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A Crisis Situation Due to Uranium and Heavy Metal Contamination of Ground Waters in Punjab State, India: A Preliminary Report

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Abstract

Punjab is facing a crisis situation due to high levels of uranium (U) and heavy metals in underground water table of Punjab. Uranium poisoning in Punjab first made news in March 2009, when a South African Clinical Metal Toxicologist, Carin Smit, visiting Faridkot city in Punjab found surprisingly high levels of uranium in 88% of the blood samples collected from the Baba Farid Centre for Special Children in the Malwa region of Punjab. In this preliminary report, groundwater quality data pertaining to uranium and heavy metals, such as iron, nickel, cadmium, mercury, chromium, aluminium, lead, arsenic and selenium, are reported. A bird's eye view of survey report on groundwater contamination by basic parameters, such as TDS (total dissolved salts), calcium, magnesium, sulphate, nitrate, chloride and fluoride, is also given. The final report enumerating the health hazard effects of heavy metals on population in Punjab will be presented after compiling the data analysis.

Keywords: *Heavy metal contamination, Uranium, Punjab*

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INTRODUCTION

Uranium poisoning in Punjab first made news in March 2009, when a South African Clinical Metal Toxicologist, Carin Smit [1], visiting Faridkot city in Punjab found surprisingly high levels of uranium in 88% of the blood samples collected from amongst mentally retarded children in the Malwa region of Punjab. The results revealed that 87% of children below 12 years and 82% beyond that age having uranium levels high enough to cause diseases, and in the case of one child, the levels were more than 60 times the maximum safe limit. The reports of this study when published in local newspapers created a fear psychosis in the minds of public. Many scientists from Universities of Punjab jumped on the band wagon of Carin Smit to support her claim of high uranium content in blood samples by providing results of uranium analysis of soil and groundwater samples collected from some villages of Malwa region of Punjab [2–4].

The echo of these reports resonated in the corridors of Indian Parliament and special efforts were made by a group of scientists of Bhabha Atomic Research Centre (BARC) and Guru Nanak Dev University, Amritsar (my old students and research collaborators) to delineate the causes of high U content in groundwater and soil of Malwa belt of Punjab. A public interest petition had been filed in Punjab and Haryana High Court to monitor the progress made by Scientists to find a solution to this problem. Recently, Centre for Environmental Science and Technology, School of Environment and Earth Sciences, Central University of Punjab, Bathinda has entered this domain to study U and heavy metal content in soil and groundwater as well as in food chain. Tata Memorial Hospital has started functioning at Sangrur in Malwa belt to diagnose and monitor the cancer causing agents and offer treatment facility.

Punjab is facing a crisis situation due to high levels of uranium and heavy metals in underground water table of Punjab. More than two dozen reports have been published in The Tribune (www.tribuneindia.com) during the last decade concerning high toxicity of U in the waters of Punjab. The latest report appeared on May 18, 2016 by Ruchika M. Khanna [5] regarding use of Canal water for

drinking and toxic groundwater for purposes of irrigation. Ruchika report is based on results of uranium reported by a team of scientists of Bhabha Atomic Research Centre (BARC). It also refers to presence of heavy metals in water pumped from tube wells based on data collected by Punjab Water Supply and Sanitation Department (PWSSD). It will be of interest to general public that PWSSD has collected data from more than 50% habitations (villages) of Punjab and analysed in its sophisticated laboratory set up in Mohali (Punjab), using state of art instrumentation including ICPMS (Inductively Coupled Plasma Mass Spectrometry) and Ion Chromatography Mass Spectrometry (IC-MS). The analysis presented in this paper is also based on PWSSD data collected in three phases during 2009 to 2016 and compiled in April 2016. Most of this data is available on the website of Ministry of Water Resources, Government of India [6].

URANIUM IN GROUNDWATER

The total number of habitations (village or a cluster of houses) covered in PWSSD survey is 6182 in three phases. To demarcate quality affected (QA) habitations, two limits have been set up by PWSSD in the data table: 30 microgram/litre (ppb) is called acceptable limit (AL) and 60 microgram/litre (ppb) is shown as permissible limit (PL) which has been set by Atomic Energy Regulatory Board (AERB), DAE, Trombay [7], which is higher than limits set by all other countries of the world. The World Health Organization (WHO) limit is set at 15 microgram/litre (ppb). When we analyse the U data according to these limits, we get different results of QA habitations. According to PL criteria, 785 habitations are having QA groundwater in Punjab but when we use AL criteria, the number goes up to 1141. But I prefer to use WHO limit of 15 ppb for safe drinking water. Using this limit, the QA habitations augment to 2144, which is 35% of total habitations covered in PWWSD survey. As a matter of fact, more than one third of Punjab groundwater is unfit for drinking purposes according to international criteria set by WHO [8].

The highest number of QA habitations belong to Malwa belt, namely, districts of Fazilka (217), Moga (180), Barnala (120), Sangrur (95), Patiala (85), Bathinda and Mansa, followed by Tarn Taran, Hoshiarpur, Ludhiana and Jallandhar districts. SAS Nagar (Mohali) district has not a single habitation QA by high U; hence, it has no source of U contamination in groundwater at all. A large variation of U content has been observed from district to district and habitation to habitation depending upon the nature and profile of groundwater which may depend upon geomorphology and geo-hydrology of water table.

The highest Uranium content in ground waters of Punjab has been recorded in 15 habitations of Hoshiarpur district in the range of 2109 to 2277 ppb, which is almost 20 times the average value of U content (115 ppb) for the whole of Punjab as per AL criteria. Both the average and the highest values of Uranium content in ground waters of Punjab must set the alarm bell ringing for the general public as well as political leadership as the health of Punjab population is at stake due to over-exploitation of ground water for purposes of drinking and irrigation. Our calculation reveals that excess cancer risk for 2277 ppb U is 6.5 per 1000 persons, which is alarming! If we consider the average value of 115 ppb, the cancer risk for whole of Punjab is 3.3 per 10,000 persons. There is an urgent need to study the epidemiological effects of high U content in drinking water on public health.

The health effects of Uranium concentration in water on humans are not well documented. The overall indications are that there is no clear evidence of effects below an exposure concentration of 30 μg/l (ppb). In fact, the evidence for effects on the kidney, which appears to be the most sensitive organ, is equivocal until much higher exposure concentrations. At higher concentrations, above about 100 μg/l (ppb), radioactivity will begin to be a consideration.

Several methods are available for the removal of uranium from drinking-water, although some of these methods have been tested at laboratory or pilot scale only. Coagulation using ferric sulphate or aluminium sulphate at optimal pH and coagulant dosages can achieve 80–95% removal of uranium, whereas at least 99% removal can be achieved using lime softening, anion exchange resin or reverse osmosis (RO) processes. PWSSD has

recommended installation of RO system in rural areas of Punjab with U concentration higher than the permissible limit of 60 ppb.

HEAVY METALS

Iron Content in Groundwater

The total number of habitations (village or a cluster of houses) covered in PWSSD survey is 4383 in 3 phases during 2009 to 2016. To demarcate quality affected (QA) habitations, PWSSD has set an acceptable limit (AL) of 1 milligram/litre (ppm) for potable underground water to be used for public consumption. It has been reported by PWSSD that 539 habitations have higher content of iron in groundwater than AL value, as a consequence, the population inhabiting these will suffer from overload effect of iron. Normally, iron deficiency in human body leads to anemia and fatigue. But an overload of Iron in the body produces toxic effects leading to hemochromatosis, a severe disease that can damage body organs. The highest number of QA habitations are reported in Amritsar and Ropar, followed by Gurdaspur, Patiala and Tarn Taran districts. An overload of 14.58 ppm, the highest value in Punjab, has been detected in the water drawn from a hand pump of Bagrian village in Amritsar district. The other high values are reported from Harijan Abadi (8.90 ppm) of Tarn Taran; Harijan Basti, village Mangarh (8.99 ppm) of Fatehgarh Sahib; Bolri (8.83 ppm) in Patiala; and Daulowal (7.03 ppm) in Hoshiarpur district. To get rid of excess Iron from potable water, RO system is most effective.

Nickel and Cadmium Content in Groundwater

Nickel and cadmium AL values have been considered to be 0.02 ppm and 0.003 ppm, respectively. According to PWSSD report, 174 habitations are under QA category for nickel and 165 for cadmium out of a total number of 6404 habitations covered in this survey. Patiala district has highest number of habitations with Cadmium overload. However, highest value of Nickel (0.33 ppm) is reported in ground water of Lalton Kalan in Ludhiana district.

Mercury and Chromium Content in Groundwater

The AL values for mercury and chromium have been taken as 0.001 ppm and 0.05 ppm, respectively. Mercury has been detected in 107 habitations out of a total of 6831 covered in this survey but the number of QA habitations is just 41. The highest value of mercury (0.038 ppm) is reported in Hero Kalan village of Mansa district. Chromium content is wide spread in Hoshiarpur, Ludhiana and Amritsar districts. However, the toxic effects of both these heavy metals need to be investigated epidemiologically for the safety of population in QA habitations.

Aluminium and Lead Content in Groundwater

There are two limits set for aluminium in groundwater of Punjab; acceptable limit (AL=.03 mg/l or .03 ppm) and permissible limit (PL = 0.2 mg/l or 0.2 ppm). According to AL criteria, 3662 habitations out of a total of 6974 surveyed during 3 phases, show higher Aluminium content. If we consider the PL criteria, the number of QA habitations reduces to 1087. Aluminium contamination is highest in Hoshiarpur district with more than 150 habitations failing to qualify even under PL criteria. The highest value of Aluminium content (5.03 ppm) is reported for a tube well installed in Balon village of SBS Nagar (Nawanshahar) district, which is 25 times the PL value.

Lead is another dangerous toxic heavy metal reported in Punjab. The AL for lead has been set at 0.01 mg/l (0.01 ppm). Out of 7009 habitations covered under lead survey, 710 fail to qualify the safety limit. Gurdaspur district has maximum number of failed habitations (128) followed by Jallandhar (98). The maximum reported value of Lead content (0.467 ppm) has been found in a cluster of villages in Jallandhar district, namely, Dhuleta, Patti Kamalpur and Bara Pind.

Arsenic and Selenium Content in Groundwater

A team of Punjab Agriculture University (PAU) scientists reported their findings in The Tribune, Chandigarh of Jan. 2, 2010, blaming arsenic content in groundwater of Malwa belt as one of the major causes of cancer [9]. A research report recently prepared by the Indian Council of Agriculture Research (ICAR) has reported arsenic beyond safe limit in 13

districts of Punjab [10]. However, PWSSD survey report is more revealing and contradicts the findings of PAU team. According to PWSSD report, with AL set at 0.01 mg/l (ppm) [11], there are 2748 habitations out of 6884 surveyed in Punjab, which fall under QA category (40% nearly). Out of all QA habitations in Punjab, 60% fall in Majha belt of Punjab, namely, Amritsar and Tarn Taran districts. Gurdaspur occupies the 3rd position but the Malwa belt, including Patiala, Barnala, Mansa and Bathinda have fewer QA habitations due to excess or overload of Arsenic. SAS Nagar and SBS Nagar are relatively much safer with hardly any QA habitation. The source of Arsenic in ground waters of Majha belt needs to be investigated. However, it is well established that the strongest evidence for a cancer risk involves arsenic, which is linked to cancers of the liver, lung, bladder, and kidney.

Selenium is a non-metal and a very useful component in our diet. Selenium is a nutritionally essential element. People need selenium for healthy joints, heart and eyes. It plays a critical role in DNA synthesis, the immune system and the reproductive system. It also helps fight cancer and other diseases. But its excess is dangerous for human health. Epidemiologic studies have shown that chronic exposure to selenium compounds is associated with several adverse health effects in humans [12].

Selenium AL is fixed at 0.01 mg/l (ppm) by WHO [13]. Following these criteria, PWSSD survey reported 587 QA habitations out of 7009 surveyed in Punjab. The maximum number of QA habitations fall under Jallandhar (130), Ludhiana (70), Patiala (55) and Tarn Taran (50) districts. However, the highest reported value of Selenium (2.00 ppm) has been reported in tube well water of Passiana village in Patiala district, which is 200 times the safe limit (AL).

BASIC PARAMETERS

TDS Contamination

This report undertakes the study of some basic parameters, namely, TDS (total dissolved salts), fluoride, chloride, nitrate, sulphate, calcium and magnesium. There are two limits defined by Punjab Water Supply and Sanitation Department (PWSSD) for analysis of quality affected (QA) groundwater in habitations (village or a cluster of houses) in Punjab. The acceptable limit (AL) for TDS is fixed at 500 mg/l (ppm) and permissible limit (PL) is allowed to be 2000 mg/l (ppm). Out of 2768 habitations surveyed in Punjab for TDS contamination, 609 are found to be QA according to AL criteria. However, using PL criteria, the number of QA habitations drops down drastically to 31 only. The highest value of TDS contamination (5650 ppm) has been found in four habitations of SBS Nagar district, namely, Jhungian, Mehatpur, Mehmoodpur Gadrian and Auladni.

Fluoride and Chloride Contamination

According to WHO (1984) and Indian standard drinking water specification (1991), the maximum permissible limit of fluoride in drinking water is 1.5 ppm. Fluoride concentrations above 1.5 ppm in drinking water cause dental fluorosis and much higher concentration skeletal fluorosis [14]. In the present survey, the AL value for Fluoride contamination in groundwater is fixed at 1.0 mg/l and PL value at 1.5 mg/l (ppm). Out of 3214 habitations surveyed in Punjab, 637 have been found to be QA using AL criteria. Fluoride contamination is wide spread in Patiala district of Punjab. The highest value of 11.39 ppm recorded in village Jala Lakha Ke Hither in Fazilka district.

Chloride AL value is taken to be 250 mg/l (ppm) and PL value as 1000 mg/l (ppm). There are 41 QA habitations using AL criteria but none using PL criteria. The Chloride contamination is found to be highest in Fazilka district, accounting for almost 50% of total QA habitations.

Nitrate and Sulphate Contamination

The AL allowed for Nitrate in Punjab is 45 mg/l (ppm). Out of 3197 habitations surveyed, 237 are found to be QA with highest number falling in Patiala district. The highest value of Nitrate contamination (2553 ppm) is recorded in Sukhewal and Bhilowal villages.

The AL and PL values for sulphate contamination are taken to be 200 ppm and 400 ppm, respectively. Using AL criteria, there are 92 QA habitations in Punjab, with

Fazilka district accounting for 40 out of 92. Pehar Kalan and Pehar Khurd of Patiala district record highest value of 4980 ppm of sulphate contamination in Punjab.

Calcium and Magnesium Contamination

The AL values for calcium and magnesium are taken to be 75 ppm and 30 ppm, respectively. Out of 247 habitations surveyed in Punjab, 27 are QA with Amritsar accounting for 12. The maximum calcium contamination of 297.6 ppm was found in Peher Kalan and Peher Khurd of Patiala district.

Magnesium AL value is fixed at 30 ppm. Out of 247 habitations surveyed, 125 are reported to be QA with maximum number (54) falling in Fazilka district. Surprisingly, the highest contamination of magnesium (145.75 ppm) is found in the same pair of villages, Peher Kalan and Peher Khurd, in Patiala district.

The data for sodium and potassium is not available. It will be interesting to investigate the contamination results of Peher Kalan and Peher Khurd in Patiala district for linkage between calcium, magnesium and sulphate in groundwater.

CONCLUSIONS

1. Nearly 35% habitations in Punjab are affected by excess concentration of U in ground water in terms of WHO limit. Seven districts of Malwa belt (Fazilka, Moga, Barnala, Sangrur, Patiala, Mansa and Bathinda) have higher U content compared with the other districts of Punjab.
2. Heavy metal contamination in Punjab has assumed alarming proportions. Arsenic and selenium concentration in groundwater is higher in Amritsar, Tarn Tarn and Gurdaspur districts.
3. The maximum number of QA habitations with respect to basic parameters in groundwater belong to Patiala district.
4. It will be of interest to study epidemiological effects of U and heavy metals in groundwater on the population of Punjab.

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