing rivers between Cauvery and Pennar basins comprising Ponniayar and Palar river systems that drain into the Bay of Bengal separately (Figure 1). Pumping Cauvery water from a distance of 80 km to a height of 920 m above mean sea level (amsl) itself is river diversion and inter-basin transfer of water, as the water from the Cauvery basin is supplied by the Bangalore Water Supply and Sewerage Board (BWSSB) to those parts of the city that lie in river basin that drains into the Ponniayar or Palar river systems. So, if river diversion is opposed or objected to, then the present inter-basin transfer of Cauvery water undertaken by BWSSB to Bangalore city should also be opposed. In that case, Bangalore will lose even the assured supply of 24,923 ha-m/yr of water (after 'conveyance losses') from BWSSB which will turn the water scenario of Bangalore city into a catastrophe.

Hegde and Subhash Chandra have considered the water balance for Bangalore city from the perspective of quantity, but have ignored quality aspects that can upset any water balance. Hence a false sense of complacency has been created by the authors in meeting the demand of 95 lakh people by 2020. According to CGWB report (2010)[2], in the absence of alternate source, the groundwater within unconfined aquifer around Bangalore has been identified as 'groundwater quality hotspot' based on certain water quality parameters like iron, fluoride, nitrate and conductivity exceeding their permissible limits. Also, the Purpose-Driven Studies (PDS) under World Bank-aided Hydrology Project-II have found that out of 2209 groundwater samples, 14 were found with increased fluoride content, 638 with increased nitrate and 145 samples with increased TDS, besides the occurrence of heavy metal pollution around industrial sites and *Escherichia coli* due to mixing of sewer water in Bangalore city[3]. These PDS conducted by the Department of Mines and Geology (Government of Karnataka) have confirmed the deteriorating groundwater quality and increasing health hazards around Bangalore city. Government being fully cognizant of the fact that groundwater is unsafe for consumption, cannot afford to be a mute spectator and allow unfettered consumption of contaminated groundwater by the unsuspecting public. Consumption of unsafe water continuously will precipitate health crisis in Bangalore with considerable intangible social costs like cost of overcoming health crisis, loss of employment due to ill-health, etc. associated with it. Also, providing unsafe and contaminated water for consumption to citizens denies them the human right to water[4] and the Government is under obligation to fulfil this all important fundamental right to life. Thus, the authors'[1] figure of groundwater overdraft of 12,741 ha-m/yr, as an assured source of water for Bangalore is unreliable. Hence the demand–supply gap remains at 23,677 ha-m/yr and that can trigger a massive water-cum-health crisis amongst as many as 47 lakh people, i.e. about 50% of Bangalore city population by 2020 (considering a projection of 95 lakh population). To avert the possible water crisis it is relevant to keep open the option of inter-basin transfer of water from west-flowing rivers like Nethravathi or water transfer from long distance like River Krishna instead of viewing the diversions purely from cost economics and environment point of view.

The authors'[1] suggestion of harnessing and utilizing the surface run-off of about 17,040 ha-m/yr only for Bangalore city is an outdated 'silo' approach of water management that does not take into consideration river basin perspective widely accepted and implemented worldwide at present, including the National Water Policy. Utilizing surface run-off of 17,040 ha-m/yr for quenching the thirst

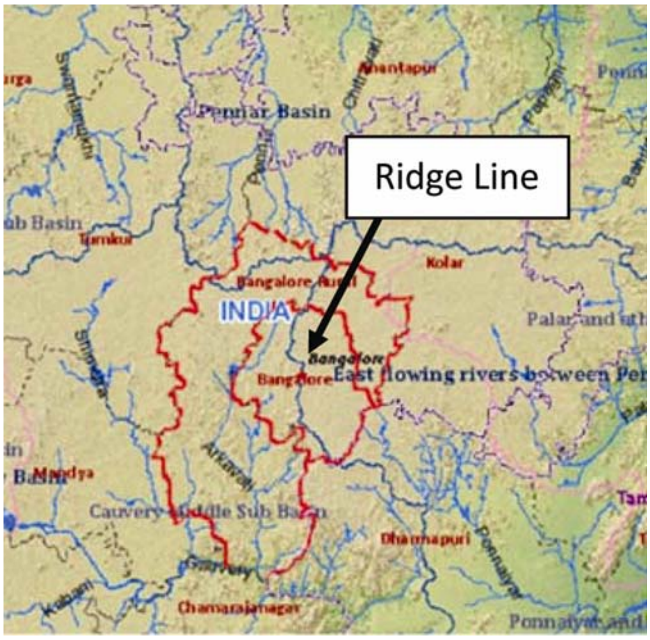

Figure 1. Bangalore flanked on either side of the ridge-line of the Cauvery river basin and east-flowing rivers between Pennar and Cauvery basins[12].

*Views expressed here are those of the author's and shall not be construed as views of his employers.

of Bangalore city denies an equal quantity of water to the river systems of the Cauvery basin or east-flowing rivers between Cauvery and Pennar river basins (i.e. basins comprising Ponniayar and Palar river systems). Thus, utilizing 17,040 ha-m/yr of water for Bangalore city is a zero-sum game from basin perspective (except for the loss in evapotranspiration) with shifting of the crisis point from Bangalore to some other part of the river basins across different sectors. So, the authors'[1] viewpoint that 17,040 ha-m/yr of surface run-off as being wasted is incorrect. If this water is used for Bangalore city, then the loss to the Cauvery basin water budget can only be augmented from the other diversion like Nethravathi–Hemavathy link. Waste water from Bangalore flows in three valleys namely Vrishabhavathy, Koramangala–Challaghatta and Hebbal[5]. The surface run-off estimated by the authors[1] is split amongst the three valleys and gets mixed with waste water. So, if basin perspective is ignored and the same has to be harnessed for the benefit of only Bangalore city, then the option that remains is recycling. There is no alternative to harness 17,040 ha-m/yr of surface run-off, except treating it along with 26,316 ha-m/yr of waste water to a degree that makes it suitable for domestic consumption.

The option of recycling is not without any challenges, as Bangalore offers limitations not seen in other parts of the world that are examples for recycle and reuse of waste water. However, it is not the panacea for all the future water crisis of Bangalore city as has been projected by authors. Bangalore is situated at an elevation of 920 m amsl at the junction or ridge-line of two river basins. It has a population of about 85 lakhs as on 2011 and is expected to cross 95 lakhs in a span of 8 years; that in itself will generate enormous quantity of waste water. The city is about 300 km away from the sea. The slope of Upper Vrishabhavathy valley[6] of Bangalore city is 1 in 60, while other valleys in the upper regions are about 1 in 270. Towards the east of Bangalore following River Ponniayar, at about 40 km, there is the inter-state boundary with Tamil Nadu which limits harnessing of any form of run-off. Any unilateral attempt to use the run-off of River Ponniayar or River Palar, or modifying the flow for the purpose of recycling has inter-state ramifications. The total run-off generation according to the authors[1] is 17,040 + 26,316 = 43,356 ha-m/yr (= about 433 MCM), which is four times more than the storage capacity of the Tippagondana Halli reservoir (storage capacity equal to about 90 MCM). Even if 70% of 26,316 ha-m/yr that is 18,421 ha-m/yr is considered, the total storage capacity required will be 17,040 + 18,421 = 35,461 ha-m/yr (still about 4 times the storage capacity of TG reservoir). This should include a part of the 'conveyance losses' considered as 30% by the authors[1] for BWSSB supply, as any leakage from piped supply will eventually have to either appear as surface run-off or infiltrate into the ground, with the exception of the part subjected to evapotranspiration (which in the true sense is lost water).

Even if the topographical constraints in storing and treating about 43,356 ha-m/yr or 35,461 ha-m/yr waste water are overcome, then the waste water recycled has to be pumped to a height of 900 m amsl at a head of minimum 100–200 m depending on the location of the waste water recycling plant close to Bangalore's 800 sq. km area. Then, waste water recycled at the tertiary level is never used for domestic purposes, but for agriculture, landscaping, gardening, etc.[7]. So, the authors[1] suggestion that waste water recycled at the tertiary level could be brought to safe standards of drinking water and domestic usage is like assuming the process as simplistic, which is quite misleading. To bring the recycled water to the standards of domestic use, the treatment process is much beyond the tertiary level that includes microfiltration, reverse osmosis and UV/ozone treatment followed by recharging groundwater aquifers or releasing into reservoirs for natural purification, where the water again is sent for normal treatment process before delivering for domestic use. It requires additional space to create reservoirs to store about 433 MCM of recycled water. If not 433 MCM capacity, the storage capacity of reservoirs required is certainly high as the detention time of waste water in treatment plants as well as storing recycled water to attain standards of domestic use is long in comparison to normal sewage treatment process. Either the recycled water has to be released into the existing system of reservoirs like T. G. Halli or fresh reservoirs have to be constructed. However, the process followed in getting recycled water treated for domestic consumption should match the technology and professionalism seen in countries like Singapore. The authors[1] have not provided any cost economics to show that waste water recycling is a viable option for Bangalore than river diversion. For example, in the Orange County District, California, USA, it costed about Rs 2500 crore or US$ 480 million to set up a state-of-the-art water reclamation facility in 2008, with operating costs at Rs 150 crore or US$ 29 million per year that generate about 320 MLD or 89 million gallons a day[8]. With the enormous challenges offered by Bangalore city mentioned above, the cost may only rise further. So, the impression created by authors[1] that the recycling and reuse of waste water alone would completely redress the future water crisis is incorrect, except that it may be a partial water solution, that too only after overcoming the constraints.

The contaminants of Bangalore waste water are diverse ranging from normal domestic sewage load to industrial waste comprising heavy metals, pharmaceuticals, pesticides called 'emerging contaminants' and there is no one single method that can remove the entire range of contaminants and ensure that the water is fit for domestic consumption[9]. While the standard treatment processes like membrane technology, UV/ozone treatment can remove the organic and inorganic load, it requires better technology to remove pharmaceutical contaminants like antibiotics, hormone supplements, etc. The safe disposal of the dangerous removed waste offers challenges, as any contact of the same with groundwater would deteriorate its quality further. The danger remains even with the use of recycled water for agriculture, landscaping or gardening. Further, the constraint is that either the recycled waste water should be mixed with regular pipelines carrying water from the Cauvery or separate pipelines must be laid and distributed to the public. Mixing recycled waste water with the normal water from the Cauvery has to overcome the social stigma attached with consuming water that was once a human waste product. This is another hurdle that has to be overcome. Recycling of waste water, thus, is not as simple a solution as suggested by the authors[1] and hence the conclusion that surface run-off plus treated waste water could serve about

50 lakh people or 53% of the population is misleading.

Bangalore's water scarcity does not end with utilization of surface run-off and recycling waste water. The population is expected to cross 95 lakhs by 2020. Bangalore's growing water crisis is the outcome of unplanned growth and haphazard urbanization offering plenty of opportunities for livelihood and attracting millions of people across the world. The population of Bangalore Urban Agglomeration is 85 lakhs according to censuskarnataka-2011, while cities like Mandya and Hassan (within Karnataka part of the Cauvery basin), at a distance of just 100–150 km have a population of less than 1.5 lakhs (ref. 10). The high population gradient existing within the Cauvery basin at a distance of about 150 km between Bangalore, Mandya and Hassan outlines the extent of abnormal importance given to a single city in terms of investment and development at the cost of other smaller cities. Both Mandya and Hassan are in the Cauvery river basin and are closer to the source of water, i.e. River Cauvery and its tributary Hemavathy; both cities at a lesser in elevation compared to Bangalore. In the case of Bangalore city, BWSSB requires 67 booster pumps to pump Cauvery water from a distance of 80 km at a head of about 500 m to a height of 920 m amsl. No amount of water would suffice for Bangalore unless migration of the population from all over the world to Bangalore as a consequence of Bangalore centric planning, haphazard growth and development by disparate agencies of government, private and non-government sectors is dissuaded. If Bangalore should continue with the current level of focus at the cost of other small cities attracting further investment and development and causing migration of millions from across the world, then the option of river diversion from Nethravathi–Hemavathy or long-distance diversion from River Krishna should not be disregarded.

The Cauvery river basin is considered as a 'closed' basin with water use exceeding water availability. However, large tracts of the basin are cultivated with crops like paddy and sugarcane that are water-intensive. Provision of subsidies for certain crops and fertilizers, lack of incentives for saving water, regulated food prices and low water rates have all led the farmers to choose water-intensive cash crops like paddy and sugarcane in Cauvery basin[11]. Irrigation is the largest consumer of water and hence, from the perspective of the water-scarce river basin, if the water-intensive crops in the basin are replaced with less water-intensive crops, along with incentives for conserving water, applying higher or discriminatory water rates, then substantial amount of water can be spared to cater to the growing thirst of Bangalore city. The spared water would also cater to domestic or industrial purposes in other parts of the river basin. If crops like paddy and sugarcane are indispensable, then water productivity of these crops has to be increased through a combination of water-saving techniques like system rice intensification in the case of paddy and micro-irrigation methods for other water-intensive cash crops. The water thus saved can serve as another option for assured water supply to Bangalore city.

With no stopping of Bangalore's haphazard growth, deteriorating groundwater quality and to avert Bangalore's water crisis by 2020 or later, it is not appropriate to rely on one single measure like recycling of waste water or groundwater alone, as suggested by the authors[1] due to the above-mentioned constraints. With basin perspective of water management recognized and practised across the world, it is not appropriate to focus on water management only on narrow sectoral perspective or a city or a small part of a basin, as that would perpetuate the present water mismanagement further on basin scale. For a comprehensive long-term water solution for Bangalore city to cater to a projected population of about 95 lakhs and more by 2020, a combination of measures like spreading out the development to other smaller towns/cities of the basin like Mandya and Hassan or even in Tamil Nadu, reduction in cultivation of water-intensive crops in the basin, increasing the water productivity of crops, long-distance water transfer and river diversion should be considered. These basin scale water management measures are in addition to the option of recycling of waste water, but only where it can overcome the constraints of technology, space, topography of Bangalore city, cost economics and then where it does not affect other regions of Cauvery basin and basin comprising east flowing river systems.

With human right to water gaining ground in India, the government has an obligation to provide water to all people. As long as Bangalore is the focus of development attracting millions from across the world, to avert the long-term water crisis, overriding cost economics and environment point of view, measures like long-distance transfer of water from River Krishna and inter-basin transfer/diversion of water from Nethravathi to Hemavathy for Bangalore city are also needed.

1. Hedge, G. V. and Subhash Chandra, K. C., *Curr. Sci.*, 2012, **102**, 1102–1104.
2. CGWB, Groundwater quality in shallow aquifers of India, Central Ground Water Board, Government of India, Faridabad, 2010.
3. Krishnamurthy, P. and Hegde, G. V., *J. Geol. Soc., India*, 2011, **100**, 490–492.
4. Harsha, J., *Curr. Sci.*, 2011, **100**, 1778–1780.
5. http://bwssb.org/?page_id=402
6. Ramachandra, T. V. and Mazumdar, P. P., *J. Natl. Inst. Disaster Manage.*, 2009, **3**, 1–98.
7. http://www.epa.gov/region9/water/recycling/
8. http://blogs.ei.columbia.edu/2011/04/04/from-wastewater-to-drinking-water/
9. Wedick, M., Report, 6 December 2007, UP502 – Environmental Planning; www.watertownps.org/file/13588/download
10. http://censuskarnataka.gov.in
11. Ferdin, M., Gorilitz, S. and Schworer, S., ASIEN 117, October 2010, S.27–44; http://www.asienkunde.de/content/zeitschrift_asien/archiv/pdf/117_Cauvery.pdf
12. http://www.india-wris.nrsc.gov.in/Geo-Visualization.html

Received 30 May 2012; accepted 15 June 2012

J. Harsha

Central Water Commission,
Jalasoudha, H.M.T. Post,
Bangalore 560 013, India
e-mail: infoharsha@yahoo.com