must find out why this is so and what is causing this? Is it due to diet, environment or due to some other cause.

Recently, you have stressed that medical scientists should look at why gall bladder cancer is so common in Bengal?

Yes. It is necessary to find out the cause, whether it is due to insecticides in the food, food habits, etc.

Do you think medical scientists should publish more? Have you set an example?

Yes. I know it is very difficult to do research as a doctor. I was earning a lot of money, so I spent some of my earnings to do medical research.

General

Common people would like to know what you are going to do about food adulteration. This is a big concern as it involves their daily food intake?

We have held some meetings and again, being a state subject, we have to take the help of the states. Food adulteration and spurious medicines, these are the two concerns with which we are really worried.

What about iodine deficiency?

Yes, we are taking care of iodine deficiency disorder all over the country. And wherever we find that there is some carelessness about it, we want to supplement that area with iodine. There are pockets that need to be addressed in this manner.

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SCIENTIFIC CORRESPONDENCE

Radon and helium monitoring in some thermal springs of North India and Bhutan

The Geological Survey of India (GSI) reported the location of 303 thermal springs[1] in different states of India. Besides the thermal springs, there are also a number of natural cold-water springs. These springs (Figure 1) are related to tectonic belts, grabens and fault zones spread over the entire geographical area of the subcontinent[2]. Some of these springs have linkage with Indian mythology and are famous pilgrimage centres since historical times. While people visit these springs for pleasure and remedial purposes, unconsciously they may be exposed to a large dose of radioactive emissions[3] from some of these. The purpose of this study is two-fold: (i) To measure radon concentration in natural and hot-water springs in some of the north Indian states, viz. Uttaranchal, West Bengal and Sikkim, and in Bhutan to determine the level of radioactivity, and (ii) to monitor helium concentration in some thermal springs of West Bengal, Jharkhand, Uttaranchal and Himachal Pradesh for purposes of industrial exploitation.

Geochemical studies[4–8] have been carried out recently in India to determine the chemistry of geothermal gases and their radioactivity. However, data available on radon and helium concentrations in natural and thermal springs are scanty. The experimental techniques used for radon and helium concentration measurement in the liquid phase have been reported elsewhere[7]. Radon concentration has been measured in 1 l of spring water by using scintillometry technique. Alpha Scintillometer GBH 2002 (GBH Electronic, Germany) with Lucas cell assembly was used to record alpha counts and the radon concentration is measured by using the calibration constant (10 counts = 1 Bq/l). Helium leak detector ASM 100 HDS (Alcatel, France) based on mass spectrometry and using sniffing technique was used for helium estimation in thermal springs. The whole operation is fully automatic and it can measure the helium concentration from 0.1 ppm to 100% helium.

The results of radon concentration measurement are summarized in Table 1. The radon recorded its lowest value of 0.1 Bq/l in a natural spring in Bhutan. The highest value of radon (441.2 Bq/l) was recorded in a natural spring at village Swastik Burtu near Gangtok, Sikkim. It is observed that natural as well as thermal springs in Uttaranchal record relatively low values of radon concentration, while natural springs in and around Gangtok, Sikkim, record high radon values. In West Bengal, the highest radon concentration is reported for a thermal spring at Bakreshwar, which is 34.5 Bq/l. The radon concentration measured in groundwater of Punjab[9] varies from 3.3 to 8.8 Bq/l. Due to high radon concentration in natural springs, the residents in the city and villages around Gangtok are likely to be exposed to radiation hazards due to consumption of potable spring water.

It has been observed that helium is released in periodic bursts and shows both spatial and temporal variations[8]. The results of helium concentration in bubble gases from thermal springs are

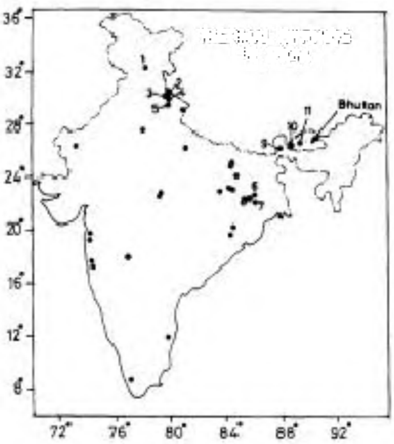

Figure 1. Location of natural and thermal springs in India and Bhutan. Monitored springs are numbered: 1, Manikaran; 2, Yamunotri; 3, Gangnani; 4, Kedarnath; 5, Rudraprayag; 6, Bakreshwar; 7, Tantloi; 8, Bhuri; 9, Gangtok; 10, Samtse; and 11, Paro Road.

Table 1. Radon concentration in thermal and natural springs

Place	Source	Radon concentration (Bq/l)
West Bengal		
Darjeeling	Natural spring	3.3 ± 0.6
Bakreshwar	Thermal spring	34.5 ± 1.9
Bhuri, Raniganj	Thermal spring	3.5 ± 0.6
Sikkim		
Tadong 5 miles, Gangtok	Natural spring	25.9 ± 1.6
Upper Chanmari 2 mile, Gangtok	Natural spring	100.5 ± 3.2
Lower Chanmari, Gangtok	Natural spring	16.1 ± 1.3
Zero Point, Gangtok	Natural spring	225.4 ± 4.7
Swastik Burtu, Gangtok	Natural spring	441.2 ± 6.6
BulBule, Gangtok	Natural spring	27.1 ± 1.6
Bhutan		
Dyna Bridge, Samtse District	Natural spring	0.1 ± 0.1
Dyna Bridge, Samtse District	Natural spring	10.1 ± 1.0
Dyna Bridge, Samtse District	River water	6.0 ± 0.8
Chhaja, Paro Road	Natural spring	1.2 ± 0.4
Khatchatabchu, Paro Road	Natural spring	0.1 ± 0.1
Uttaranchal		
Suryakund, Yamunotri	Thermal spring	0.8 ± 0.3
Gangnani	Thermal spring	2.6 ± 0.5
Netala, Gangnani	Natural spring	1.1 ± 0.3
Gauri Kund, Kedarnath	Thermal spring	4.4 ± 0.7
Kund (on way to Kedarnath)	Natural spring	2.6 ± 0.5
Rudraprayag	Natural spring	3.1 ± 0.6

Table 2. Helium concentration in thermal springs

Place	Source	Helium concentration* (ppm)
West Bengal		
Bakreshwar	Thermal spring	40,000
Bhuri, Raniganj	Thermal spring	1000
Jharkhand		
Tantloi	Thermal spring	12,000
Uttaranchal		
Gangnani	Thermal spring	100
Yamunotri	Thermal spring	15
Gauri Kund, Kedarnath	Thermal spring	10
Himachal Pradesh		
Gurudwara, Manikaran	Thermal spring	200
Shiv Mandir, Manikaran	Thermal spring	40
Manikaran	Bore-hole (open)	8

*Based on single spot measurements.

reported in Table 2. The highest value of 40,000 ppm is recorded in a thermal spring at Bakreshwar, West Bengal. Originally started by the Variable Energy Cyclotron Centre, Kolkata, it is now being exploited by Saha Institute of Nuclear Physics, Kolkata for research and semi-commercial purposes. Another thermal spring at Tantloi in Jharkhand has helium concentration of 12,000 ppm. All other thermal springs in Uttaranchal and Himachal Pradesh, which attract both Indian and foreign tourists because of their scenic beauty and spiritual sanctity record low concentrations of helium. Hence these do not qualify for commercial exploitation. In fact, helium gas is a high-tech material and India needs it to run its high-energy accelerators and fast-breeder technology programme. Helium anomalies along with radon anomalies can serve as a useful earthquake precursor in India[10,11].

Since the source of helium is alpha emissions from radium and its daughters, our study reveals that there is no serious radiation health hazard to the public bathing in the open in thermal springs of Uttaranchal and Himachal Pradesh. Radon concentration is usually much higher in groundwater than in surface water, and internationally recommended[12] safe values range from 4 to 40 Bq/l for groundwater used for human consumption. Hence there is a need to store natural spring water in open tanks before its supply to people.

1. *Geothermal Atlas of India*, GSI Spl. Publ. No. 19, Govt. of India, 1991, pp. 137–142.
2. Sharma, S. C., in *Rare Gas Geochemistry: Applications in Earth and Environmental Sciences* (ed. Virk, H. S.), GND University Press, Amritsar, 1997, pp. 193–199.
3. Sharma, S. C., *Geol. Surv. India, Spec. Publ.*, 1997, **48**, 151–158.
4. Chatterjee, S. D. and Ghose, D., *Indian J. Phys.*, 1984, **58A**, 345–349.
5. Singh, J. R., *Indian Miner.*, 1989, **43**, 7–18.
6. Singh, R. and Bandyopadhyay, A. K., *ibid*, 1995, **49**, 55–60.
7. Virk, H. S., Sharma, A. K. and Kumar, N., *J. Geol. Soc. India*, 1998, **52**, 523–528.
8. Ghose, D., Chowdhury, D. P. and Sinha, B., *Curr. Sci.*, 2002, **8**, 993–996.
9. Virk, H. S., Bajwa, B. S. and Walia, V., *Indian J. Pure Appl. Phys.*, 2001, **39**, 746–749.
10. Ghose, D., Das, N. K. and Sinha, B., *Curr. Sci.*, 1996, **71**, 56–58.
11. Virk, H. S., Walia, V. and Kumar, N., *J. Geodyn.*, 2001, **31**, 201–210.
12. UNSCEAR, Report to General Assembly, United Nations, New York, 1982.

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