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Fluoride in water in parts of Raniganj Coalfield, West Bengal

In recent times, there have been media reports[1] that fluoride contamination is widespread in West Bengal. It has been highlighted that 60 blocks in eight districts, viz. Bankura, Barddhaman, Birbhum, Purulia, Midnapur, Malda and West Dinajpur are affected. This had prompted us to study the fluoride content in water from all sources in parts of the Raniganj Coalfield and adjoining Chhotanagpur Gneissic Complex (CGC). The study area has a long history of coal mining with several industrial establishments and traditional agricultural activities.

Fluorine, the 13th abundant element, has a crustal abundance of 625 g/t. In magmatic rocks, fluorine content increases with the increase in silica content. It ranges between 600 and 1000 ppm in granite, 200 and 900 ppm in alkali rocks, 200 and 300 ppm in carbonate rocks and may be as low as 250 ppm in diabase[2]. In the hydrothermal phase, the concentration of fluorine may even exceed 1.0 mg/l (e.g. tourmaline). Concentration of fluorine in sea water is 1.3×10^3 μg/l and is directly proportional to salinity. The residency of fluorine in sea water[3] is 5.2×10^5 yrs.

Fluorine as hydrofluoric acid is also released due to intrusive igneous and volcanic activities in the oceanic and continental domains. In the Raniganj Coalfield (study area) there have been lamprophyre intrusions, which might have contributed fluorine to the pore fluid of the rocks. In the atmosphere, fluorine is found as CFC, HCFC and HFC gases, which when washed down by monsoon precipitation may increase the fluoride content in surface and groundwater. The Younger Toba Ash (YTA) has been deposited over wide areas in the east coast of India following the volcanic eruption of Toba cauldera in northern Sumatra[4]. Precipitation of these ashes and the accompanying rainfall might have also contributed fluorine in the soil and water.

According to the World Health Organization (WHO), the problem of fluorosis is well known from Australia, New Zealand, Kenya, Tanzania, China, Mexico, Chile, Sri Lanka and Bangladesh for some years. India has now joined the group. Fluoride concentration in water up to 1.0 ppm is good for health, but in excess of 2.0 ppm it causes conditions for dense and brittle bone, and dental problems.

Fluorine exists as simply charged F^- ions in minerals like fluorite, or as complex ions in avogadrite (KBF_4) or cryolite (Na_3AlF_6), and also in fluorine-bearing varieties of mica, amphibole. Fluorite occurs as a vein mineral or as a gangue mineral with various metallic ores, especially those of Pb, Zn and Ag. Besides rocks like granite, nepheline syenite, carbonatite or late-stage pegmatite may contain a number of fluorine-bearing minerals, viz. fluorite (CaF_2), fluorapatite [$Ca_3(PO)_2Ca(FCl)_2$], topaz [$Al_2(SiO_4)(OH,F)_2$], tourmaline [$Na(Mg,Fe,Mn,Li,Al)_3Al_6Si_6O_{18}(BO_3)_3(OH,F)_4$], avogadrite ($KBF_4$), cryolite ($Na_3AlF_6$), fluorine-bearing micas (muscovite, biotite, phlogopite) and amphiboles (tremolite, actinolite, hornblende, etc.), and pyrochlore–microlite [$(Na,Ca)_2Nb_2O_6(OH,F)$–$(Na,Ca)_2Ta_2O_6(O,OH,F)$].

The area selected for preliminary appraisal covers two segments in the south-western and south-central parts of the Raniganj Coalfield, extending onto the Chhotanagpur gneissic terrain (Figure 1) to the south. The western segment (study area I) is bounded by lat. 23°30′N and 23°45′N, and long. 86°47′E and 86°53′E. The eastern segment (study area II) is bounded by lat. 23°30′N and 23°40′N, and long. 87°00′E and 87°15′E. The area covers part of Survey of India toposheet nos 73 I/12 and 73 M/2.

In the study area, Ironstone Shale Formation, Raniganj Formation, and Panchet and Supra Panchet Formations of Gondwana Supergroup were exposed. The Raniganj Formation covers the

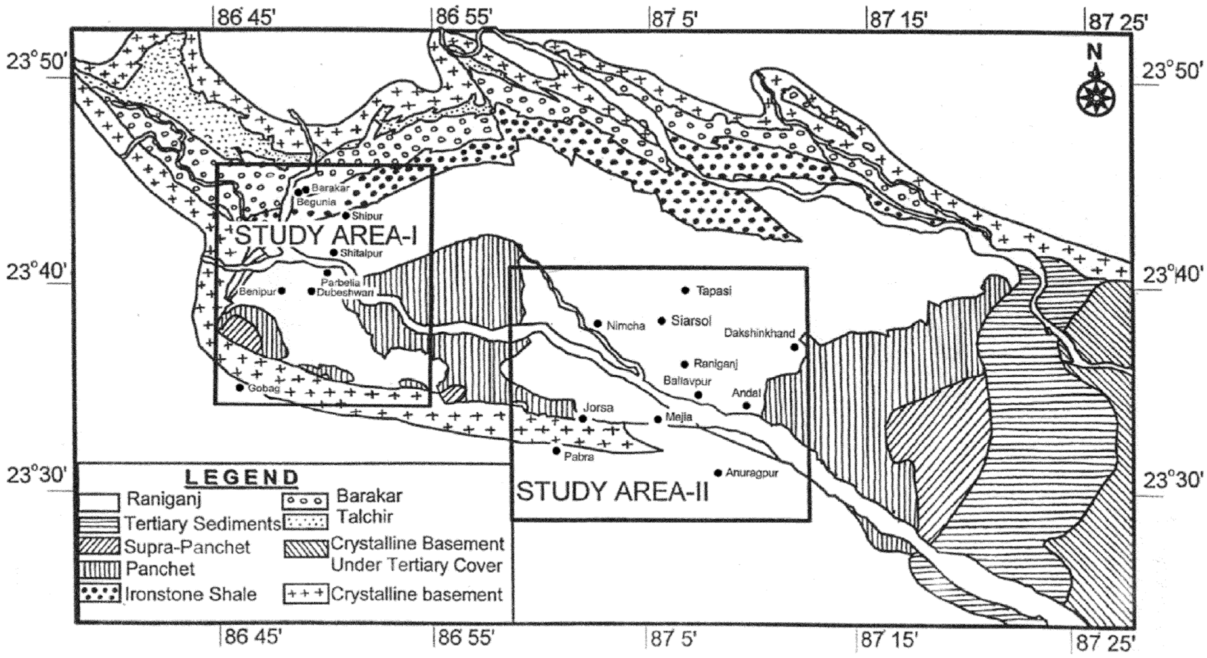

Figure 1. Geological map of the Raniganj Coalfield area showing the study areas I and II, and sample locations.

Table 1. Fluoride content in pre- and post-monsoon water samples of the study area and analyses data of some water quality parameters, including fluoride from the study area

	Pre-monsoon							Post-monsoon						
Location	pH	TDS	TH	HCO_3	Cl	F	Fe	pH	TDS	TH	HCO_3	Cl	F	Fe
Open well														
Andal	8.1	510	455	191	75	0.965	0.2	7.8	460	395	215	62	0.51	0.13
Dakshinak	7.9	625	423	201	69	0.979	0.18	7.8	502	395	152	48	0.32	0.11
Siarsol	7.9	690	470	330	51	0.948	0.17	7.5	545	395	256	38	0.49	0.09
Raniganj	8.2	655	485	250	67	0.862	0.18	8	590	438	203	53		0.12
Shipur	7.9	575	450	295	64	1.15	0.2	7.8	515	385	165	39	0.65	0.14
Mine water														
Nimcha	7.7	820	490	440	105	0.895	0.12	7.4	680	300	260	60	0.39	0.07
Parbelia	8.1	990	750	370	68	1.217	0.11	7.75	850	620	225	50	0.62	0.08
Dubeswari	8	950	740	340	72	1.056	0.13	7.8	780	590	215	60	0.62	0.09
Begunia	8.1	810	360	550	80	0.971	0.21	7.5	750	280	470	70	0.46	0.1
Tube well														
Ballavpur	8.9	760	340	225	22	0.954	3.9	8.2	690	305	201	15	0.53	2.2
Tapasi	8.2	515	377	270	15	1.031	0.55	7.8	490	350	221	12		0.42
Barakar	8.15	890	310	280	39	1.055	0.19	8.5	805	301	140	45	0.66	0.13
Shitalpur	7.7	450	405	250	20	0.895	0.25	8.15	410	325	195	12	0.67	0.2
Benipur	8.1	965	770	285	69	1.053	0.75	7.9	895	688	230	54	1.04	0.6
Gobag	7.7	970	840	315	65	1.218	0.82	7.9	901	795	235	48	0.81	0.59

TDS, Total dissolved solid; TH, Total hardness; HCO_3, Bicarbonate; Cl, Chloride; F, Fluoride; Fe, Iron.

maximum area. The residual soil cover over the area is oxidized and can be designated as Alfiosol. The uppermost sand bed of Supra Panchet has been thoroughly lateritized and this has led to the development of nodular hardpan.

The present study, a preliminary appraisal, involved (i) delineation of geological units of the Raniganj Coalfield in the study areas I and II; (ii) collection of representative pre- and post-monsoon samples from tube wells, mine-water discharges, open wells and surface water sources (Figure 1), and (iii) analysis of samples for pH and fluorine content. Fluoride in water samples was determined by SPADANS–zirconyl oxychloride method[5] using UV–VIS spectrophotometer (Hitachi model-U3210, Japan). The absorbance values obtained at λ_{max} = 570 nm were compared with the standard calibration curve for fluoride concentration. Finally, an attempt has been made to indicate the extent of fluoride contamination.

There are unpublished reports of high fluoride content in underground mine water and open-well water from some coal seams of the Raniganj Coalfield, where the maximum reported fluoride content is up to 3.2 ppm. The results of the present study have been summarized below:

1. Dilution of fluoride content was observed in the post-monsoon water sample from all sources. The pH value of water also reduced sympathetically.

2. In general, fluoride content in water was higher in the Raniganj Formation than the basement areas in the south. Even within Raniganj Formation, fluoride content of groundwater was higher in the western block (study area I) than in the area to the east (study area II), where the sediments are rich in finer clastics and iron cement. Fluoride content (pre-monsoon) in the eastern part ranged from 0.63 ppm (Pabra) to 1.03 ppm (Tapasi) and that in the western part from 0.81 ppm (Sarbari) to 1.22 ppm (Gobag, Perbelia). Similarly, the post-monsoon fluoride values ranged from 0.27 ppm (Jemua) to 0.52 ppm (Ballavpur) in the east, and 0.34 ppm (Belijhupa) to 0.81 ppm (Gobag) in the west.

3. High fluoride content in water has been found associated with relatively high TDS, HCO_3^- and TH.

4. In both the study areas, iron content of the water samples was less during the post-monsoon period than the pre-monsoon period, which indicates that iron does not get into groundwater through percolation from the vadose zone (Table 1).

5. Fluoride content increases from east to west even within the Raniganj Formation, in spite of dilution effect during post-monsoon.

6. It is evident that water from all sources in the study area of the Raniganj Coalfield has fluoride locally higher than the WHO[6] limit of 1.0 ppm. It would be worthwhile to undertake a systematic geological formation-wise monitoring of fluoride content in the Raniganj Coalfield area, starting from the east of Durgapur to Kumardhubi.

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Earthquake probabilities and pre-earthquake signals

In his recent letter to *Current Science*, Bapat[1] has drawn attention to the concept of 'probability'[1] and argues that when applied to earthquake science, it makes little sense. To underline his point, Bapat presents a table, published in a recent report submitted by the Director, Geological Survey of India (GSI) to the Government of Uttarakhand, Dehradun about the vulnerability of different districts of this northern part of India to destructive earthquakes. This table lists the probabilities of occurrence of such earthquakes between 81.6% and 98.3%. The same GSI report contains a statement that 'earthquakes cannot be predicted'. What does prediction mean and how is it to be judged?[2].

Seismology has done an admirable job over the past 100 years, unravelling the hidden structures deep in the earth. Using earthquakes as 'flashlights', seismologists have developed powerful tools to create three-dimensional images of the interior of the earth. They can reconstruct with second resolution how catastrophic ruptures propagate along faults and radiate-off seismic waves, which unleashes their destructive power as soon as they reach the surface of the earth. This impressive body of work has put the seismologists firmly in control of earthquake science. Nobody knows more about earthquakes than the seismologists.

However, there is a snag. Everyone who lives in a seismically active region of the world would like to know when an earthquake will occur. But earthquakes are notorious for striking suddenly. They cause death and devastation apparently without warning. Tens of thousands of lives could be saved, if early warnings are available. The damage to structures and infrastructures, often reaching hundreds of billions of dollars, a sizeable fraction of the GNP even for wealthy nations, could be reduced. Yet, famous seismologists have been quoted as saying categorically[3]: 'earthquakes cannot be predicted'.

In a certain way, this statement is true: if the only tools in the scientific toolbox are those of seismology, earthquakes can indeed not be predicted[4].

What are these tools? Seismologists have long determined where the tectonically active faults lie. They have mapped most of them. They also know how the tectonic plates move relative to each other, whether they collide in a thrust-like fashion or rub past each other in a strike-slip fashion. Seismologists can measure the speed of relative plate motions with astounding precision. They can look at past seismic events, small and large, using seismograph data that go back at least a century. For large events