MEETING REPORT

Geogenic groundwater pollution*

A workshop on naturally occurring pollutants affecting water quality in India was organized recently. The main objective was to initiate a dialogue between scientists, policy makers and the general public and influence decision making at the regional level. S. K. Satheesh (Divecha Centre for Climate Change (DCCC), Indian Institute of Science (IISc), Bengaluru) in his opening remarks indicated that the sustainable water future programme, a core activity of the Water Solutions Lab of DCCC, addresses water-related science and policy. R. Srinivasan (DCCC, IISc) provided the context for the workshop. Water resources are becoming more and more difficult to sustain with tremendous pressure on the quality of water resources in the country. The aim of the workshop was to develop an updated geographical map of areas affected by natural pollutants, identify the possible sources of contamination, understand the disease burden in such areas, take stock of existing practices for minimizing the effects of pollutants and construct a roadmap for developing methods to overcome the effects of pollutants.

To start with, groundwater quality owing to pollution needs to be assessed in India. This overview was provided by Subhajyoti Das (formerly with the Central Ground Water Board (CGWB), Bhubaneswar). He highlighted that several factors control groundwater chemistry, salinity, arsenic, fluoride, iron, nitrates and other toxic chemicals. He also emphasized that industrial wastes are the main sources polluting groundwater. He indicated that water management strategies should include periodical monitoring, mapping pollutant susceptibility, attenuation processes and remedial treatment, and raising public awareness to ensure availability of groundwater of requisite quality in sufficient quantity.

*A report on the Workshop on 'Naturally Occurring Pollutants Affecting Water Quality in India', organized by the Water Solutions Lab, Divecha Centre for Climate Change, Indian Institute of Science, Bengaluru in partnership with Future Earth, South Asia Regional Office during 20, 21 June 2018 at Indian Institute of Science.

Srinivasan talked about medical ailments due to geogenic contamination of groundwater by arsenic, fluoride and radon, and treatments/mitigation steps to overcome these effects. The permissible limit of arsenic in India is about 50 μg/l and for radon it is 60 μg/l, both in excess of thresholds prescribed by international standards (10 and 30 μg/l respectively). Excess arsenic causes pigmentation, keratosis, basal carcinoma, liver diseases and so on. Excess radon can cause lung cancer from inhalation and stomach cancer by ingestion. Fluoride consumption above 1.5 mg/l is known to cause dental and skeletal fluorosis.

Shakeel Ahmed (CSIR-National Geophysical Research Institute, Hyderabad) talked about the genesis, assessment, monitoring and containment of fluoride contamination in groundwater. He indicated that although the major cause of fluoride contamination is geological, it is catalysed by climate. Thus, specific studies need to examine various aspects of its dissolution, mode of transportation, enrichment, etc. He recommended monitoring of the contaminant, and containment of the associated problem through interventions.

D. Chandrasekharam (Indian Institute of Technology, Hyderabad) highlighted the fluorosis problem in India. Of the 63 million people in the country suffering from fluorosis-related health issues, a large percentage lives in rural areas. Previously only regions receiving low rainfall were considered to have high fluoride content in groundwater. However, this was proved wrong with a report of 15 ppm of fluoride in groundwater in the alluvial aquifer of Karbi-Anglom district, Assam, and 5.7 ppm of fluoride in basalt aquifer in Alibagh district, Maharashtra. Both these areas receive rainfall greater than 4000 mm/yr.

The fluoride segment also included assessments and impacts of fluoride occurrence in groundwater in Karnataka, Telangana, Gujarat, Rajasthan, Maharashtra and Bihar. The medical aspects of fluoride contamination were also discussed and supplemented by case studies that were carried out in Gujarat and Madhya Pradesh.

An overview of fluoride occurrence in the groundwater of Karnataka was provided by K. C. Subhash Chandra and co-workers (Department of Mines and Geology, Karnataka). Thematic maps generated by Karnataka State Remote Sensing and Application Centre were studied to understand the factors that may have contributed to fluoride-rich groundwater resources. The dominance of fluoride-rich waters in the eastern part of Karnataka suggests that the K-feldspar-rich Closepet and related granites may be the main source of fluoride in the state. Research showed that fluoride content is generally more when total hardness is less in groundwater. Also, pH and TDS showed no specific bearing on fluoride.

The hydrochemical evaluation of fluoride in groundwater of Halia sub-basin, Nalgonda district, Telangana, which is well known for endemic fluorosis, was covered by P. N. Rao (Central Ground Water Board, Southern Region, Hyderabad). He attributed the fluoride enrichment in the sub-basin to fluoride-rich minerals which are released into the groundwater due to continuous rock–water interactions, intense structural deformation of rocks and weathering processes, residence time and evapotranspiration.

Fluoride hotspots in groundwater from the Deccan traps and associated basement in Maharashtra were discussed by Raymond Duraiswami (University of Pune). High concentrations of fluoride are reported from the groundwater of Amravati–Nagpur and South Konkan regions of Maharashtra, with 93% of the rural population in these regions dependent upon groundwater as their main source of drinking water. Work on fluoride hotspots in Maharashtra revealed that 'hydrogeological' interventions yield only limited results, and the best way forward is ensuring overall socio-economic upliftment and dietary fortification for the poor and marginalized people.

D. D. Ozha (Ground Water Board, Rajasthan) talked about the scourge of fluoride in groundwater in Rajasthan, where fluorosis is widespread and acute with all

32 districts being declared fluorosis-prone. He called for mitigation of the fluoride problem through the use of economically viable de-fluoridation techniques.

Fluoride which has been removed from the list of essential trace elements by the World Health Organization (WHO) a decade ago, can enter the body through water, food, drugs, cosmetics, etc. Association of dental caries and skeletal fluorosis with fluoride-rich water is generally known. Tapas Chakma (ICMR-National Institute for Research in Tribal Health, Jabalpur) talked about the effects of fluorosis on all systems of the body, including effects on the central nervous system which cause autism, lowering of IQ in children and Alzheimer's in adults. Chakma highlighted the success story of fluorosis mitigation in Madhya Pradesh, where deformities due to fluorosis were aggravated by several micronutrient deficiencies. A study undertaken five years after the implementation of dietary recommendations revealed a complete reversal of bone deformities in mild and moderate cases and partial reversal in severe cases.

Sangita Patel (Medical College, Baroda) presented a case study on the association of dental fluorosis and dental caries with high levels of fluoride in drinking water in Gujarat.

The next session of the workshop focused on radioactive contaminants. P. M. Ravi (Bhabha Atomic Research Centre, Mumbai) opened the session with a comprehensive background on radiogenic pollution of water sources. In many regions like Punjab and Telangana, radioactive elements are present in large quantities. They leach out into the groundwater degrading its quality. This may have strong medical consequences. However, he elucidated that neither the health effects of groundwater radiogenic pollution, nor the abundance of these metals in other areas of the country has been examined methodically.

K. Md. Najeeb (CGWB, New Delhi) highlighted the importance of mapping radiogenic pollutants, but focused on radon contamination. Through work done in the southern part of Karnataka, Najeeb and his team found that contamination is not related to the depth of the wells, as is the case with other pollutants like arsenic and iron. Instead, type of rock in the area may influence the amount of radon present in the environment. At present, no data are available regarding the amount of radon in the environment, but the concentration is expected to be higher in some granite-rich regions.

The talks in the session revealed the gaps in our knowledge regarding the extent of radiogenic contamination. Earlier in his talk, Ravi shared a project in progress to create a national database on uranium availability in different regions and its effect on water quality. Under this approach water samples are collected from areas divided into 6 km square grids to detect any associated radioactivity. Members proposed that other lesser-known radiogenic contaminants may also be scanned in the same samples to create a comprehensive and updated radiogenic groundwater pollution map of India.

Another element that adds to the water woes in the country is arsenic. A session on the second day was devoted towards gauging the full scale of arsenic contamination in India and ways to mitigate arsenic pollution. S. P. Sinha Ray (formerly with Central Ground Water Board, and Centre for Groundwater Studies, Kolkata), discussed theories concerning groundwater arsenic enrichment. He explained how pre-monsoon and post-monsoon periods differ in terms of water-table chemistry and how this altered chemistry in addition to soil microbes may contribute to arsenic mobilization.

In West Bengal, where the problem of arsenic contamination affects more than one crore people and is most rampant, the condition is of a geogenic origin. The alluvial soil found in the region has been produced from the Shivalik ranges rich in this element. This was not taken into account when dug wells were being constructed in the region. Since dug wells provide ample amount of water for irrigation and are less labour-intensive, people shifted to them as a perennial source of water. Later these were found to be rich in arsenic. Debashish Chatterjee (University of Kalyani, Kolkata) showed how increasing the depth of aquifers can limit arsenic contamination and the geological basis for this observation – clay usually found beneath the alluvium traps the arsenic leaving the water below free from the toxic metal.

The same approach would not hold true for Uttar Pradesh (UP) as the geomorphology of rocks differs in this region. Talks revealed that in UP, instead of exploiting water from deep aquifers, people should build shallow wells or use surface water to prevent arsenic toxicity.

In West Bengal, where arsenic toxicity has become a health issue, the Government is implementing a master plan to provide safe water in eight arsenic-affected districts by supplying water from 12 rivers. Another 338 groundwater schemes have also been considered and 50% of them have been implemented.

S. Bhadury (Centre for Groundwater Studies, Kolkata) argued that all these measures will be effective only when the public and community actively participate in the process. Her talk elucidated the importance of fostering a behavioural change in people from afflicted areas and the need to make them understand the perils of consuming contaminated groundwater.

This session also brought out the fallacies in contamination assessment. The participants suggested various tweaks in the existing survey methods to improve contamination assessment, highlighting the need to cultivate more agency–university partnerships. The discussion served as an appropriate curtain raiser for the next session dealing with current practices for water pollution remediation.

In this last and final round of talks, emphasis was laid on the development of sustainable technologies that can be upscaled to provide safe drinking water to a large population. Pawan Labhasetwar (Water technology and management, CSIR-NEERI, Nagpur) discussed the upcoming techniques for water remediation like electrolytic defluoridation, zero liquid discharge and the use of nanoparticle-impregnated membranes to check microbial contamination. K. Kesava Rao (Department of Chemical Engineering, IISc) discussed a pilot plant that was constructed to treat reject water from fluoridation units using anion exchange resins. The strategy is yet to be optimized in the field.

Water solutions derived from biological agents have attracted a lot of attention. Chandra Shekhar Sharma (Department of Chemical Engineering, IIT Hyderabad) discussed two such strategies. One focused on preparing activated carbon using biomass waste (jamun seed and coconut shell), while the other dealt with the synthesis of adsorbent nanofibres from cellulose. Both the strategies were found to be efficient for defluoridation.

In the last talk of the session, Yale Lingaraju (River Rejuvenation Project of the

Art of Living Foundation, Bengaluru) presented the work taken up by his organization in remediation of water pollution in Hussain Sagar Lake (Hyderabad) and Ulsoor Lake (Bengaluru). In both cases, waste disposal from tanneries and slaughterhouses was polluting the lake water. Polluting sludge was treated with a concoction of bacteria to digest the solid waste. Within a fortnight, the nearly dead and decaying lake water was practically rid of pollution.

The workshop concluded with a brief closing session at the end, where all specialists from diverse fields proposed recommendations for designing water solutions. It was unanimously agreed upon by all participants that the problem of water contamination is more complex than it appears and requires multi-institutional partnerships for developing sustainable solutions. Many scientists agreed to be a part of a think-tank to take the recommendations forward. In this context, the workshop set the tone for collaborative work in this area.

The recommendations will be collated in the form of a report and shared with Government officials, scientists, policy-makers and NGOs working towards improving water quality.

The event concluded with the following recommendations from the participants:

(1) Improving alternate sources of water supply such as ponds and rivers. Encouraging rain-water harvesting to dilute pollutants such as fluoride, radon and arsenic in groundwater.

(2) Investing in research on alternate solutions such as: (i) geological solutions to prevent the leaching of contaminants; (ii) nanotechnology-based solutions; (iii) microbiological solutions; and (iv) techniques to follow the natural biological/hydrological cycles of nature.

(3) Updating CGWB's geogenic contamination maps by conducting more integrated surveys by different departments and disseminating this information at the grassroots level (like panchayats).

(4) Evaluating and trying out solutions from various studies and publishing the research results. Development of pollutant measurement kits and popularization of the same even at school level, to reach more number of people and create awareness.

(5) Coming up with a region-wise safe drinking water policy for the whole country and legislating the extent of use of groundwater.

(6) Focusing more on the medical/socio-economic aspect of the problem. In the case of projects on fluorosis, arsenicosis and radionuclide pollution studies, medical aspects should be included along with the water-treatment aspects.

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