The promise and turmoil of India's freshwater

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Water is the nectar of life; the essential ingredient for survival. There is no substitute for water, The oil crisis in recent times brought confrontation in the Middle East, and continues to dominate. The limited availability of freshwater in the Middle East is taking a new dimension of conflict; Israel is proposing to divert the Mediterranean Sea waters through the Gaza strip to its land for irrigation, for drinking and for energy requirements after desalination. The confrontation on this vital water resource is bound to grow and widen. This growing awareness, the challenges water presents, implies that we should evolve a healthy environment that encourages readiness to face these challenges.

In contrast to the Middle East region, India is blessed with a bounty of freshwater. The Himalayas, the Vindhyan, the Western and Eastern Ghats intercept the monsoon rainfall and thus, the rivers flow in abundance during a short period of rainfall. It has been so since time immemorial. Yet, paradoxically, civilization after civilization has lived in a peripheral manner without utilizing the advantage of this perennial bounty and subjected itself to the ravages of floods and scourge of famines. Why is it so?

Not that nothing was done; it was attempted in isolation according to the generous attitudes of native kings and leaders in the rural community. Hundreds and thousands of irrigation/water tanks all over peninsular India, low dams built in the Vijayanagar kingdom and classic works like Jalsamudra of Rajasthan built in the seventeenth century, the several anicuts across the river Cauvery both in Karnataka and Tamil Nadu bear testimony for the concern to avail freshwater. During the British rule in the early part of the 19th and 20th centuries, significant engineering works were carried out which became the forerunner of dam engineering. To illustrate a few, the canal systems in undivided Punjab and in Madras Presidency, the Marikanive Dam in Karnataka and Bavanipattana water-supply dam (1888) in Orissa represented a scientific approach to impound and utilize water. These works still continue to serve the nation effectively. In fact, these later works formed ground rules in assessing hydrological aspects of river flow and assessing the engineering and geological parameters of storage works. They formed a model for engineering practices in river training, formation of barrages and providing gates for release of flood water and execution of canal system. The services rendered by stalwarts like late Sir Arthur Cotton, Kennedy, Russell and the band of army officers of the British period need to be remembered with gratitude.

Water resources

Land and water resources are environmentally interlinked. The geographical area of the country is 328.3 million hectares (m ha) of which cultivable area is 186 m ha, i.e. 56% of the geographical area. The net cultivated area as in 1990 was 141 m ha, which is almost 75% of cultivable area. There is no possibility of extension of cultivable area. In fact, industrialization, establishment of big industries like steel plants, aluminium plants, etc. take away the bulk of land. Urbanization and its related uses and abuses make a harsh impact on cultivable lands. This is a price development pays. It is an indisputable fact. It has corresponding impact on water availability and means of providing industrial and drinking water supply and related urban sewage/pollution treatment, etc.

When compared to other developed countries like Europe and USA, water resources in India are substantial. Yet, it must be remembered that its spread, and regional, seasonal and spatial distribution over its geographical area are uneven. Large tracts of Karnataka, Rajasthan, Gujarat and coastal Orissa/Andhra Pradesh are semi-arid and arid. In fact, Karnataka has the biggest semi-arid region, about 79%, exceeding that of Rajasthan, and mostly hard rock stratum. This constitutes the real problems that bring in social upsurge for want of developmental works, which hinge on adequate provision of much needed freshwater.

All the more, the region calls for a specialized action plan. Any neglect would give rise to a situation similar to the Chambal valley which produced bandits prior to the Chambal Valley Development. It is not political peace negotiations that transformed the hostile, ethnic temperament of the valley. It is the Chambal canal bringing prosperity to Bhind and Morena districts that has done the trick – 30,000 cusecs of water flows into the canal that metamorphosed the Chambal valley – which is otherwise an arid region.

According to Central Water Commission's (CWC)s brochure entitled 'Water Resources of India' April 1998, the total water resources of our country are as follows:

(a) Nationally available surface-water resources, 1880 kilo cubic metres. (b) Actually utilizable surface water-resources, with regard to topography, location and other constraints 690.309 kilo cubic metres. (c) Actually utilizable groundwater resources, 418.540 kilo cubic metres. (d) Total utilizable water resources (b + c) 1108.849 kilo cubic metres, say, 1110 kilo cubic metres.

Resources development

Utilizable water from both surface and underground which could be regarded as one hydrological unit, is about 1110 kilo cubic metres. One of the cardinal principles enshrined in the National Water Policy (1987) is to conserve this bounty of nature. Therefore, it implies conservation of water as an effective utilizable commodity. It may be relevant to observe that USA which has almost the same water potential as India, has already a storage capacity of about 70 million (Ham) which is 230% of India's ultimate storage capacity. As of now, the storage capacity in our country is about 50% of ultimate possibility. USSR has a built-in storage capacity of the order of 112 million Ham. With the same water potential as that of India, USA has 40,000 large dams while we have around three thousand dams and another 700 in various stages of construction. In such a situation, there should be greater emphasis on creating water-utility structures, than we have done in the last fifty years.

Impact of dams

In the last two or three decades of water resources development, there has been a growing awareness of the impact of large-scale projects. This is so all over the world. In developed countries, more so in USA, the dam-building activity has been practically halted. The well-known United States Bureau of Reclamation (USBR) had to restructure its organization for water management and monitoring of the projects already commissioned. With the result, vast experience in water planning, resource mobilization and specialized construction industries are available. The financiers have grouped themselves and considerable funding for Third World projects is available. Developing countries like South Africa, India, Pakistan, Sri Lanka and China are the playing grounds for utilizing this package of hard-earned experience and finance. China undertook the famous 'three gorges dams'. The feasibility study of the project was carried out by a joint venture of Canadian engineering firms (Acres International, B.C. Hydro International, Hydro-Quebec International, SNC) which advised building of the dams at an early date. The study was funded by Canadian International Development Agency (CIDA), supervised by CIDA, the World Bank and China's Ministry of Water Resources and Electric Power. The study could not be pursued, more so the additional studies on environmental and resettlement aspects. Canada suspended work on the project shortly after the 1989 confrontation in Tiananmen Square. It is of importance to observe that the jury of International Water Tribunal (February 92-*WPDC*-May 92) found the Canadian feasibility study for the 'three gorges' project 'inadequate', stating that it lacked a catchment area treatment plan upstream, and a disaster management plan downstream, and failed to account for the population which would be forced out if flood waters rose to the maximum level in the reservoir. The jury felt that 'the very high ecological and socio-economic risks of the dam had not been adequately addressed, because the feasibility study starts with the objective of justifying the project to secure international funding'; notwithstanding, the project is being executed full steam. We, in India, are not unfamiliar with such problems.

Thus, there is turmoil in the process of river harnessing. There is emotional awakening, which has led to a fair amount of scientific study on areas which seldom drew attention earlier, except cosmetic attempts. The Silent Valley movement of the seventies and the Chipko Andolan are the forerunners of this awakening. This is now followed by Narmada Bachao Andolan.

Now the ongoing projects, Narmada Dam Complex as well as Tehri Hydroelectric Project, are snailing towards their avowed completion. A monumental study by an independent review panel (Bradford Morse's report) castigates the Sardar Sarovar Project authorities as well as the World Bank. According to this report, 'the history of the environmental aspects of Sardar Sarovar is a history of non-compliance. The nature and magnitude of environmental problems and solutions remain elusive. This feeds the controversy surrounding the projects. As with the resettlement and rehabilitation issues, this has placed our review in difficult position. To complete our work, we have had to assemble basic ecological information to establish the likely effects of the projects upstream, downstream, and in the command area. This work should have been done by others before the projects were approved'. The case is no different with respect to the Tehri Project. There is thus an intellectual neglect. Those who share concern for both economic development and the conservation of environment, of which water is as much an ingredient as much the human habitat, should lose no further time in building up an adequate comprehensive database (not speculative), evolve a generally acceptable methodology for environment studies and make the appraisal of projects and their impact assessment objective and unbiased. It is essential that the information thus collected and evaluated should be available to the public before the project is implemented. Let not the water resources development projects in the coming decades get into quagmire foundations.

At this stage one must recapitulate the basic facts about Sardar Sarovar–Narmada Complex. The Narmada river is the only one that was left unutilized before these mega projects were conceived and feasibility studies were initiated three decades ago, and later construction was taken up with World Bank participation and review by its staff personnel. The project envisages no less than 30 large dams, 135 medium dams and 3000 small dams on the stem and tributaries of the main river. The geomorphological spread is vast. Consider the upstream utilization by various schemes contained in the basin development plan. To what extent would the terminal structure (Sardar Sarovar) receive its evaluated storage for release to its vast network of the main canal and its subsidiary canals? In what time-frame would this be materialized? These remain very inconvenient questions! There seems to be a need to reappraise the impact of the entire basin projects *vis-à-vis* the two mega projects.

Rehabilitating existing storage dams and upgrading the utilities

In the light of serious issues concerning the mega projects illustrated above, it is more appropriate to review all the storage and hydropower utilities that are under use by experts, to find a way of augmenting the water and energy sectors.

In contrast to the new multi-purpose projects, the existing storage dams and their hydropower plants and canal systems are in a known established regime and environment. The civil engineering utilities are in service for over a decade or more. We are no longer in a speculative realm. The modernization and safety could be definitive and fund requirement would be clear. The development could be step by step. We have over three thousand dams in service. Their modernization and safety review are likely to be substantial and of added advantage. It is likely, that by such measures, at least 25 to 30% additional benefits may be introduced.

The refurbishment of existing hydroplants at these storage dams would definitely be far more beneficial, economical and environment-friendly than establishing equivalent thermal and captive plants for any specific industry.

Poverty and its eradication

The objectives of eradication of poverty, upliftment of rural mass, both economically and socially, are only possible if water and land development are taken together. There is an irreversible damage taking place all over the country, with mining industries removing the top land mass and forest cover. Hence erosion of the land material is taking place, and stream and river sources are affected. Considerable sediments are being carried in the river streams. A number of water-storage utilities are being filled with

increased proportion of sediments. The Bhadra and Tunga in Karnataka and the streams of Orissa are some examples, where ore deposits form the sediment's deposition. It would be worthwhile to get them removed for recycling and processing. It is also necessary to enact a ceiling on land use for mining in the river basins of the country for a period of another fifty years. Toxic wastes should not be released into the natural streams without treatment, as is being done by most of the industries. In the last fifty years, forest land exceeding 50 m ha, has been destroyed for unspecified reasons other than water storage works by the timber lobby. It must be noted (as documented) that in the last fifty years in developing all the irrigation projects, the country has not destroyed or utilized more than 2 m ha of prime forest land. There is considerable disinformation by vested interests. In order to take a holistic approach of riverbasin development and corresponding effective utilization of water, awareness among the public, orientation and channellization are important.

It must also be noted that the rural people are more conscious of the relevance and importance of conservation of water. This is well reflected in their readiness to participate at the micro-level in rural development. This has been well brought out by 'the statement of shared concern' in the Citizens Fifty Report signed by numerous scientists, environmentalists and social workers, and the article 'Towards a green millennium' (*The Hindu* 14 March 1999). Replication of the illustrated micro projects of socio-agro development is a far effective means of rural development, without any injurious impact on community as well as the land mass.

Recently, with drought relief as the basis, linking of Ganga–Cauvery has been projected. It is all the more necessary to examine each river basin development in its existing socio-geomorphological set-up. One has to establish whether such river basins. collectively two or three river basins in the same geomorphological set-up, cannot be examined for water resource development to provide relief to drought-prone area of the region. The plan of action should be towards fulfilling the task of detailed study of such a scheme, duly processed and cleared by the Planning Commission.

Unfortunately, there is no lasting stable and enduring governance of the country. Leaders are pulling each other and indulging in fissiparous activities and digressing all their energies towards no enduring social objective of democratic society. This must stop. Only then will the virtues of development and utilizing nature's bounty be on firm ground. There is promise, but the turmoil must cease.

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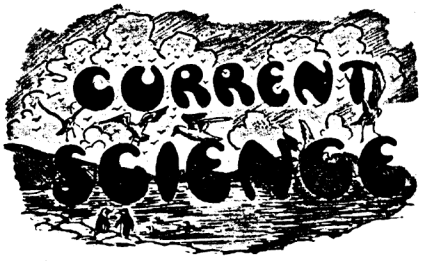

Vol. X] NOVEMBER 1941 [No. 11

X-rays, crystals and the infra-red spectrum

Sir C. V. Raman

The *Proceedings of the Indian Academy of Sciences* for October 1941 is devoted to a symposium of fifteen papers dealing with the interaction between X-rays and crystals which results in an excitation of the infra-red vibrations in the solid and a consequent reflection of the X-rays with change of frequency. This phenomenon was first described in an article in *Current Science* for April 1940 by the present writer and Dr P. Nilakantan, and was further reported on in the issue of *Current Science* for May 1941. The symposium now published is a comprehensive account of the whole subject and shows that the new facts and ideas put forward in April 1940 were solidly based on reality. The theory given in broad outline in earlier publications is now fully developed and finds striking experimental confirmation in various directions.

The phenomena of the scattering of light in crystals show clearly that the interactions between matter and radiation which involve a change of frequency in the latter can only be successfully interpreted on the basis of quantum mechanics. That a similar situation also arises in regard to X-rays becomes evident when, it is recalled that the secondary X-radiation from a vibrating atom in a crystal appears, in part, with a change of frequency. Any coherent vibration of the atoms in a crystal with a specifiable frequency is therefore capable of giving rise to radiations of altered frequency which can interfere with each other and give rise to observable effects. The change of frequency involves an exchange of energy between the crystal and the electromagnetic field, and this can only occur in complete quanta or units of the particular vibration frequency. The interferences which arise may therefore be regarded as due to an inelastic collision of the X-ray photons with the crystal lattice. They appear as geometric reflections of the X-rays by the lattice planes of the crystal, analogous to, but quite distinct from, the reflections of the usual kind involving no change of frequency. . . .

An important result indicated by the quantum theory of X-ray reflection is that in particular cases, the classical reflections may vanish while the quantum reflections persist, or *rice versa*. In a remarkable paper appearing in the symposium, Mr Rama Pisharoty calculates the intensities of the (222) and (662) quantum reflections by diamond and shows that they are in agreement with the intensities as actually observed, thereby indicating that these so-called 'forbidden' reflections which should not appear on the classical theory are in reality quantum reflections. Another remarkable case of the kind is furnished by the ratio of the intensities of the (111) and (222) reflections by the lattice planes in rock-salt. The theoretical calculations by Dr Venkateswaran indicate, in striking agreement with observation, that this ratio is far smaller for the quantum reflections than for the classical reflections. . . .