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Research Note

Chemical Quality of Ground Water in Relation to Incidence of Cancer in Parts of SW Punjab, India

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Abstract: Chemical quality and radon activity of ground water along with F, NO_3, SO_4, U, Pb, Cr and Ni was monitored in certain parts of SW Punjab to assess the role of these elements in causing cancer in Jajjal and Gyana villages of Bhatinda district, Punjab. The work shows that contents of U, Pb, Cr, Ni, F and SO_4 are above the permissible limits. The interaction of groundwater with soils formed by the weathering of high heat producing granites of Tosham area and with evaporites including foetid limestone/dolomite is responsible for high contents of radon and other elements. Indiscriminate use of pesticides and the air and water pollution caused by the effluents of thermal plant are also responsible for the degradation of quality of water in the area.

Key words: Water, cancer, quality, Punjab.

Introduction

The state of Punjab is located in the northwestern part of India. It lies in the western component of the Great Northern Plains i.e. the Satluj-Ganga plains of India. It extends from 29° 30′ to 32° 32′ N latitude and from 75° 55′ to 76° 50′ E longitude. It shares international border with Pakistan in the west and Jammu and Kashmir lies in the north and is bounded by Himachal Pradesh in the northeast. The state of Haryana lies to its south. It shares its border with Rajasthan in the southwest (Figure 1).

Geology

The Siwalik hills form a narrow tract on the northeastern side of the state. The rest of state is a vast alluvial plain which is composed of Quaternary alluvium deposits—Older alluvium (Bhanger), Newer Alluvium (Khadar) and the Aeolian deposits. The Quaternary sequence is underlain by Tertiary deposits which in turn are underlain

Figure 1: Location map of the study area.

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by a thick sequence of Vindhyian evaporites and halites, with cumulative thickness of 130.77 m (Dey et al., 1991). The rocks of Aravalli-Delhi Supergroup and the Malani igneous suite comprising greywacke, ortho-quartzites, carbonate sediments, calcareous shales and slates, and the high heat producing granties and felsites form the basement in the region (Tripathi and Rajamani, 2003; Kochhar, 1989, 2000). The scattered outcrops of the Aravalli-Delhi Supergroup occur at Tosham (Haryana) just south of the study area i.e. the Bhatinda and Mansa districts.

The geomorphic surface of SW Punjab and adjoining Haryana is undulating typical of an aeolian deposition characterized by medium to coarse-sized sand particles blown due to strong currents of wind. The sand dunes are seen scattered all over the area. The major pockets of sand dunes are observed along the old river courses. Singh (1992) has identified Older plains and Aeolian deposits (both transverse Barchans and longitudinal dunes) in the area.

The soil in the study area falls in the arid and moisture regime. The soils associated with Alluviual plains show better indurations and mature development of soil profile. They are composed of different layers of clay, sticky clay and fine to coarse grained micaceous sandstone. The top layer is dark reddish silt and generally rich in concretions and calcareous nodules due to high evaporation. The sticky layer at shallow depth (1 to 6 m) help in confining the water under artesian conditions. The soil drainage is obstructed resulting in accumulation of Na and Mg salts (Gill and Arora, 1997). The soils in the adjoining Hisar and Bhiwani districts of Haryana are composed of sand in the upper horizons whereas the lower horizons comprise silt-loam texture. Due to low rainfall, the soils have not undergone any pedogenic activity (Basirani, 2001).

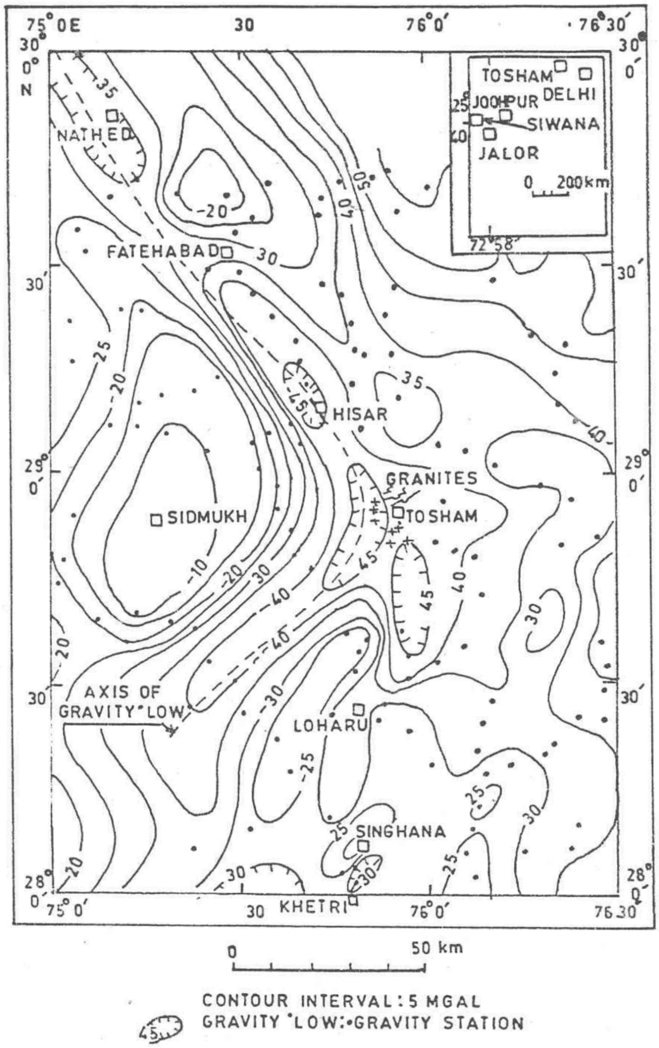

Figure 2: Gravity map of Tosham and surrounding areas.

Subsurface Geology

Delhi-Lahore Ridge

According to Krishna Brahamam and Kochhar (1989), the Aravalli-Delhi strike turns northwest from Tosham. Further the gravity data show that Tosham lies on triple gravity junction and a considerable portion of gravity low is caused by arcuate granitic intrusion (240 km long and 6 km wide) (Figure 2). There is a trifurcation of gravity trend from Tosham marked by the extension of Aravalli basement towards Himalaya in the form of Delhi-Hardwar ridge, Delhi-Moradabad ridge in the eastward direction and Delhi-Lahore ridge in NW direction (Mishra and Laxman, 1997). The Delhi-Lahore ridge is a broad regional basement high separating Rajasthan platform (of the Indus basin) from the Punjab platform of Himalayan basin. On the Rajasthan side, to the SW of basement high, sedimentary formations from Paleozoic and Mesozoic to Tertiary ages occur. On the other hand, under the Punjab platform, on the NE side of the basement ridge, no rocks older than Siwaliks have been found over the basement. Between Tosham to Bhatinda, the basement goes down rapidly (Figure 3) (Ramchandra Rao, 1973). East of Sirsa, rocks of Delhi Supergroup and Malani suite of rocks are encountered just below the Quaternary overburden (Dey, 1991).

A borehole on Adampur ridge (near Jalandhar) reached basement of depth of 2500 m (Agarwal, 1977). At Zira near Ferozepur, granitic rocks were met at a depth of 700 m below middle and upper Siwaliks, while the maximum depth to the basement in Punjab plains is about

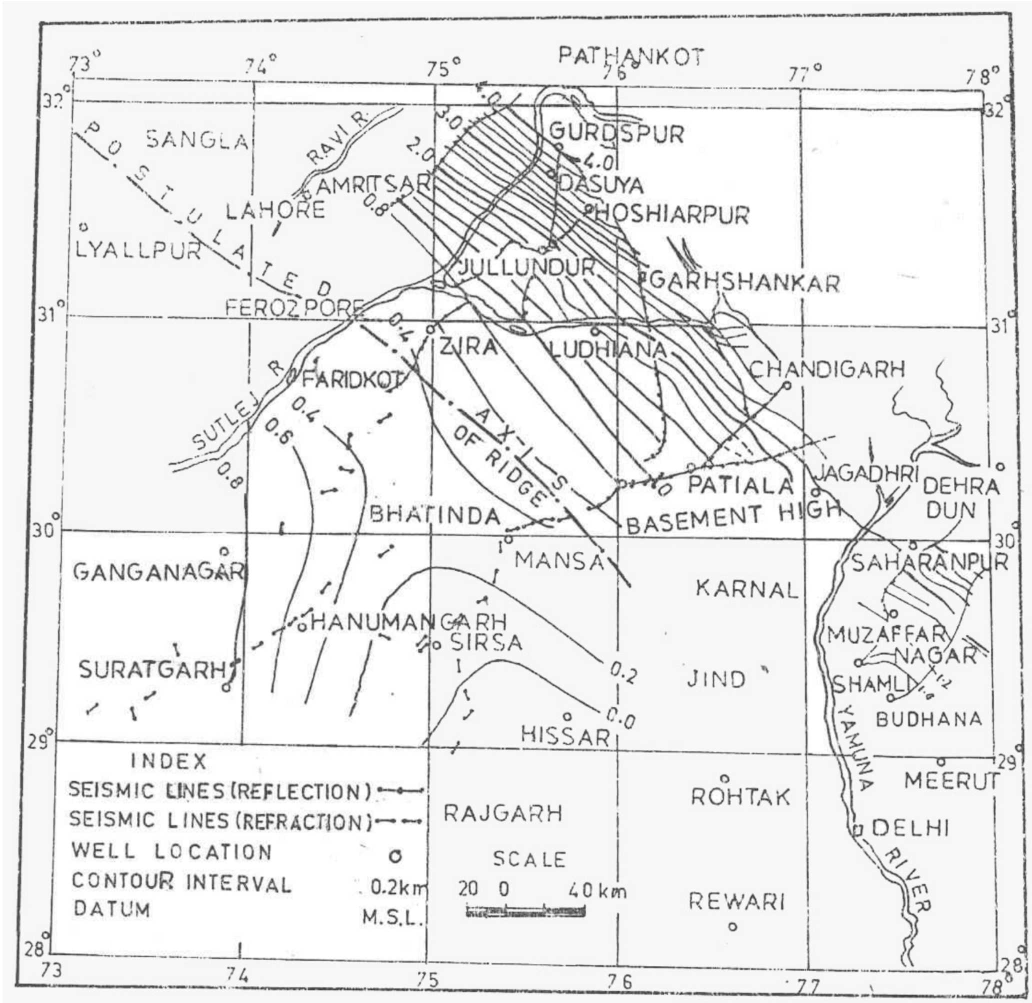

Figure 3: Basement structure map of Punjab-Rajasthan plains.

4 to 5 kms and the depth increases to some extent under Siwaliks. Marble at a depth of 4790 m was met at on the Janauri anticline in the foothills 15 km north of Hoshiarpur (Ramchandra Rao, 1973; Balakrishna, 1997; Powers et al., 1998).

Under a thick blanket of Quaternary sediments (305-350 m) of SW Punjab (Faridkot and Ferozepur districts) and SW Haryana (Sirsa district), a thick sequence of halite and associated evaporites (polyhalite, anhydrite, limestone and dolomite) homotaxial to Hanseran Group overlie Jodhpur group (Dey, 1991). Five cycles of evaporites with a cumulative thickness 130.77 m occur under Punjab plains, and three cycles of evaporites (cumulative thickness 50 m) occur under Haryana plains. The dolomite/dolomitic limestone is of foetid character which probably represents basin limestone subjected to bacterial reduction in the subphotic zone or was probably deposited in restricted/euxenic environment.

Quality of water

The chemical quality of ground water in terms of major and trace elements and other parameters is given in Tables 1 and 2.

pH: The desirable limit of pH in ground water for drinking purposes is 6.5 to 8.5. Beyond this range water affects mucos membrane. The pH of the water samples of study area varies from 7.73 to 8.86 and is marginally high in six samples.

EC: The values of electrical conductivity of ground water of the research area range from 880 to 7040. In eleven samples, EC is more than 2000 micromhos/cm i.e. the limit for fresh water quality.

Calcium: It is essential for human body with the requirement from 0.7 to 2 g per day. The low content of

Table 1: Chemical quality of groundwater major elements (ppm) and other parameters

S. No.	*Location*	*pH*	*EC*	*Na*	*K*	*Ca*	*Mg*	*SO_4*	*F*
1.	Gurudwara – Jajjal	8.86	1511	534.98	22.14	127.01	48.79	110	3.82
2.	Veterinary Hospital– Jajjal	8.48	946	199.97	13.20	126.85	59.73	130	.54
3.	Dera – Jajjal	8.54	1367	80.43	254.15	165.99	89.40	70	.48
4.	Darshan Singh Bagar Singh S/o Sh. Nikka Singh, Jajjal	8.14	3170	274.61	69.79	320.96	289.40	310	1.08
5.	Jasbir Singh S/o Sukhdev Singh, Jajjal	8.33	2396	567.23	18.15	159.92	119.43	440	.94
6.	Babur Singh S/o Ajmer Singh	8.15	2210	172.97	25.22	256.92	176.94	240	1.02
7.	Ban Singh S/o Mukhtar Singh (Malkana)	7.73	4020	176.33	119.54	993.51	176.33	180	.30
8.	Gurdeep Singh (Malkana)	8.85	3370	835.03	104.56	133.54	165.18	560	1.64
9.	Gurcharan Singh (Gyana)	8.12	1049	1037.91	34.96	193.33	213.12	820	1.52
10.	Major Singh (Gyana)	8.09	3370	361.09	150.36	217.25	247.08	260	.76
11.	Jagral Singh (Gyana)	8.38	3090	450.41	139.72	228.03	270.03	460	1.96
12.	Rajpal Singh, (Gyana)	8.33	2450	279.73	357.04	151.06	192.70	260	1.36
13.	Kartar Singh (Gyana)	8.48	1337	210.38	54.21	112.95	95.55	80	1.02
14.	Mita Singh, (Gyana)	8.86	880	166.30	28.15	74.83	57.06	50	1.52
15.	Near Old age home Devi Road (Takht Mal)	8.60	4360	1257.95	29.40	113.66	83.10	860	3.8
16.	Tube well near Water works (Canal Main line)	8.68	1074	269.81	9.09	100.76	52.82	140	.76
17.	Shemsher Singh (opp. to house) handpump (Taruwana)	8.46	7040	2023.84	54.46	291.99	246.43	>880	2.56
18.	Banta Singh (Panch) (Taruwana)	8.54	6350	1681.57	40.83	208.08	332.25	880	2.08
	BIS(2003) Desirable	6.5	—	—	—	75	30	200	1.0
	Permissible	8.5	—	—	—	200	100	400	1.5

EC: <2000 Fresh water, 2000-4000 marginal, >4000 Saline

Table 2: Chemical quality of groundwater trace element data (ppm)

S. No.	*Location*	*Pb*	*U*	*Cr*	*Ni*
1.	Gurudwara - Jajjal	.06	.113	.021	.10
2.	Veterinary Hospital– Jajjal	.06	.016	.016	.055
3.	Dera – Jajjal	.084	.005	.019	.48
4.	Darshan Singh Bagar Singh S/o Sh. Nikka Singh, Jajjal	.095	.031	.017	.16
5.	Jasbir Singh S/o Sukhdev Singh, Jajjal	.041	.045	.016	.044
6.	Babur Singh S/o Ajmer Singh	.042	.047	.016	.051
7.	Ban Singh S/o Mukhtar Singh (Malkana)	.073	.009	.017	.052
8.	Gurdeep Singh (Malkana)	.18	.185	.018	.36
9.	Gurcharan Singh (Gyana)	.0038	.063	.017	.058
10.	Major Singh (Gyana)	.03	.141	.017	.10
11.	Jagral Singh (Gyana)	.053	.17	.018	.03
12.	Rajpal Singh, (Gyana)	.042	.065	.017	.02
13.	Kartar Singh (Gyana)	.037	.088	.018	.06
14.	Mita Singh, (Gyana)	.015	.057	.004	.034
15.	Near Old age home Devi Road (Takht Mal)	.143	.316	.019	.06
16.	Tube well near Water works (Canal Main line)	.047	.066	.018	.09
17.	Shemsher Singh (opp. To house) handpump (Taruwana)	0	.007	.019	.002
18.	Banta Singh (Panch) (Taruwana)	.016	.06	.019	.03
	BIS (2003) Desirable	0.05	—	0.05	—
	Permissible	0.05	—	0.05	—
	WHO (2001)		2ppb		

calcium in soft water is linked with rickets and defective teeth. While low level of calcium in human body may have adverse effect, excess of Ca is also harmful resulting in formation of concentration such as kidney and bladder stones. High concentration of Ca is also linked with gout and rheumatism. Maximum desirable limit in drinking water is 75 mg/l and maximum permissible limit is 200 mg/l. In the ground water of study area, the values varies from 74-83 to 993.51. In 11 samples, it is more than permissible limit (Table 1).

Magnesium: According to Bureau of Indian Standards (BIS 2003) the desirable limit for Mg in drinking water is 30 mg/l and permissible limit is 100 mg/l. High concentration of Mg in water may cause gastro-intestinal problem. It has been found that for persons living in hard water area, Mg and K are significantly in heart muscles whereas the ratio of Mg-K is low in soft water areas. In the study area, value of Mg varies from 48.19 to 332.25. In 11 samples it is more than the permissible limit.

Sodium: The value of Na ranges from 80.43 to 2023.84. In 13 samples, it is more than the permissible limit.

Potassium: According to BIS (2003), limit of K within drinking water is 10-2000. In all the samples K is in permissible limit.

Flouride: The natural concentration of fluorine in drinking water is normally 0.1 to 1.0 mg/l. WHO has set the limit 1.5 mg/l. There is a direct relationship between dental care and fluorosis. Fluoride concentration supplies an important consideration. In study area it varies from 0.32 to 3.82 mg/l. In 10 samples, it is under permissible limit, but in eight samples it is more than permissible limit.

Sulphate: The permissible limit of SO_4 in drinking water is 400 mg/l (BIS 2003). In the samples studied SO_4 varies from 50 to 880 mg/l. In seven samples sulphate exceed the permissible limit (400 mg/l) and 11 samples are in range. Beyond the desirable limit (200 mg/l) SO_4 causes gastro-intestinal irritation when Mg and Na are present. The sulphate ions when associated with high concentration of Mg and Na ions act as laxative and may cause gastric disorder. In the adjoining areas of Peerkot of dist Mansa, high values of F (1.5-2.60 mg/l) and SO_4 (400-800 mg/l) have been observed.

Lead: It is cumulative poison and accumulates in the skeletal structures of man and animals. It has adverse effect on the central nervous system, kidney and may cause cancer and brain damage. The BIS (2003) has prescribed maximum permissible limit 0.05 mg/l for drinking water. Concentration of Pb greater than this has been observed in six samples out of 18 samples. To safeguard the health of people it is essential that water with high concentration of Pb should not be used for drinking purposes. The US Environmental Protection Agency has established a reference dose for Ni (soluble salt) at 20 mg/kg/day. The carcinogenecity of Ni is well established (Adriano, 2001).

Uranium: Certain granites, alumshales and pegmatites have elevated uranium contents. The bed rock in present area consists of high heat producing granites and acid volcanics which have high concentration of uranium. WHO guidelines for U in drinking water is 2 mg/l (Adirano, 2001). Uranium concentration in samples studied varies from 0.007 to 0.316 ppm. All the samples have higher uranium than the permissible limit. The general public ingestion of soluble uranium compounds should not exceed the tolerable intake of 0.5 mg/kg of body weight per day. However in case of insoluble compounds a tolerable intake is 5 mg/kg of body weight per day (Rao, 2003). Inspite of high concentration of uranium in water, the radon activity is within permissible limit (<400 bgl) (Bajwa et al., 2003).

Chromium: According to BIS (2003) the permissible limit of Cr in water is 0.05mg/l. All 18 samples are under permissible limit. Hexavalent form of Cr^6 is toxic to men and main adverse effects are on skin, mucos membrane and lung. Hexavalent form of humans is more mobile in surface and subsurface environment than the trivalent form. Cr is skin allergen, next to Ni (NRCC, 1976). Trivalent Cr^3 has essential biological role. Oxidation of Cr^3 does not take place in living matter. Role is played by Cr^3 only. High concentration of Cr in water may be due to the thermal plant. In phosphate fertilizer Cr is 30-300 ppm, in super phosphate it is 60-250 ppm, in bone meals <20 to 500 and limestone <1 to 200.

Nickel: BIS or any other agency has not prescribed any limit of Ni in drinking water. The concentration of Ni found in groundwater in study area are given in Table 2. In absence of any prescribed standard it is difficult to evaluate the harmful effects in study area. The source of Ni in the area under study may be due to fly ash from the thermal plant, as Ni gets concentrated in it after combustion of coal.

Conclusion and Discussion

Higher than desirable values of F, NO_3, SO_4, Ca , Na and Mg have been reported in ground water in certain villages of Bhatinda district (CGWB Groundwater Year Book, 2000-2001. There appears to be correlation between these high values and high uranium and radon activity in ground water (Kochhar and Dadwal, 2004).

Besides the area under study, there are villages in Bhatinda district where contents of F, NO_3, SO_4 (Jhanduke, NO_3: 165, SO_4: 403; Maur Mandi, F: 1.10, SO_4: 1080; and Nahinwla, NO_3: 276 and Balluana, SO_4: 1722, F: 1.10) have been recorded.

The interaction of ground water with the soils formed from the weathering of Malani granites and the basement rocks (Delhi quartzite) encountered in the region might have been the cause of high U and radon values recorded in ground water. Further, the evaporites and foetid limestone/dolomite might have been the cause of salinity, and high sulphate, Mg, Na and K content in the water sample.

Human activities and urbanization is responsible for increase in specific conductance, pH, and the concentration of bicarbonate, nitrogen and pesticide. The Jajjal and Giana villages of Talwandi Sabo block of Bhatinda district record the maximum number of cancer patients in the region. About 70-80 persons have died due to cancer of the different body parts since late seventies. The area falls in the cotton belt of Punjab and there is widespread use of pesticides such as diammonium phosphate and cyhalothrein, and fertilizers such as urea, superphosphate and NPK. These fertilizers also contribute Pb, As and Ni to the water/soil system. People attribute cancer to the ground water quality. The present work shows that chemical quality of water including radon activity coupled with the effect of pesticides may be responsible for the cancer incidence in the region. More detailed work is underway.

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