URANIUM IN GROUND WATER

WATER-LOGGING IN MALWA REGION

SCIENTIFIC OPINION & FACT SHEET

OVERALL, THE LOCATION OF URANIUM CONTAMINATED GROUND WATER DISTRIBUTED OVER A LARGE REGION DOES NOT FAVOUR A PARTICULAR LOCALISED SOURCE OF URANIUM CONTAMINATION.

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The draft is open for peer-review by the experts from different fields. The readers can post their comments by e-mail to Dr. D. Mehta, Department of Physics, Panjab University, Chandigarh (dmehta@pu.ac.in). The input will be gratefully reflected in the final text.

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ABSTRACT

Sources of Uranium : The existing theories and perceptions with regard to the source of uranium in the ground water of the Malwa region have been rebutted. It is rejected that the flyash from thermal power plants in Bathinda, Budha Nullah in Ludhiana and other sources like existence of Tethys sea, weathering of granite rocks at Tosham hills, pesticides and depleted uranium used in wars. There are no signatures of uranium deposits as the soils have largely developed on the material laid by rivers up to depths of thousands feet. Agrochemical processes are responsible for extracting uranium existing in the soils and result in uranium (Chemical) contamination of ground water. The uranium content in the soils is ~3 ppm (microgram/g). Most of the region is water-logged. At the same time, extensive irrigation and drinking water supply schemes in the Malwa region are mainly based on canals. Soils in the region are calcareous. Solid pieces of calcium carbonate (kankars) are common in Baluana and Karamgarh Sattran villages, where maximum uranium concentrations of ~500 microgram/Land total dissolved salts (TDS) of 7g/L have been reported in the ground water. Uranium content constitutes only 1/10,000 of the total dissolved salts. **Agrochemical process is responsible for uranium contamination of ground water** - Irrigation water percolating through soil dissolves carbon dioxide gas produced at high pressures from the plant root respiration and the microbial oxidation of the agricultural matter. The resulting carbonic acid reacts with the insoluble calcium carbonate to produce soluble bicarbonate, which leaches uranium from soils and adds it to the ground water. **Due to the minimal use of the ground water, its TDS level is continuously increasing as loss of water is only through evaporation. It mainly contains bicarbonates, nitrate, chlorides, bromine based anions; calcium, magnesium, potassium, sodium and strontium cations. Fertilizers used also add to the chemical contamination of ground water but their contribution to uranium is negligibly small.**

Waterlogging - Various possible solutions have been suggested for Waterlogging problem. It is suggested that Government agencies may plan uranium extraction from the ground water in the Malwa region using RO equipment with special filters.

Drinking water - It is observed that canal water based supplies show chemical contaminations well within permissible limits. The quick solution RO based community water supplies appears attractive, but it has its own limitations and health effects. Canal water based supplies are the safe future of the Water supplies in Punjab. It is recommended that the use of ground water for building construction and other huge consumption activities must be made compulsory.

Health effects - The facts regarding the health problems like autism and sub normal physical growth of special children, and growing incidences of cancer, which are being misleadingly linked to uranium. Several studies have been held in Finland involving people who drink water of wells having uranium concentrations much higher than observed in the Malwa region. None of the studies on human beings reported so far have shown clear link between the uranium ingestion through drinking water and cancer risk, or clinical symptoms of toxicity. The available cancer data does not favour higher cancer patients in the Malwa region. Detoxification of uranium at the existing levels does not require any treatment. Simple shifting to clean water and consumption of natural powerful metal chelating agents such as citrus fruits, cilantro and garlic, should be increased.

SECTION - I

Background of the problem

The electronic and print media is emphatically reporting that the uranium ingestion from ground water being a possible cause for multiple health hazards like cancer, increased defective birth rate or abnormalities among children (Autism), early graying of hair etc in the Punjab state of India. These reports also link problems like cerebral palsy and Autism, with the presence of uranium in the ground waters of Malwa region (Annexure I). **A good fraction of these reports make un-substantiated, un-scientific and preposterous claims; and attribute uranium to Tosham hills in Haryana, thermal power plants, fertilizers, pesticides, nuclear reactors, winds carrying depleted uranium from Afghanistan and Iraq. It is noticed that misleading messages have been conveyed, which are causing confusions in the further investigations and taking necessary remedial measures** and thus lead to wastage of human effort and Tax payers money.

Objectives

We wish to submit our report on this burning issue stating occurrence of uranium in ground water, possible remedial measures and health effects on its ingestion along with the world wide scenario. This fact sheet has been released for people in Malwa region and Government to take necessary corrective measures. Other facts regarding the cancer and autism are also discussed to correct the misleading messages. The objective of this study is to broadly share ideas with People of Punjab, groundwater resources managers, engineers, policymakers and politicians on the subject.

Details of all the relevant subjects is given in Sections II, III, and IV, which are supported by annexures.

Conversion factor

1ppm = 1mg/L

1ppb = 1µg/L

SECTION II

SOURCES OF URANIUM CONTAMINATION OF GROUND WATER

Uranium is a naturally occurring element, which is widespread in nature. It is found in low levels within all rock, soil, and water. This is the heaviest element to be found naturally in significant quantities on earth. According to the United Nations Scientific Committee on the Effects of Atomic Radiation the normal concentration of uranium in soil is 300 μg/kg (micro gram per kg) to 11.7 mg/kg (milli gram per kg) **[1]**. Higher concentrations of uranium are present in certain types of soils and rocks, especially granite, and the ocean [Fig. 1]. Some important uranium ores found include pitchblende, uraninite, carnotite, autunite, and torbenite. It has exceptionally low radioactivity of the major isotopes, U-234 (abundance = 0.0055 %), U-235 (abundance = 0.72 %) and U-238 (abundance = 99.27 %), and their daughter products. The half-life values of these uranium isotopes are 0.25 million years, 700 million years and 4.47 billion years, respectively. High natural uranium concentrations in water are found in wells drilled in bedrock in certain areas in Finland, Norway, Greece, Canada and the USA. Exceptionally high uranium concentrations (up to 12,000 g/L) are found in wells drilled in bedrocks in Finland.

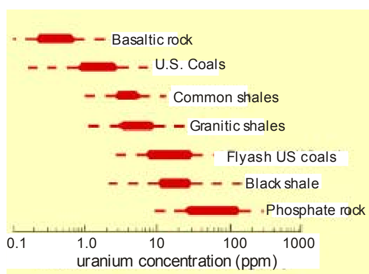


Fig. 1. Typical range of uranium concentration in coal, fly ash, and a variety of common rocks.

Uranium in Ground water in Malwa region – background of Investigations

The research group at Physics Department, Guru Nanak Dev University, Amritsar, has been involved in studies **related to uranium in ground waters in Punjab [2-5]** for the past more than a decade. They have already reported uranium concentration analysis in ground water samples belonging to Malwa region in Punjab state and Himachal state using standard scientific techniques, viz., fission track and laser fluorimetry. The reports till few years back showed maximum uranium concentration ~ 100 μg/L in the handpump water samples from Giana village. **Recently even higher values of uranium concentrations approaching 1000 ppb have been reported in certain regions like Karamgarh Sattran. Some of the published data is given in Annexure II.** Prof. N. Kochhar **[6]**, Department of Geology, Panjab University, has also reported similar value of uranium concentration in the ground waters of Jajjal, Malkana and Giana villages in that region. Considerable fraction of the villages surveyed have shown uranium values in the ground water more than the WHO (World Health Organization) recommended level of 15 μg/L.

for drinking waterThe Atomic Energy Regulatory Board, India has put the limit for uranium in drinking water of 60 μg/L. According to the DAE reports the radioactivity levels in soil samples from the Malwa region to be comparable to the national and global average levels. Also, the radon concentrations in the water are not unusally high. These observations do not favour presence of local source with high uranium concentration. The soil samples from Punjab show up uranium concentrations **~ 2-3 ppm [7].**

The above mentioned studies were mainly concentrated on presence of uranium and radon in the ground waters. So, till date focus is is mainly on presence of uranium in Ground waters. The research group at Physics Department, Panjab University, Chandigarh did studies related to presence of uranium in drinking water from the Malwa belt. The analysis technique used is Energy dispersive X-ray Fluorescence, which is capable of detecting many elements simultaneously. The detection method is further improved by analyzing the residue obtained after drying about 500 ml of water sample **[8].** Also, literature survey on the possible sources of uranium and its health effects on ingestion were carried out. The water samples collected from the Bathinda, Abohar and Moga districts were analyzed. Samples from the ground water and canal water based water supply schemes, handpumps, flyash dykes and surroundings of thermal power plants in Bathinda city and Lehra Mohabbattan **[9,10]** were collected by Department of Water Supply and Sanitation, Mohali (Punjab), Punjab Pollution Control Board, Punjab, respectively. The research group members from Punjab University participated in the sample collection procedure. The water samples from Budha Nala, Ludhiana and other Beins in Phagwara which add up to the Sutlej river are also analysed as these have been reported as possible sources of uranium in the media. The canals based on Satlej river carry water to southwestern Punjab which is used for drinking and irrigation.

The uranium concentration in the shallow ground water from handpumps is found to be higher with a maximum up to 100 *ppb*, and it is below 5 *ppb* for the canal based drinking water supply schemes. For water treated using RO system it is certainly below 1 ppb. Arsenic concentrations in all the analysed samples are found to be below the permissible limit of 10 ppb. Strontium and Bromine in handpump water are observed in general higher concentrations with maximum value up to 1650 μg/L and 1100 μg/L. The water samples from the canal water schemes have shown lower uranium concentrations below 5 μg/L and strontium concentrations up to 300 μg/L. Molybdenum was also observed with considerable concentrations. The strontium and molybdenum concentrations are not known to have harmful effects. However, bromine in Bromate ion is a carcinogenic chemical with the permissible levels of just 10 ppb and these can be produced from the normally available bromide ions in the water purification based on ozonation or chlorination or ultra violet radiation. The ground water showing higher concentrations of uranium ~ few hundred μg/L is found have large amount of residue [Total dissolved salts (TDS) - bicarbonates, chlorides, nitrates)] ranging 2-7 g/litre. In general, this water is not even drinkable due to its bad taste. Further on, the measured data of concentration of

uranium in ground water over a decade or so indicates somewhat increasing trend or at least sustaining trend.

Currently, proof of negative health effects associated with the ingestion of high TDS water is not evident (WHO, 2006). Hence, the World Health Organisation has not defined a health based drinking water quality guideline value for TDS (earlier WHO had a highest desirable TDS guideline of 500 mg/l and a maximally permissible TDS guideline of 1500 mg/l). Such values do exist for individual chemical components like fluoride that contribute to salinity. Moreover, the presence of high levels of TDS in drinking-water (greater than 1200 mg/L) is assumed to be tastewise objectionable to consumers.

Various sources of Natural Uranium in Ground Water

The migration and/or mixing of contaminant chemicals in the groundwater are put into action by certain drivers. These drivers can be anthropogenic factors, such as drainage, irrigation, groundwater pumping, waste or wastewater disposal from industry. Natural uranium can also be released into the environment from various Anthropogenic or man-made activities such as the use of phosphate fertilizers, pesticides, combustion of coal in thermal power plants, mining, depleted uranium from the wars **[11]**. In the following section of fact sheet we wish to discuss the various sources of uranium contamination in ground water reported in research journals and our studies in this context.

(A) PLANT ROOT RESPIRATION AND MICROBIAL OXIDATION OF ORGANIC MATTER IN SOILS, CALCAREOUS SOILS, WATER LOGGING AND IMMOBILE GROUND WATER – A FAVOURED SOURCE OF URANIUM MOBILISATION IN GROUND WATERS IN MALWA REGION :

A CASE STUDY – Bathinda District

Ground water– The shallowest water level recorded was 3.67 m bgl (below ground level) at Balluana/Karamgarh Satran in Bathinda block and the deepest water level recorded was 15.86 m bgl at Dialpural in Bagtha Baika block. In the nearby Muktsar district it is in the range 2-5 m. The shallow ground water in the Bathinda district is alkaline in nature and its salinity varies from moderate to high. The shallow ground water is of **$Na\text{-}HCO_3$ type**. (ANNEXURE I)

The ground water is alkaline in nature in the Bathinda district. The pH values ranges from 7.42 to 9.0 indicating that the ground water is neutral to alkaline (weak base type in nature). Specific conductivity is a measure of total dissolved solids present in water and it ranges from 312 to 5800 micro/mhos at 25^{o}C and it is directly related to chloride values.

Typical characteristics and ranges of ion concentrations obtained from ground water samples from Bathinda District [12] -

pH	7.42	9.0
Specific conductivity	312	5800 micromhos/cm at 25°C
CO_3	Nil	
HCO_3	132	1463 mg/l
Cl	7.4	752 "
NO_3	0.1	1140 "
F	0.14	7.5 "
Ca	6.2	189 "
Mg	2.4	257 "
Na	2.9	1450 "
K	3.9	665 "
Total hardness as $CaCO_3$	42	1329 mg/l
Total chemical content	**155 mg/L**	**5923 mg/L**

Nomenclature:

Salinity range	**EC [µS/cm]**	**TDS [mg/l]**
Fresh	Up to 1,500	Up to 1,000
Brackish	> 1,500 – 15,000	>1,000 – 10,000
Saline	> 15,000	> 10,000

For comparison, seawater has a TDS of 35,000 mg/l.

Canal water and Rain water –

There is no river flowing through the district. A number of artificial drains crisscross the Malwa region, which carry the excess run off water during rains. The Bathinda district has a good network of canals for irrigation and domestic purposes. The main canals in the area which feed the various distributaries and minor canals are the Bathinda branch and Kotla branch canal originated from Sirhind canal. All of which originate from Satluj River. The major Bathinda branch canal traverses whole of the district except the southern and extreme north part of the district. The Southern and south-eastern part of the district is traversed by Kotla branch canal and the extreme north part of the district is covered by Abohar Branch canal. In the Muktsar district, two major canal Sirhind feeder and Sirhind canals are the main source of water supply which is further divided into various distributaries and minors. More than 80% of the area is irrigated by canals and rest is shared by the shallow tubewells with the general depth ranging between 25m and 60m. **The Bathinda district as a whole (~ 95 %) is completely dependant on canal water based schemes for drinking purpose.** The ground water quality of Bathinda district shows that Ground water in more than half of the district area is suitable for drinking as well as for domestic purposes. The villages located on the Northwest part of the district are dependant on Ground Water for drinking purpose. Almost entire northern segment is having a declining water level trend due to heavy withdrawal of ground water for drinking as well as irrigational purposes. **In southwestern parts of the district the water table is rising due to limited/non-extraction of ground water because of its brackish / saline quality and more availability of canal water for domestic and irrigation purposes.**

Characteristics of *Soils in Malwa region* - ***The soils in the district have largely developed on alluvium the material laid by rivers under the dominant influence of climate followed by topography and time. The region has two types of soils, the arid brown soils (desert soil) and siezoram soils. The arid brown soils are calcareous in nature; these soils are imperfectly to moderately drained. The arid brown soils are found in mostly eastern parts. The Sierozem soils are light yellowish brown to pale brown in colour. Soils are calcareous and usually there is accumulation of calcium carbonate in amorphous or concretionary form (kankar). Kankars are frequently observed at a depth of 2-4 ft and even on the surface in the agricultural fields in Baluana and Karangarh Satran villages. The EDXRF analysis of these pieces shows it to be mainly calcium carbonate, iron, strontium and barium.***

Fig. – Kankars found in agriculture fields.

In the Malwa region, we have observed that uranium concentrations in the ground water samples from hand pumps/shallow tubewells are in general high wherever the leftover residue (Total Dissolved Salt) after drying of water is high ~ 2-7 g/litre. See Annexures II and V for elemental analysis of water samples of the region. The ground water is found to be rich in bicarbonates, nitrate, chlorides and bromide anions and calcium, magnesium, potassium, sodium and strontium cations (Table III).

TABLE - Elemental analysis of the samples collected from villages of Bathinda district using EDXRF technique. The analysis was done for the elements in the range Z=19 to Z=47 and Z=78 to Z=92. *Guru Nanak Dev Thermal Power Plant (GNDTPP), National Fertilisers Limited (NFL), Guru HarGobind Thermal Power Plant, Lehra Mohabat (GHGTPP).*

Water sample location	Residue (mg/litre)	Elemental concentration (ppb)				
		U	Mo	Sr	Br	Fe
Bathinda branch canal along GNDTPP	93	<2	<2	103	3	537
Lake water (GNDTPP)	289	<3	23	239	9	1425
Hand Pump, Near ash dykes (GNDTPP)	602	3	9	1024	58	905
Hand pump in between the ash dykes and	108	3	4	268	2	1918
Private Tube well 100 m away from ash	1225	45	152	916	212	1762
Private Tube well 150 m away from ash	491	5	50	255	114	739
Hand pump opposite GNDTPP	247	18	5	1210	16	691
Distributory of Bathinda canal branch near	100	<2	<2	93	8	267
Hand pump near carbon slurry dykes of	985	70	262	757	159	3386
Hand pump near NFL	95	<2	<2	75	<1	122
Hand pump near APEX Carbonics Pvt.	123	<3	8	543	7	370
Hand pump in between GNDTPP and APEX	1693	25	131	1219	399	1090
Hand Pump near NFL township	268	<3	<2	309	<2	604
Tap water at the guest house of NFL	74	<3	<2	59	2	566
Hand pump, Jajjal village	3467	98	27	1650	994	210
Hand pump, Giana village	998	18	40	720	780	140
Hand pump, Malkana village	1242	6	5	970	1248	110
Hand pump, bus stand, Gill Patti village	3130	36	27	2428	1085	<20
Private Tube well , Gurudwara, Gill Patti	1000	22	2	793	198	<10
Hand Pump, Railways crossing,	2552	78	45	3044	1043	<20
Handpump, Main road side, Baluana	4750	212	-	6165	4432	1140
Hand Pump water, at G.T. Road opposite	694	14	15	842	241	<10
Hand pump near main gate of GHTPP	656	19	47	1061	201	916
Hand pump near wagon tripler near GHTPP	236	22	5	822	58	456
Hand pump near ash dykes of GHTPP	320	11	5	280	45	254
Hand Pump at G.T. Road near Lehra	230	<3	54	144	7	667

Other elements Ca, Ni, Cu, Zn, As, Rb, Pb were also observed at some places. The values of As and Pb are not alarming.

Ref- [M. Alrakabi et al, J. Radioanalytical and radiochemistry (2012).]

<u>Source of Chemical pollution of ground water:</u>

Plant root respiration and microbial oxidation of organic matter in soils produce carbon dioxide (CO_2), resulting in CO_2 partial pressures (P_{CO_2}) in the soil zone that are greater than atmospheric pressure. Water percolating through the soil equilibrates with the soil atmosphere by dissolving CO_2 (g) to form carbonic acid. The carbonic acid reacts with the calcium carbonates (calcareous soil) to form bicarbonate which is a well-known efficient leaching agent for uranium from soils and sediments. Formation of bicarbonate while water is percolating through soil enhances its leaching efficiency. Carbonic acid participates in mineral weathering reactions that increase Dissolved Inorganic Carbon (DIC) concentrations in water, primarily in the form of bicarbonate. Humic and fulvic acids are also formed by the microbial degradation of dead plant matter. They are also very good chelators for metal ions. There is continuous addition of chemicals like bicarbonates and nitrates resulting from decay of the agricultural crop waste, which is leading to an alarming situation of alkaline contents in the ground water. Further, ground water logging and nearly disrupted cycle of water charging cycle of ground water in the region is responsible for the increased concentrations of chemicals and uranium in the ground water. Excessive use of canal water for irrigation of agricultural land has led to a situation where ground water at many locations is immobile and there is hardly any removal of ground water. In the waterlogged areas where the water table is few meters it also becomes easier to leach the salts from the ground soil and get added to ground water.

The water table is rising due to (i) limited/non-extraction of ground water because of its brackish/saline quality and (ii) more availability of canal water for domestic and irrigation purposes. It is worth mentioning that calcium bicarbonate exists only in aqueous form and on drying it converts to calcium carbonate. Indeed calcium carbonate kankars **frequently observed at a depth of 2-4 feet and even on the surface in the agricultural fields at Karangarh Satran and Baluana. It is worth pointing out that uranium concentration in ground water have been reported to be high at these locations [Annexure V].**

It is worth mentioning that that the ground water is in continuous cycle at other locations in Punjab due to its excessive use and soils are not calcareous.

High ground water table due to water logging and formation of Bicarbonates in Malwa region due to percolation of carbonic water through soils rich in calcium carbonate content, leads to many fold enhancement in its efficiency for leaching uranium from soils. Indeed, the other important factor in the Malwa region is the immobile ground water.

It is worth mentioning that farmers in the Malwa region use minimum water for irrigation from tube wells because of the availability of canal water and there is hardly any use of the ground water. This adds to the problem of Water logging, and salinity. This makes the ground water stale. More and more salts are added to ground water through irrigation. Only the water is evaporated and salts are left behind. It is to be noted that most of the soils of Malwa region were having high salt content even before irrigation began in this region.

Uranium contamination have also been observed in groundwater in several parts of the eastern San Joaquin Valley (ESJV) [Annexure III A], which is a part of the Central Valley, California, US. The Central Valley, California, US is one of the most productive agricultural regions in the world, with a cash value of more than $20 billion in 2007 [Fig. 1]. Seven counties within the Central Valley are among the top 10 counties in the United States for agricultural products sold. It has led to the removal of at least 23 public-supply wells (PSWs) from service within the last 20 years in the ESJV. Strong correlations between U and bicarbonate suggest that U is leached from shallow sediments by high bicarbonate water, consistent with findings of previous work in Modesto, California. Because the developed portion of the Eastern San Joaquin Valley (ESJV) aquifer system is largely oxic, uranium is expected to remain mobile in groundwater and therefore poses a significant threat to the long-term sustainability of groundwater as a potable source (see Annexure III A and IV).

(B) CONTRIBUTION OF FERTISERS TO URANIUM CONTAMINATION –

***Use of agricultural additives* - Fertilizers can also contain elevated levels of uranium as their phosphorus component is derived from phosphate rock (uranium concentration ~100 ppm) [Annexure III B]. Regular use of phosphate fertilizer in waterlogged and calcareous soil conditions can also contribute significantly to contamination of ground water.**

The total fertilizer consumption in India is ~ 27 million nutrient tonnes. About 20-25 % of the total consumption for nitrogen and phosphorus nutrients depends upon imports from USA, Jordan, China, Russia, Morocco, Israel, Lithuania, Egypt **[Annexure III C]**.

Punjab consumes ~ 4.15 million MTs of fertilizers out of which 0.90 million MTs is DiAmmonium Phosphate (DAP). Other fertilizers (MOP 60 % K_2O), NPK, Single superphosphate (SSP) and Triple superphosphate (TSP) are used in small amounts. SuperPhosphate (SSP) contains only low levels of uranium as major portion of uranium goes with the phosphoric acid byproduct. However, triple superphosphate and DAP can contain higher levels of uranium depending upon whether the quality of phosphoric acid used in manufacturing of the fertilizer **[Annexure III B]**.

Consumption of Fertilisers in Punjab (2010)

Fertiliser	Kharif (APRIL-SEPT)	Rabi (OCT-MARCH)	Total (MTs)
UREA [$CO(NH_2)_2$]	1248277	1432408	2,680,685
DAP	378460	483209	861,669
DAP Lite	0	0	0
MAP	5426	256	5682
MAP Lite	0	0	0
TSP	937	264	1201
SSP	26246	23610	49856
CAN	703	1126	1829
A/S	4560	1767	6327
MOP	59864	36714	96578
NPK (12:32:16)	45732	12664	59396
NPK (20:20:0)	5162	7264	12426
NPK (10:26:26)	1315	7263	8578
NPK (15:15:15)	2584	2384	4968
NPK (13:33:0)	0	0	0

DAP fertilizer is the most popular in Punjab, it is chlorine and nitrate free NP fertilizer.

We have performed elemental analysis of about 40 fertilizer samples of DAP fertilizers from the various regions in Punjab. About 30 % of the samples showed high concentration of uranium 80-120 ppm. Rest 70 % show it to be generally in the range 5-40 ppm, which are produced using phosphoric acid after uranium extraction.

Reference – Information given by a farmer from Malkana village in Bathinda.

	Fertiliser used per Killa	Fertiliser used per hectare
Wheat Rabi (OCT-MARCH)	50 kg DAP 100 kg Urea 5 kg Zn	125 kg DAP 250 kg Urea 12.5 kg Zn
NERMA Kharif (APRIL-SEPT)	25 kg DAP 100 kg Urea 25 kg MOP 25 kg SSP 5 kg Zn 2 kg Sulphur	62.5 kg DAP 250 kg Urea 62.5 kg MOP 62.5 kg SSP 12.5 kg Zn 5 kg Sulphur
1 kanal = 505 sq m; 1 killa = 8 kanal = 4000 sq m; 1 hectare = 2.5 killa		

Total DAP used per hectare ~ 200 kg/hectare.

For the first order calculations, Taking 50 % of samples contain high uranium content ~ 100 ppm. It is safe to take that 100 kg of DAP fertilizer is used per hectare with 100 ppm of uranium level.

Taking ~ 100 ppm level of uranium in the DAP fertiliser, 100 kg of phosphate fertilizer contains ~ (100 x 1000 x 100)/1000000 g = 10 g of uranium. This 10 g of uranium is spread over 1 hectare field with 8 inches of active soil layer (density ~ 1.2 g/cm^3) thickness contributes = 10g /[(100x100x100x100 cm^2 x 20 cm) x(1.2 g/cm^3)] ~ 4 ppb only which is about 10,000 times smaller as compared to normally available uranium content in soils as 3-4 ppm. This amounts to ~ 4 ppb of uranium is being added to top soil layer every year. It has to percolate through 5-10 m of soil layer to reach to water. It is worth noting that the shallowest observed ground water level is ~ 3 m near the Baluana village. Even if we take gradient such that 1 % is reaching the ground water. It means 0.1 g of uranium will reach the 1 hectare area of ground water. Taking with 10 ft water layer (density ~ 1.0 g/cm^3) thickness contributes = 0.1g /[(100x100x100x100 cm^2 x 30 x 10 cm) x (1.0 g/cm^3)] ~ 0.003 ppb per year only compared to available content >10 ppb in water at shallowest ground water regions. Therefore, contribution of uranium contamination to ground water via fertilizers is not favored. However, fertilizers used may contribute to overall chemicals in ground water.

Another point favouring the insignificant contribution of phosphate fertilizers that concentration of phosphate ions in the ground water (mean value 1.3 x 10^{-7} mol/L) is even lower than the uranium concentration (mean value 4.2 x 10^{-7} mol/L). Indeed phosphorus is mainly taken up by plants being an essential nutrient. Otherwise If we do not take the mobility factor in to consideration, the uranium concentration (~100 ppm) should have been 10,000 times smaller than the phosphate ion concentration in water.

ION/ELEMENT	Mean concentration
U (mol/L)	4.2 x 10^{-7}
Ca (mol/L)	1.78 x 10^{-3}
Mg (mol/L)	4 x 10^{-3}
Na (mol/L)	2.03 x 10^{-2}
K (mol/L)	1.03 x 10^{-3}
Cl^- (mol/L)	9.16 x 10^{-3}
HCO_3^{-1} (mol/L)	7.12 x 10^{-3}
CO_3^{-2} (mol/L)	1.51 x 10^{-3}
SO_4^{-2} (mol/L)	4.2 x 10^{-3}
NO_3^{-1} (mol/L)	1.38 x 10^{-3}
PO_4^{-3} (mol/L)	1.32 x 10^{-7}
F^{-1} (mol/L)	1.52 x 10^{-5}

Ref - [Ajay Kumar et al, Journal of Geology and Mining Research 3 (5) (2011) 137]

Also, from the recent investigations of degraded quality of groundwater within the Eastern San Joaquin Valley (ESJV), which is part of the Central valley, California, US [Annexure III A], it is concluded that uranium is naturally abundant in soils and aquifer sediments in the ESJV.

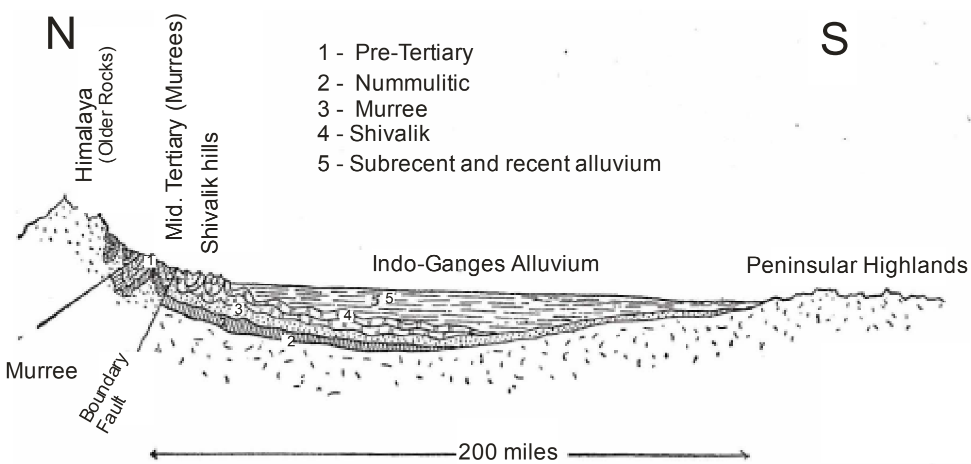
The uranium contaminants in groundwater are not linked to patterns of fertilizer and pesticide use and their rate of application at the surface.

(C) Existence of Tethys Sea

Tethys sea is a former tropical body of salt water that separated the supercontinent of Laurasia in the north from Gondwana in the south during much of the Mesozoic Era (251 to 65.5 million years ago). Laurasia consisted of the present day North America and the portion of Eurasia north of the Alpine-Himalayan mountain ranges, and Gondwana consisted of present-day South America, Africa, peninsular India, Australia, Antarctica, and those Eurasian regions south of the Alpine-Himalayan chain. **The continental collisions that eventually eliminated Tethys sea and resulted in creation of the modern Alpine-Himalayan ranges**, which extend from Spain (the Pyrenees) and northwest Africa (the Atlas) along the northern margin of the Mediterranean Sea (the Alps and Carpathians) into southern Asia (the Himalayas) and then to Indonesia. Remnants of the Tethys sea remain existss today as the Mediterranean, Black, Caspian, and Aral seas. **According to the some of the soil experts, the presence of salinity is attributed to existence of Tethys Sea.** The dominant sedimentary faces of Tethys are limestones which are often very rich in fossils, indicating an abundant and diverse tropical marine fauna. Reefs are also common. Tethyan deposits can be found especially in the Alpine and Himalayan regions and Myanmar and Indonesia. It is important to point out that general concentration of Uranium is ~ 200 μg/L in the ground waters of Malwa Region and the TDS is ~2 g/L, i.e., the ratio is ~ 10^{-4}, which is much higher than that for the sea water ~ 10^{-7} with TDS of ~35 g/L. It does not favor the Tethys Sea water to be the source of the present ground water. Tethyan deposits are not observed in geological surveys in the present subsoil system in the southwest Punjab. Sediments which form the aquifer system in southwest Punjab belong to Quaternary period during which alluvium was deposited by rivers draining the area. The soils in the area are also developed on alluvium. Some of the excerpts from the Text book "Geology of India" (The English Language Book Society, Macmillian & Co Ltd., London, Sixth edition 1966, First edition 1919) written by the famous Indian geologist D.N. Wadia, are given below.

1. **Geology of great plains of North India – the region which separates the Peninsula from extra peninsular regions:** The whole expanse of the plains of North India from one end to another is formed with unvarying monotony of Pleistocene and sub-recent alluvial deposits of the rivers of the Indo-Gangetic system (see figure below). Alluvial deposits have completely shrouded the old land-surface to a depth of thousands of feet. The lands in front of the newly-upheaved mountains formed a depression, which was rapidly being filled up by the waste of the highlands. The area of these alluvial plains is 300,000 square miles covering the largest portion of Sind, Northern Rajputana, almost whole of Punjab, Uttar Pradesh, Bihar, Bengal and half of Assam (width 300 miles in west to 90 miles in

east). The exact depth of the alluvium has not been ascertained, but recent gravity, magnetic and seismic explorations shows that it is variable, from less than 1000 m to over 2000 m. The depth is not even - it is greater in the northern than in the southern sector. The depth of alluvium is at a maximum between Delhi and the Rajmahal hills, and it is shallow in Rajputana and and between Rajmahal and Assam. The floor of the Gangetic trough is thus not an even plane, but is corrugated by inequalities and buried ridges. Two such ridges have been indicated by geodetic surveys: an upwarp of the archaen rocks in structural prolongation with the Aravilli axis, between Delhi and Hardwar; and a ridge, submerged under the Punjab alluvium, striking north-west from Delhi to the salt-range.



Diagrammic section across the Indo-Gangetic synclinorium

2. In the drier parts of the alluvial plains, **a peculiar saline efforescencent product – reh or Kalar** – is found covering the surface and destroying in a great measure its agricultural fertility. The saline efflorescence is composed of a mixture of sodium carbonate, sulphate and chloride, together with varying proportions of calcium and magnesium salts, and found on the surfaces of alluvial soils in the drier districts of Gangetic plains. Some soils are so much impregnated with these salts that they are rendered quite unfit for cultivation. The cause of this impregnation of the salts in the soil and subsoil is that the rivers draining the mountains carry with them a certain proportion of chemically dissolved matter, besides that held in mechanical suspension in their waters. In the plains-track of the rivers, these salts find their way, by percolation, into subsoil, saturating it up to certain level. In many parts of the hot alluvial plains, which have got no underground drainage of water, the salts go on accumulating and in course of time become concentrated, forming new combinations by interaction between previously existing salts. Rain water percolating downwards, dissolves the more soluble of these salts and brings them back to the surface during the summer by capillary action, where they form a white efflorescent crust.

3. ***The thickly populated agricultural province with alternately warm and humid climate, offers the most favourable conditions for the accumulation of Nitre in the subsoil.*** "The nitre-impregnated soils of Punjab and Bihar are a variant of the Kalar or reh soils, the difference being that the salt (potassium nitrate) is introduced into the soil cap from above by activities of man in densely populated cultivated districts under a warm humid climate. The large quantities of animal and vegetable refuse gathered round the agricultural villages are decomposed into ammonia and other nitrogenous substances; these are acted upon by certain kinds of nitrifying bacteria in the damp hot weather, with the result that at first nitrous and then nitric acid is produced in the soil. This nitric acid readily acts upon the salts of potassium with which the soil is impregnated on account of the large quantities of wood and dung ashes being constantly heaped by villagers around their habitations."

4. "Gravel and sand become scarcer as the distance from the hills increases. At some depth from the surface there occur a few beds of compact sands and even gravely conglomerates. A characteristic of the clayley part of the alluvial plains, particularly in the older parts of the deposits, is the abundant dissemination of impure **calcarereous matter in the form of irregular concentrations – kankar**. The formation of Kankar concentrations is due to segregation of the calcareous material of alluvial deposits into the lumps or nodules. **Such Kankars are frequently visible even on surface in the fields of Baluana and Karamgarh Satran villages of Bhatinda District."**

5. An old river bed, the Hakra, Sotra (ghaggar), or Warhind, more than 600 miles in length , the channel of a lost river, is traceable from **Ambala near the foot of Himalayas through Bhatinda, Bikaner and Bhawalpur to Sind**. It is probably the old bed of Saraswati (the Jamuna when it was an affluent of the Indus) at a time when it and the sutlej flowed independently of the Indus to the sea, i.e., Runn of Cutch. The present dry river bed to the east of Sind, known as eastern Nara, is either the old bed of the Indus or, more probably, the channel of the Sind portion of the Sutlej after the river has deserted it.

   The reclaiming of these barren Kalar lands into cultivable soils by the removal of these salts would add millions of acres to the agricultural area of India, and bring back under cultivation what are now altogether sterile uninhabited districts. *The carbonate and sulphate of sodium, the chief constituents of Reh, were formerly used as a source of salts of alkalis, and were produced in some quantity for local industry.*

(D) FLYASH FROM THERMAL POWER PLANTS -

Indeed there are two coal-fired power stations in the Bathinda district, the first power plant near the city was commissioned in 1974, followed by another in nearby Lehra Mohabat in 1998. In the east Punjab, there is a third one at Rupnagar, which was commissioned in 1984. **So far, no**

such uranium contamination problems in ground water or increased defective birth rates/cancer have been reported from the villages neighbouring the Rupnagar power plant (capacity ~1200 MW/year). At present, the total installed capacity in Punjab state is about 2500 MW/year of thermal power with total consumption of coal about 120 Lac MT/year. The average fly ash yield is approximately 35 weight percent. Therefore, the concentration of most radioactive elements in solid combustion wastes will be about 3 times the concentration in the original coal.

Recently, we have taken up water studies from the two thermal Power Plants and National Fertilisers Limited, and the surrounding regions in the Bathinda District. Coal and flyash samples were also analysed.

BRIEF DESCRIPTION OF METHODOLOGY FOR ANALYSING FLY ASH AND CONCLUSION

500 ml of each of the water samples were dried at 60^o-80^o in an oven. The leftover residue of water, coal and flyash samples were analyzed for elements using Energy-dispersive X-ray fluorescence technique. The set up consisted of Mo-anode X-ray tube and Power supply (Panalytical, The Netherlands). A combination of selective absorbers of Zn, Sr, and Y was used in the incident beam for improving the detection limit for Uranium and removing the Mo K X-rays from the incident beam. Fundamental parameter approach was used for calculations of elemental concentrations. For basic calibration, standards of various elements obtained from MICROMATTER INC., USA were used. **The results are given in Tables I and II (Annexure V).** Our studies revealed that

1. None of the water samples the flyash reserves at the Guru Nanak Dev Thermal Power (GNDTP) plant shows high concentrations of uranium. Therefore, it cannot result in higher uranium concentrations observed in enormous amount of ground water
   Flyash cannot not be the potential source contributing to uranium in ground water.

2. **The uranium concentration of fly ash (< 2 ppm) from the thermal power plants is well below the range found in some granitic rocks, phosphate rocks, and shales (10-85 ppm) [13] and even soil samples from Punjab (~ 3 ppm).**

The fly ash includes substantial amounts of silicon dioxide (~30 %) and calcium oxide (~ 30 %), Alumina (~3 %) and ferric oxide (~6 %). Depending upon the source and makeup of the coal being burnt, the components of fly ash vary considerably. Other elements like Ti (~50 ppm), V (~20 ppm), Mn (~50 ppm), Cu (~30 ppm), Zn (~30 ppm), Ga (~30 ppm), As (~30 ppm), Rb (~20 ppm), Sr (~100 ppm), Y (~ 80 ppm), Zr (~300 ppm), Nb (~20 ppm), Mo (~10 ppm), Pb (~20 ppm) and Th (~7 ppm), are also present in significantly high concentrations compared to uranium (< 2 ppm) [13,14]. **The uranium has been observed to be uniformly distributed throughout the glassy silica particles, which cannot be easily weathered out by normal acids or alkalis. Uranium in the flyash is generally in its oxide form which is not soluble in water [Fig.2].** The apparent absence of abundant, surface bound, relatively available uranium suggests that the rate of release of uranium is dominantly controlled by the relatively slow weathering0 of host ash particles.

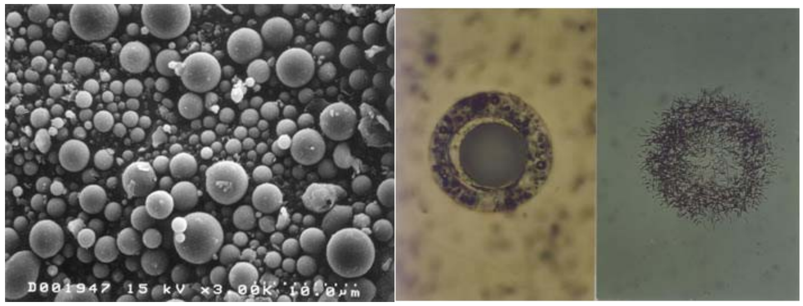


Fig. 2. Scanning electron microscope picture (left) of flyash. Photograph (middle) of a hollow glassy fly ash particle (0.01 cm diameter) and its fission track radiograph (right). Uranium distribution and concentration are indicated by the location and density of dark linear fission tracks in the radiograph. [USGS Factsheet http://pubs.usgs.gov/fs163-97/FS-163-97.html]

3. Uranium in the Ground waters, i.e., water taken from the handpumps or tube wells in vicinity and from the thermal power plant, are observed with concentrations range similar to that observed in the Giana, Malkana regions far away (about 20 km) from the Thermal power Plants. Even higher uranium concentrations have been observed in the ground water in Karamgarh Sattran and Baluana, where very high TDS more than 5 g/L has been observed.
4. To look for the leachate elements from flyash and coal samples, simple treatment with water and mechanical action using mixer revealed leachates Cu, Y, Mo. The samples were also treated with different acids, viz., hydrochloric acid, nitric acid and citric acid. Some of the leachate elements observed in the filtered solution were: Fe, Cu, Zn, As, Se, Pb, Sr, Y, Zr, Mo, Th. Further investigations being pursued in this direction. Recent studies with bicarbonate solution has shown molybdenum to be the dominant leaching element followed by Selenium. Molybdenum is also observed with concentration 200-300 ppb in the standing water on flyash dykes, even though its concentration in flyash sample is ~10 ppm. Molybdenum is also observed in the ground water samples of Bhatinda with lesser concentrations, but selenium is not observed. Otherwise, molybdenum is not known to be harmful for consumption. Uranium is not observed in the leached solution. As observed by others that uranium is generally embedded in the silica (glass like particles), which cannot be leached with any normal chemicals/acids.

5. **Molybdenum is observed in the GNDTP region near Bathinda city but not in Lehra Mohhabat. In some of the samples in Lehra Mohabat, even Fe is not observed, which is present in the flyash to an extent of ~3 %. Same coal is used in the thermal power plants at the two places in Bathinda district.**

The contamination of the ground waters of the whole region to the high concentration levels ~10-100 μg/L due to flyash appears to be unrealistic.

In the recently concluded workshop on "INCIDENCE OF CANCER IN PUNJAB" conducted by Punjab Pollution Control Board – Er. G.S. Dhillon (Retd. Chief Engineer) and Er. Kalsi (Expert from Oil and Natural Gas Agency) commented:

"Flyash samples analysed by some other groups have shown higher values of uranium ~ 8 ppm rather than less than 2 ppm as measured by Panjab University group. The rain water with pH values deviated from 7 leaches uranium from the flyash and is responsible for uranium in ground waters of Bhatinda." They insisted upon flyash to be the potential source of uranium contamination of ground water. Perhaps, they also argued that uranium is sticking on the surface of silica beads rather than being embedded in the silica beads of the flyash (as shown in Fig. 2).

Indeed our data point on flyash elemental analysis is not based on exhaustive sampling procedures with collection period spread over significant time periods. Though ~ 8 ppm value seems too high for Indian coal - We avoid commenting on variation from sample to sample. Even taking uranium concentration to be 8-10 ppm or even higher does not affect none of the above discussed points and do not favour the flyash as source of uranium in ground water.

More than 90 % flyash is removed from the site and is used by the Cement industry. Where are the other elements present in the flyash with much higher concentration than uranium???

In Bhatinda district: Normal Annual Rainfall : 408 mm

Normal monsoon Rainfall : 335 mm with Normal Rain days : 20

First of all, 335 mm (~ 1ft) of rain spread over 20 days, when falls on a huge mounds of flyash. It will be able to wet at the most 1m of top layer that too under extreme case of ignoring evaporation of water.

Just an attempt to calculate the amount of water under the Bathinda region (50 km x 50 km) 50,000 m x 50,000 m area with a layer of shallow water of average thickness 3 m (~10 ft), i.e., 7500, 000, 000 cubic meter = 7500, 000, 000, 000 Litres of ground water. For a uranium concentration of 20 microg/Litre, one requires ($75 \times 10^{11} \times 20 \times 10^{-6} \times 10^{-3}$ kg) 150,000 kg of uranium. Considering simple calculations on flyash with 10 ppm of uranium. To get 150,000 kg of uranium, the corresponding flyash weight will be ~[$150{,}000/(10 \times 10^{-6})$] kg or 15 million ton, i.e., some activity around the thermal power plant should dissolve 15 million ton of flyash. At least similar orders of magnitude ~ millions of tons of concentrated acid is required. This will release other elements present in higher concentrations, e.g., ~ half a million ton of iron. To achieve uranium contamination at the existing levels in the whole region it requires mammoth effort at the thermal power plant flyash dykes. It is further added that there are no big industrial units in Malwa region which can discharge such water with pH **value considerably different from 7.**

Above all, concentration of uranium has to be high on the flyash dykes and the ground water in the region surrounding thermal power plant. Pozzolanic properties of the produced flyash [11] collected in the form of huge mounds above the ground soils will hinder any seepage in to the ground water. At present, most of the flyash from the Bhatinda Thermal Power plant is used for making cement by Ambuja cements. No unusual numbers of Cancer and autism cases linked with uranium from flyash have been reported from any where in the world.

(E) INDUSTRIAL WASTE DRAINS FALLING INTO SUTLEJ RIVER:

Our studies on water samples from the Budha nullah, Ludhiana and Drains in Phagwara also rule out man-made uranium contamination of ground water/river water (see TABLES II and III) (Annexure V).

(F) HOT GRANITE ROCKS DERIVATIVES FROM TOSHAM HILLS ARE CONTAMINATING GROUND WATER OF PANJAB

Some of the experts link the high concentration of uranium in ground water with **Tosham hills in Haryana** [5] where granite rocks are found which have high radioactivity (double than th normal value). Granites are igneous rocks and generally have uranium concentrations ~ 4 ppm. Weathering of these rocks is rather difficult. The underground water source is large. Assume that only the shallow layers of water are contaminated, which is generally true. Just an attempt to calculate the amount of water under the Bathinda region (50 km x 50 km) 50,000 m x 50,000 m area with a layer of shallow water of average thickness 3 m (~10 ft), i.e., 7500, 000, 000 cubic meter = 7500, 000, 000, 000 Litres of ground water. For a uranium concentration of 20 microg/Litre, one requires ($75 \times 10^{11} \times 20 \times 10^{-6} \times 10^{-3}$ kg) 150,000 kg of uranium. Considering simple calculations on rocks with 10 ppm of uranium and density ~ 2.5 g/cm^3. To get 150,000 kg of uranium, the corresponding rocks weight will be ~[$150,000 \times 10^6$ / 10 kg] or a volume of [$150,000 \times 10^5 \times 10^3/(2.5 \times 10^6)$ m^3 = 6000,000 m^3), i.e., a rock of size 1 km x 1km x 6 m. Further on, the concentration of uranium in ground water at the source, i.e., Tosham hills, should have been enormously high. One has to look for geological symptoms indicating the drastic change of pH value of water which lead to weathering of underground rocks. Certainly the present conditions do not favour any such possibility. Also, there are no reports of high uranium contaminations in ground waters of the in-between districts, Hisar and Fetahabad of the neighbouring Haryana state. Above all, the geological predictions are beyond simple calculations. Again, this possibility has to be linked with the direction of flow of underground water from Tosham to south west Punjab.

(G) Uranium used in Wars –

Some leading Newspaper and News Channels have created panic in the minds of people by stating that uranium has reached in ground waters in Malwa/Bathinda region by winds carrying depleted uranium of Iraq and Afgan wars, where nuclear war heads might have been used extensively. The use of such war heads have not been reported by any independent news channel across the Globe. Moreover if these unreasonable claims are to be believed, then the levels of uranium on surface and sub surface soils have to be excessively high to justify the present level from ground waters. We fail to understand how atmospheric winds reached only this region, leaving in between locations untouched.

Other FACTS RELATED TO GROUND WATER IN MALWA REGION

(A) Ground Water and Drinking water in Malwa region

(i) Strontium and Bromide ions in canal based water supply are observed with low concentrations ~ 100 μg/L and ~10 μg/L. Strontium and Bromide ions in handpump water are observed in general higher concentrations up to 1650 μg/L and 1100 μg/L (Annexure V). It is suggested that the water purification methods based on ozonation or chlorination or ultra violet radiation should be discouraged with the water supplies containing higher amounts of bromide ions. These purification methods convert bromide ions present in water to bromate ions. Bromate ions is carcinogenic with the permissible levels of just 10 ppb. These methods can be employed where bromide ions are not significantly present in water. In December 2007, Los Angeles Department of Water and Power (US) drained 600 million gallons of treated water due to bromate contamination, where a combination of bromide from well water, chlorine and sunlight resulted in bromate ions. Ultraviolet light is generally used as disinfection in various water purifiers. Chemical speciation of bromine in water is required as bromate ions are known to be very harmful. Arsenic concentrations in the analysed ground water samples are found to be below the permissible limit of 10 ppb.

(ii) Most of the drinking water schemes in the Malwa region are based on canal water. The uranium concentration in the canal-based drinking water supply schemes is below 5 *ppb*. For the Reverse Osmosis (RO) based water supply, the Total Dissolved Salt (TDS) residue level is observed to be below 20 mg/L and uranium to the level of below 1 ppb. Indeed, uranium concentrations up to few hundred ppb have been observed the ground waters (shallow water) at certain places in the Malwa Region, which are well above the Atomic Energy Regulatory Board (AERB), India, permissible levels (~60 ppb). But these ground water samples with high concentration of uranium (30 ppb - 700 ppb) are in general found have large amount of residue (Total Dissolved Salt - bicarbonates, chlorides, nitrates) ranging 2-7 g/litre. The water with high chemicals is not even drinkable due to its bad taste. It is further added that permissible limits are generally not sharply defined and different regulatory bodies have recommended different permissible limits. Further, chemical speciation of various elements is an important aspect, which needs to be considered.

SUMMARY - Source of uranium in Ground Water

It is concluded that uranium observed in the ground water in the Malwa region is not due to flyash from the thermal power plants in the region. Other manmade possibilities like uranium from industrial waste in Budha Nala in Ludhiana, which adds to Sutlej river, and depleted uranium from wars have been ruled out. In contrast to the agricultural additives like fertilizers or pesticides which themselves constitute a trace component in agricultural fields, uranium is naturally abundant in general soils and aquifer sediments and hence agricultural additives cannot be the source of uranium in ground water.

According to the soil experts from Panjab Agriculture University, presence of salinity is attributed to the existence of Tethys Sea (ocean, Mesozoic Era) in this region before the birth of Himalayas. **It is important to mention that Tethyan deposits are not observed in geological surveys in the present subsoil system in the southwest Punjab. Other point is that in sea water general concentration of Uranium is only 3.3 μg/L and TDS is about 35 g/L, i.e., the ratio is ~ 10^7. While that observed in the ground waters of Malwa Region, the TDS is > 2g/L and the uranium concentration ~ 200 μg/L, i.e., the ratio is ~10^4, which is much higher than the sea water. This means contribution from other sources is significant.**

Water logging, calcareous soils, salinity and availability of excessive canal water for irrigation to the extent that farmers do not switch on the tube wells – there is hardly any use of the ground water, which is becoming stale. More and more salts are added to ground water through irrigation. It is to be noted that most of salt in the soils of Malwa region was there even before irrigation began.

In the Malwa region, it is observed that concentration of uranium in the ground water samples from hand pumps/shallow tubewells is in general high wherever the TDS (Total Dissolved Salt) or the leftover residue after drying of water is high ~ 2-7 gms/litre. The ground water is found to be rich in bicarbonates, nitrate, chlorides and bromide anions and calcium, magnesium, potassium, sodium and strontium cations. **The region is known to be saline even before - due to existence of sea before the Himalayas came in to existence. New irrigation policies using uncemented canals introduced in first half of 20th century are the source of problem.** Plant root respiration and microbial oxidation of organic matter in soils produce carbon dioxide (CO_2), resulting in CO_2 partial pressures (Pco_2) in the soil zone that are greater than atmospheric pressure. Water percolating through the soil equilibrates with the soil atmosphere by dissolving CO_2 (gas) to form carbonic acid. The carbonic acid reacts with the calcium carbonates to form calcium bicarbonate which is an efficient leaching agent for uranium from soils. Soils in the region are calcareous and usually there is accumulation of calcium carbonate in amorphous or concretionary form (kankar). Formation of bicarbonate while water is percolating through soil enhances its efficiency for uranium leaching. There is continuous addition of chemicals like bicarbonates and nitrates resulting from decay of the agricultural crop waste, which is leading to an alarming situation of alkaline contents in the ground water. **Bicarbonates are well known for their effectiveness to leach uranium from soils and sediments. Other chemicals like humic acids formed due to agricultural product decay are also known for leaching metals from soils.** Further, ground water logging, **i.e., continuous touching of water level with the upper soils enhances the leaching of chemicals to the ground water;** and nearly disrupted cycle of water charging of ground water in the region is responsible for the increased concentrations of chemicals and uranium in the ground water. Excessive use of canal water for irrigation of agricultural land has led to a situation where ground water at many locations has become immobile and there is hardly any removal of ground water. The water table is rising due to (i) limited/non-extraction of ground water because of its brackish/saline quality and (ii) more availability of canal water for domestic and irrigation purposes. It is worth mentioning that calcium bicarbonate exists only in aqueous form and on drying it converts to calcium carbonate. Indeed calcium carbonate kankars frequently observed at a depth of 2-4 ft and even on the surface in the agricultural fields, e.g., in Karamgarh Satran and Baluana.

Although excessive bicarbonates do exist in many parts of India like Faridabad, and water table is reasonably low and there is excessive use of ground water. The formation of Bicarbonates in the waterlogged Malwa region due to percolation of carbonic water through calcareous soils rich in calcium carbonate content, leads to many fold enhancement in its leaching efficiency for uranium from soils. Indeed, the other important factor in Malwa region is the immobile ground water.

(C) Remediation measures for Drinking Water

(i) Simple regulations for residents especially in the Malwa region :

" Do not drink water, if you find it gives lot of residue". The other method to check is - put 2-3 drops water on flat glass, let it dry and check the amount of residue. The leftover residue mark on the glass must not be clearly visible.

(ii) Punjab Government is advised for canal based drinking water supply in the whole Punjab region on priority basis. On average 5 litres/person per day should be accessible within 50 m of residence.

(iii) Government be requested to provide subsidy to the residents of Malwa region, wherever the drinking water supply schemes are not canal based. The available Water purifiers like manual RO's, Pureit or from TATAs can be redesigned by removing the containers at the inlet and outlet – it will reduce cost to below Rs. 500. These must be used by the people with canal water stored in Diggies. The canal water stored in cemented wells (Diggie) for consumption by a group of families must be regularly cleaned and treated and covered by the Government/Panchayat agencies. Date on which the well is cleaned and next date when it is to be cleaned should be mentioned on the board fixed at the well.

(iii) **No untreated industrial waste from any drain be added to Sutlej river and its canals. The city producing treated water from treatment plant should be burden of city to use it for other purposes, it should not be drained in our canals/rivers like satluj. This will make the people of the city more aware and responsible about the environment.**

SECTION III

A. WATERLOGGING IN MALWA REGION OF PUNJAB STATE IN INDIA

During the last decade, the worse example of agriculture based pollution came to light in the Malwa region of Punjab state, when excessive amount of total dissolved salts (TDS) was reported in the ground waters of the region. It is so saline that it used for cannot used for drinking or even for irrigation purpose.

The established sub surface water gradient is directed from northeast to southwest which leads to rise in the water table and salinity in the districts of Bathinda, Ferozepur, Muktsar, Sangrur, and Faridkot. It is to be noted that most of the soils of Malwa region were having high salt content even before irrigation began in this region. Ground water level in most of the region is shallow and soils in the region are calcareous. Extensive irrigation and drinking water supply schemes in the Malwa region are mainly based on canals and there is minimal use of the ground water.

Agrochemical processes are responsible for producing chemicals - Irrigation water percolating through soil dissolves carbon dioxide gas produced at high pressures from the plant root respiration and the microbial oxidation of the agricultural matter. The resulting carbonic acid reacts with the insoluble calcium carbonate to produce soluble bicarbonate, which leaches compounds of various metals including uranium from soils and adds it to the shallow ground water.

Fertilizers used also add to the chemical contamination.

Total dissolved salts (TDS) level is continuously increasing and even exceeded the permissible limit ~ 2 g/L for the drained waste water from an industrial. It mainly contains bicarbonates, nitrate, chlorides, bromine based anions; calcium, magnesium, potassium, sodium and strontium cations.

***Irrigation using external source other than rain water, e.g., canal water* tends to increase gradually the salinity levels in soil water, surface water systems and/or aquifers**. This is because the crops transpire almost pure water, which means that applied irrigation leaves a residue of dissolved substances. The effects are most pronounced under arid conditions. The dissolved solutes remain behind in the non-evaporated water increasing the TDS content. [**Important points – In actual practice, all the waters contain small or large amounts of salts. For example, the river contain 150 to 250 mg/L of salts at different times of the year. The saline ground water in Malwa region contains few g/L of salts. Only the rain water does not contain salts.]**

It is worth mentioning that farmers in the Malwa region use minimum water for irrigation from tube wells because of the availability of canal water and there is hardly any use of the ground water. This makes the ground water stale with ever increasing salinity. The other regions of Punjab are safe from this problem due to excessive depletion of ground water using tubewells for rice cultivation.

Water-logging induced salinization occurs in areas with shallow groundwater tables and high evaporation rates. In the waterlogged areas where the water table is few meters, water rises by capillary action and evaporates leaving salts contained in it at the surface. These will be leached down whenever excessive irrigation is there on the top surface. Repetition of this process adds to salinity of ground water. It may be added that large capillary action helps in loss of water by evaporation. Reducing of salinization is done by either increasing the groundwater table depth or decreasing the evaporation rate or a combination of both.

If the ground water table is few tens of meters deep, it will take few tens of years of agricultural activity to make it unusable. To extend the period further, excessive usage of ground water and direct harvesting by rain water is required. One can use ground water harvesting using the canal water during the rainy season when excess of it is available.

The hydrology of this area does not favour drainage of underground water. The construction of un-cemented canals in the beginning of 19th century where 40 % of water percolated to ground gradually brought the water table very close to surface large regions of plain. The water creeps to the surface continuously by capillary action and evaporates leaving its dissolved salts behind, which are accumulated. [Taken from waterlogging problem in the adjoining areas in Pakistan; Mission to Indus by Dr. Roger Revelle New Scientist 326 (1963) 340; available on internet]

Large-scale irrigation may also lead to shallow groundwater tables (water-logging) and non-beneficial evaporation directly from that water table. Consequently, a residue of relatively mineralized water is left in the soil. From there it may adsorb to the soil matrix (soil salinity), drain to the surface water system or percolate below the root zone. It may reach an aquifer and contribute to a progressive increase in salinity of its groundwater.

There are three possible ways to get rid of salinity in ground water [Annexure IV]

(a) Dilution,

(b) Removal and

(c) Reduce further addition of salinity.

Dilution can be done in two ways:

First one is dilution while using it, i.e., planned use of canal and ground water (conjunctive use) for irrigation. Ratio can be recommended after testing of the available ground water.

Second one is *in situ* dilution, i.e., farmers having bad quality of ground water from their tubewells be advised to directly recharge water at the point of tube well during the rainy season. Rain water is free from salt. Even canal water during the rainy season can be used for this purpose. The excess release of canal water during rainy season or direct rain water, must be used directly for recharging of ground water. Amazing results can be achieved. It requires exhaustive collective effort by people of the land and the government.

Reduce further addition of salinity –

(i) **Underground irrigation water pipes (2-3 ft depth; using JVC machine) need to be laid in the agriculture farms for irrigation purposes to minimize loss of water due to percolation. The route of canal water to agriculture field must be cemented or through cement pipe. The government should provide such facility at the subsidized rates.**

(ii) If one does irrigation using limited amount of water (like drip irrigation), i.e., irrigation water applied is small just to meet the requirements of the crops, after evaporation of water the salts will be left in the soil and will accumulate with time. Once a while excessive irrigation by rain or manual efforts will be able to flush these salts to the ground water. This process also adds to the salinity of the ground water with time, though it will prolong the salinity process.

(iii) Further, presence of trees result in lowering of temperature in shades and significantly less evaporation of water.

(iv) **Minimize the use of chemical fertilizers and pesticides, which are also finally added to shallow ground waters.**

Removal of saline ground water –

At the identified locations having brackish-saline ground water, the ground water can be added to the canal water – in a controlled way and with continuous monitoring. This has to be done at the Government level/Panchayat level and not on the individual level. Use of solar panels may be preferred for producing requisite electricity. It will take a period of few years to have a notable effect in water table. For example, the water levels in central Punjab have gone down due to excessive use of ground water for rice cultivation. In 1990, about 60 % of water table was in the range 5 m – 10 m and it became to 80 % of the water table more than 10 m in 2002.

The use of ground water for building construction and other huge consumption activities must be made compulsory.

Above all, saline ground water should be removed and used purposefully for production of some useful chemicals.

G**overnment agencies may plan uranium extraction from the ground water in the Malwa region (observed up to ~ 500 ppb level in ground water) using Reverse Osmosis (RO) equipment with special filters.**

B. Remediation measures for Water logging

Remediation measures are worth only if the problem does not reoccur. It is recommended that the agriculture activity in Punjab need to be done with better planning to minimize further deterioration of water and soil. A special committee should be constituted to implement the remedial measures suggested by the visting high-level committee in a **time bound manner and preferably within the existing infrastructure**. Include younger scientists especially those having background from Malwa region. People of the region may also be asked to suggest the corrective measures. Panchayats supported by school teachers should be taken to implement the remedial measures. Campaign of corrective measures must be widely publicised through Government agencies and media.

(i) **There is an urgent need of at least continuous replacement of the logged water to avoid further chemical poisoning of the ground water. Usage of ground water is to be encouraged. The cyclic use of *Canal Water* and Tube well water to maintain/improve the soil quality and lowering of the ground water table.**

(ii) Planned use of surface and ground water (conjunctive use) has to be done to over come both over-exploitation of canal water and Ground water quality problems. At present, the farmers of the region are pampered with canal water irrigation, which will result in further poisoning of the ground water. There is no way to get rid of salinity in ground water except to dilute it or remove it. It requires exhaustive collective effort by people of the land and the government.

(iii) **Soil from agriculture fields should also be tested by the Government or private agencies. Ground water and Soil Health Cards should be issued to the farmers which describe the water quality and fertility condition of their soil**

and their deficiency of micro nutrients. Regional centers of Panjab Agriculture University, Ludhiana, with soil and water experts be opened in the Malwa region to help the farmers. Private agencies and NGO's are welcome to participate in this venture.

(iv) Identify the locations with good ground water, where tube well water can be used in conjunction with canal water for agricultural purposes. The use of tube well water must be encouraged (supported in cash or kind) wherever the water is of good quality. Canal water supply may be cut in such fields.

(v) When a farmer is using canal water for irrigation purposes, he must be advised to also switch on the tubewell water (even if it is not of good quality) so that the two can be used in real conjunction. Ratio can be recommended after testing of the available ground water.

(vi) Underground irrigation water pipes (2-3 ft depth; using JVC machine) need to be laid in the agriculture farms for irrigation purposes to minimize loss of water due to percolation. The government should provide such facility at the subsidized rates.

(vii) **Farmers having bad quality of ground water from their tubewells be advised to directly recharge water at the point of tube well during the rainy season. The normal annual rainfall of the area is ~400 mm in 20 days. Rain water is free from salt. Even canal water during the rainy season can be released in excess for this purpose.**

(viii) At the identified locations having brackish-saline ground water, the ground water can be added to the canal water – in a controlled way and with continuous monitoring. This has to be done at the Government level/Panchayat level and not on the individual level. **Solar Panels may be preferred. It will take a period of few years to have a notable effect in water table. In central Punjab, the water levels have** gone down due to excessive use of ground water for rice cultivation. In 1990, about 60 % of water table was in the range 5 m – 10 m and it became to 80 % of the water table more than 10 m in 2002.

(ix) **The canal system may be monitored and breaching of walls and base canal need to be repaired to decrease the ground water recharge from the canal. The breach in the canal system gives rise to excessive recharge of the aquifer system.**

(x) The salt-resistant plants be preferably grown to reduce water-logging e.g., contact PAU scientists - Barley, Sugar beet, Sunflower, banana, onion etc. (Tolerant EC 10-16); Wheat, Oats, safflower, Corn (EC = 4-10) etc. **Further, presence of trees result in lowering of temperature in shades and significantly less evaporation of water.**

(xi) Encourage tree plantations - this results in lowering of temperature in shades and significantly less evaporation of water.

(xii) **Minimize the use of chemical fertilizers and pesticides, which are also finally added to shallow ground waters.**

(xiii) Fish cultivation including prawn farming be adopted in ponds using saline water. These measures will help the Economy in long way.

(xiv) **Above all, saline ground water should be removed and used purposefully for production of some useful chemicals.**

(xv) G**overnment agencies may plan uranium extraction from the ground water in the Malwa region (observed up to ~ 500 ppb level in ground water) using Reverse Osmosis (RO) equipment with special filters.** Uranium leaches from the soil and adds to the shallow ground water.

It is important note that agriculture is also like a polluting industry larger in magnitude though it is slow the too with same equivalent stringent measures to check pollution and save the present resources and provide the clean ecology/environ /water resources for generations to come.

Last but not the least, it is recommended that the safe future of the Public Drinking Water supplies in Punjab is the one based on canal water.

SECTION-IV

HEALTH EFFECTS OF INGESTED URANIUM IN HUMANS

A. **Radio-toxicity of Uranium** - Because of its radioactivity, concerns are being raised about the possible carcinogenicity due to exposure to ingested uranium. Human exposure to uranium radioactivity from the drinking-water is insignificant compared with everyday overall exposure to radioactivity from natural sources in the environment. **It has been well established that the *chemical properties of uranium in drinking water are to be considered for health hazard than its radioactivity [15]*.**

B. **Maximum contaminant level (MCL) for uranium in drinking water** - MCL for uranium in the community water systems, has been set at 30 μg/L by the United States Environmental Protection Agency. The Atomic Energy Regulatory Board, India has set a limit for uranium in drinking water of 60 μg/L. The World Health Organisation (WHO) set a provisional guideline of 15 μg/L. These limits are exceeded in the drinking water of many communities worldwide.

C. **Excretion of ingested uranium [15]**, as of other toxic substances, from the body proceeds through several pathways: **feces,** urine, hair, and nails as well as perspiration and saliva. According to the recent Human Alimentary Tract model produced by the International Commission on Radiological Protection (ICRP 100), at least 98% of the uranium ingested in soluble form is discharged in **feces**. Consequently only a very small part of ingested soluble uranium (0.1-2%) is transferred to the blood because of the very low level of absorption of uranium by the gastro-intestinal tract. From this maximum of 2% ingested and absorbed into the blood, 66% is eliminated in the urine within 24 h and the rest is then distributed and stored in the kidneys (12-25%), bones (10-15%) and a lesser proportion in soft tissues.

D. ***Bioindicators of ingested uranium in humans* [15]** - Hair bioconcentrates and integrates the uranium content in the body over a period of time and samples can be measured to estimate the body burden in weeks and months. **Analyzing the uranium content in hair a single time may be a substitute for analyzing several urine samples over a lengthy period in order to estimate the exposure [15].** The daily uranium excretion by Urine (ng/day) is given by 2.06 times the daily intake of uranium (μg/day) , i.e., 0.21 %, and that by Hair (ng/day) is 3.72 times the daily intake of uranium (μg/day), i.e., 0.37 %. Through nails (ng/day), the multiplication factor is only 0.048. Urine is an instantaneous indicator, and hair/ nails are cumulative indicators for ingestion of uranium in drinking water. These comprehensive investigations have been done by Dr.

P. Kurttio of STUK, Radiation and Nuclear Safety Authority, Research and Environmental Surveillance, Helsinki, Finland, and research collaborators. The study population was selected to include broad range of uranium daily intake from drinking water (0.03-2,775 μg/day) supplied from private wells that were drilled in bedrock. The observed concentration levels extended over a broad range 1-8450 ng/L with mean 485 (80) ng/L in urine. In hair, the values were in the range 6.5-250 μg/g. Daily intake of uranium through food is 1-4 μg/day if uranium levels in drinking water are low. **The concentraion of uranium in hair (ng/g) is on average about eight times its concentarion in urine (in ng/L).**

Distribution measurements of uranium along a hair strand – study was carried out using Laser Ablation-ICP-MS technique by Sela et al **[16]** on the test subjects who consumed the drinking water containing 2μg/L uranium for 2 months and afterwards started consuming drinking water with much less concentration 0.035 μg/L. The effect on the uranium hair content started almost immediately. Starting from a stable 212 ng/g, it reached a stable low level 18 ng/g after 4 months. By converting the distance from the scalp into time (hair closer to the scalp is newer), using the hair growth rate to be ~1 cm per month.

E. Health effects of ingested uranium in humans - Several studies **[17-20]** focusing on health effects have been carried out in Finland among people who use their drilled wells as sources of drinking water. These include case-cohort studies of uranium intake and risks of leukemia, stomach, and urinary tract cancers as well as chemical toxicity studies of uranium intake and renal and bone effects. Nevertheless, none of the human studies reported so far have shown a clear association between chronic uranium exposure and cancer risk, clinical symptoms, or toxicity.

Recent studies by Dr. Kurttio and research collaborators, Finland, studied the renal toxicity of sample of 200 men and women in the age group of 18 to 80 years, who had used contaminated drinking water for 16 years. Indicators of cytotoxicity and kidney function did not show evidence of renal damage. No direct deleterious effects were found. These findings suggest that short-term exposure is most relevant for kidney effects of uranium. Renel effects of uranium were not associated with the duration of contaminated water used or with cumulative uranium intake. At the most, long-term uranium intake from drinking water affects calcium, glucose, and phosphate excretion.

Finnish study found no increase in the risk of leukemia (cancer of the blood or bone marrow) or bladder or kidney (urinary organs) or stomach cancer from ingestion of natural uranium through drinking water even at such high exposure levels.

Further, it is concluded that uranium is in the form of its calcium dependent species, which could be one of possible reasons for the lack of significant adverse health effects. Therefore, chemical speciation can be an important factor for uranium chemical toxicity of drinking water. Radiotoxicity effects of uranium are nil even at these high concentration level.

Uranium accumulates in bone, affects bone metabolism in laboratory animals, and when ingested in drinking water increases urinary excretion of calcium and phosphate, important components in bone structure. However, very little is known about bone effects of ingested natural components in the bone structure. **The typical earlier findings related to renal tubular degeneration resulting in death from renal damage in animals, involved unusually high uranium doses (tens of mg/L) in the experiments. Most important thing is that there is no indication of increase in kidney-related diseases or deaths due to kidney problems in the region.**

F. CHILDREN AND NATURAL URANIUM EXPOSURE

It is reasonable to assume that children would be at increased risk for adverse effects from exposure compared with adults, because of developmental immaturity of their kidneys and other organ systems. Further, children below the age of 10 years consume considerably more water and food per kilogram of body weight than do adults. Children of 2, 5 and 10 years of age consume four, three and two times the water per kilogram of body weight compared to an adult .

In March 2009, Dr Carin Smit, a clinical metal toxicologist, associated with the UK-based non-governmental organisation, Defeat Autism Now, and Vera Dirr, a specialist, alarmed the Indian Government after observing a high incidences of abnormalities in local children at the Baba Farid Center For Special Children (BFCSC) in Faridkot, a not-for-profit organization working with kids, ailing from autism, cerebral palsy and other neurological disorders. She started collecting urine and hair samples of 149 affected children and sent them for tests to Microtarce Mineral Lab, Germany. Preliminary reports informed ''Of the 149 children tested, 53 are likely to show more traces of uranium. We are now focusing on them to get more specific evidence,'' The results are shocking and concluded that the deformities were caused by alarmingly high levels of uranium. The report and conclusions were both momentous and mysterious [http://en.wikipedia.org/wiki/Uranium_poisoning_in_Punjab]. This led to flurry of activities and scientific investigations.

Recently, in June 2010, studies carried out by Dr Carin Smit, a clinical metal toxicologist, amongst mentally retarded 149 affected children at the Baba Farid Center For Special Children (BFCSC) in Faridkot, came in to publication. A total of 114 test persons were below the age of 12 years. Hair mineral analysis revealed 88% of children below 12 years (Group A) and 85% beyond that age (group B) are having uranium levels exceeding the refence range of 0.1 mg/kg (100 ng/g). The 95 percentile concentration value is quoted to be 1.9 mg/kg (1900 ng/g) for group A and 1.4 mg/kg (1400 ng/g) for group B. The average values are reported to be 0.58 mg/kg (580 ng/g) and 0.50 mg/kg (500 ng/g) for the Groups A and B, respectively.

However, if one considers the observed correlations among the Finnish poulation **[15]**, i.e., Daily uranium excretion by Hair (ng/day) = 3.72 * Daily intake of Uranium (μg/d) **[15]** (taking growth rate of 3 g of hair per month or 0.1 g/day). [Relevant figure taken from **[15]** is shown on next page]. The 95 percentile value of 1900 ng/g uranium concentarion observed in hair (Group A) corresponds to 190ng/day excretion through hair, which in turn corresponds to an intake of uranium (190 ng/3.72 ~ 50 μg) /day. That the 95 percentile value of uranium intake is ~50 μg/day or uranium concentration in consumed water is ~35 μg/L. For an average age of 10 years, the water intake is about 50 g/kg bw/day, i.e., about 1.5 L.

The average values of uranium in hair 580 ng/g and 500 ng/g correspond to intake of 16 μg/day and 13 μg/day.

Uranium levels as 62, 44 and 27 times higher than normal (100 ng/g) in samples of three kids from Kotkapura and Fairdkot, which correspond to 114, 81 and 50 μg/L uranium concentrations in water.

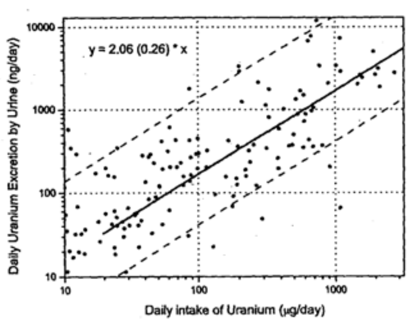


Fig. 1. A log-log plot of the daily uranium excretion by urine (in ng d^{-1}) as a function of the intake in drinking water (in $\mu g\ d^{-1}$) for the subjects that ingested 10 $\mu g\ d^{-1}$ or more. The solid line is the regression line and the two dashed parallel lines indicate lower and upper trend lines that encompass 90% of the data points.

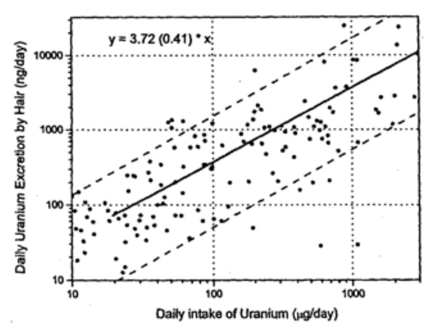


Fig. 2. A log-log plot of the daily uranium excretion by hair (in ng d^{-1}) as a function of the intake in drinking water (in $\mu g\ d^{-1}$) for each of the subjects that ingested 10 $\mu g\ d^{-1}$ or more. The solid line is the regression line and the two dashed parallel lines indicate lower and upper trend lines that encompass 90% of the data points.

(from ref [15])

In case we apply the same to the reference level 100 ng/g (mg/kg) uranium concentration in hair, it corresponds to 10 ng/day excretion through hair (hair growth rate 0.1 g/day) which in turn corresponds to an intake of uranium (10 ng/2.06 = 5 μg/day). [Relevant figure taken from **[15]** is shown on this page] In that case one may have to redefine the reference level in the light of the WHO permissible levels 15 μg/day or someother referene level in drinking water.

The 95 percentile value of uranium concentration 1.5 μg/L observed in baseline urine corresponds to 1500 ng/day excretion through urine (assuming 1.0 Litre of urine is excreted per day). Using the observed correlations among the Finnish poulation [15], which in turn corresponds to an intake of uranium (1500 ng/2.06 = 725 μg /day [Daily uranium excretion by urine (ng/day) = 2.06 * Daily intake of Uranium (μg/day)]. That the 95 percentile value of uranium intake is ~ 725 μg/day or uranium concentration in consumed water is ~485 μg/L. The mean value of 0.17 μg/L uranium concentarion observed in baseline urine sample correspond to 0.17 μg/day or 170 ng/day excretion through urine which in turn corresponds to an intake of uranium (170 ng/2.06 = 82 μg /day).

Quite a high value of daily intake deduced from urine samples [82 μg /day (mean) and 725 μg/day (95 %ile) compared to that deduced from the hair samples – 15 μg /day (mean) and 50 μg /day (95 %ile)] means that either the **Indian special children cohort** response is quite different from the Finnish cohort or it indicates possible immediate toxic exposure !!!

In case we apply the same to the reference level 0.1 μg/L uranium concentration, it corresponds to 100 ng/day excretion through urine which in turn corresponds to an intake of uranium (100 ng/2.06 = 48 μg /day).

Note to be added: The source still can be the drinking water. The consumption of drinking water in India is higher than in Finland due to hot climate.

There is no human evidence of increased complications in pregnancy due to exposure to low levels of natural uranium. However, to rule out any extreme possibility for the future baby, the pregnant women must avoid use of contaminated water as far as possible.

G. Detoxification of ingested uranium - One needs to talk of detoxification of uranium only if consumed at lethal levels. Otherwise for the low dose cases, the uranium accumulates only in hair, nails and bones. There is no accumulation in the kidneys. Detoxification of subjects with low doses within few months following cessation of uranium contaminated water consumption. Removal of hair from the parts of body helps in this direction.

Further on, Carin's group tried DMSA as metal-chelating agent on the children and found it to be ineffective for uranium [21]. There was no scientific basis for attempting DMSA for removing uranium. Simple discontinuing consumption of uranium contaminated water automatically leads to detoxification. Some of the chemicals well known for removal of uranium: bicarbonate, citric acid, diehylenetriamine pentaacetic acid (DTPA), ethidronate (EHBP) and inositol hexaphosphate (phytic acid). Regular use of natural Citric acid available in the form of citrus fruits, like orange and Lemon provides a more viable solution. Cebrian et al [22] studied the efficacy of these substances.

It is worth adding that phytochemicals, which modulate the host's defense mechanism against DNA-damaging molecules, are also found in several other types of fruits and vegetables, including members of *genus Allium* (such as garlic) and citrus fruits. The ability of these molecules to reduce the oncogenic potential of carcinogens thus makes them an efficient first-line defense against cancer.

Summary points-

(i) With the present uranium level of ingestion through drinking water in people of Malwa region, one does not require any detoxification medicine. Uranium is removed by itself within few months following cessation of uranium contaminated water consumption. Simple discontinuing consumption of uranium contaminated water automatically leads to detoxification.

(ii) Fruits (lemon, orange) rich in natural uranium metal-chelating agents like Citric acid should be regularly consumed. Other general powerful natural metal-chelating agents, Cilantro and Garlic, are already part of Indian food. Their use should be increased and regularised. These substances are also efficient first-line defense against cancer.

(iii) People must not permit any treatment by the Non-Governmental agencies without the permission of the local medical authorities. Recently, DMSA a chelator for removing lead has been attempted on a group of more than 100 special children in Faridkot for removing uranium. At the levels present in the children no medication was required. Such treatments are used only when one consumes excessive dose of a metal. Government Health Authorities must also take note of such cases.

(iv) Vegetables grown in the fields with the ground water with the present observed levels of uranium contaminations used for irrigation purposes are safe to consume.

(v) It is further mentioned that if animals consume water with the present observed levels of uranium contaminations, it will be reflected in their milk only at a much reduced levels. The milching (Lactation) process is a complex being dependent on harmone levels, and it is not a mode of waste excretion. Like humans, more than 99 % of the contaminants are excreted in feces and urine. It is safe to consume animal milk at present level of contamination. The same is true regarding the consumption of chicken and goat meat.

(vi) It is further mentioned that if animals consume water with the present observed levels of uranium contaminations, it will be reflected in their milk at a much reduced levels. The milching (Lactation) process is a complex being dependent on hormone levels, and it is not a mode of waste excretion. This process is expected to be not susceptible to intake of heavy metal contaminants. Like humans, more than 99 % of the contaminants are excreted in feces and urine. The same is true for chicken and goat meat, it is safe to consume.

H. Cancer Data from Malwa region –

Overall, in India the growth rate of cancer cases is increasing - both due to (a) early detection followed by treatment which prolongs life, and (b) due to change in our life style - especially due to excessive consumption of the continental, genetically modified, and preserved foods; Tobacco chewing and smoking habits. Use of excessive preservatives in foods, and exposure to pesticides due to their careless usage. Hot spots (villages) for the cancer be identified and must be provided with good quality of water on priority. Moreover, the data for the cancer patients showing high number of cancer patients is not reliable and is often misquoted.

A report on Cancer Patients at Acharya Tulsi cancer hospital and Regional Research Center, Bikaner by Dr. A.V.Ratnam is available at
http://cheminova.dk/download/Indien/cancer_study_report.pdf (p.11, Annx. p. 61)

Cancer patients treated in Bikaner hospital are from Rajasthan and surrounding states. Majority are from Rajasthan (46.7%), followed by Punjab (35.4%) and Haryana (15.5%). In Rajasthan 30.7% are from Bikaner, 22.5% from Sri Ganganagar, 14.6% from Hanumangarh and 11.1% are from Churu districts. In Punjab 27.6% are from Bhatinda,19.6% from Mansa, 13.5 % from Ferozpur, and 11 % from Muktsar districts. Patients from Bhatinda are coming to this hospital as it is close to Bikaner with good transport and very cheap services and the argument that Bhatinda has higher incidence of cancer could not be validated. It is worth reading this report. (see Annexure VI)

See websites –https://canceratlasindia.org/chapter4_1.htm,
https://canceratlasindia.org/map.htm, [go to these websites by Google search]
[Annexure VI]

[Minimum incidence rate of cancer in Chandigarh 107 per 100,000 for males and 148 per 100,000 for females]

[Minimum incidence rate of cancer in Bhatinda 37 per 100,000 for males and 57 per 100,000 for females]

In the developed countries, every fourth death is due to cancer as they have controlled over other causes of deaths and prolonged the life of cancer patients with early diagnosis and improved treatment techniques. The data is available at
http://www.cureresearch.com/c/cancer/stats.htm **[Annexure VI]**

I. AUTISM AND CEREBRAL PALSY

The symptoms – Lack of speech and communication, Inept social interactions and Repetitive or restrictive behaviors such as flapping or fixating in objects. Diagnoses have soared, but treatments are few. The global incidence of the autism is 1 in 500, according to the World Centre for Disease Control and Prevention, US. It is more common in boys than girls- four out of five autistic children are boys. The muted truth is that about 2 million people could have autism in India today. In spite of the vast numbers involved, the condition is often wrongly diagnosed. Since many established medical centres/hospitals in the region like PGIMER in Chandigarh, and CMC and DMC in Ludhiana, are treating the mentally subnormal juveniles. There are no specific reports from these medical centres indicating unusually higher number of cases from the Malwa region or Punjab state. According to Dr. Pritpal Singh of Baba Farid Centre for Special Children, Faridkot, high defective birth rate has been reported in certain villages in the region. In a specific village with a voter list of about 2000 (people above the age of 18 years), there are 37 cases of subnormal births. It needs further investigations. Endogamy, the tradition of marrying within same caste/community, could be the one of the likely causes for such births. One must keep track of the cases of endogamy in these villages.

The number of identified cases is increasing due to awareness among people and with the better diagnostic facilities. In US, the number is now about 100 children among every 10,000 children. In the past, either parent used to ignore vital clues, assuming that their child will eventually grow into a healthy adult without any help or lack of diagnostic facilities fail to identify the problem in time. The Indian print/electronic-TV media is having highly appreciable role in making it more socially acceptable. Recently discovered genetic variations in children with autism could reveal a cause, but related therapies are yet to evolve. Increased public awareness and social acceptance – Research funding is required. Hundreds of thousands of parents every year succumb to the same desire to find something –that may alleviate. **Parents turn to dubious, and often risky, alternative therapies. Even in US, as many as 75 % of autistic children are receiving alternative treatments not developed by conventional medicine, which are often bogus [23].** Some practioners prescribe drugs that never been tested for safety or efficacy for autism. Even Lupron (Injected drug normally used for prostate cancer), Immunoglobin (Injected antibodies approved for leukemia and AIDS), Secretin – Injected harmone and Stem cells (Injected over several days; not approved in the US), etc. are being tried without success. For other prescriptions like Vitamins and supplements, Gluten- and casein-Free Diets – costs and risks can be moderate, but benefits are difficult to distinguish. Dubious therapies like Chelation (Injected drug used to purge lead and mercury), Hyperbaric Oxygen Chamber (Pressurized oxygen delivered in a closed chamber) or Sensory integration Therapy (Pressure applied to the body with blankets or machines), or Audiotory Therapy are also in use. Parents must make themselves aware – spare considerable amount of time for the case – discover methods of communication (Behavioral therapy). **People must not permit any treatment by the Non-Governmental agencies without the permission of the local medical authorities. Recently, DMSA a chelator for removing lead has been attempted on special children for removing uranium. At the levels**

present in the children no medication was required. Such medicines are used only when one consumes excessive dose of a metal. Government Health Authorities must also take note of such cases.

Infants from Endogamy are more vulnerable to the genetic diseases like autism. Large number of Autism cases in a particular area can be genetic. The people of those villages with high defective birth rate should be encouraged for exogamy, i.e., they should prefer out of caste marriages.

J. Pesticides exposure – possible reason for cancer/ defective birth problems: It has been reported that the agrochemicals and pesticides in particular are impacting the ecology and environmental health of Punjab. Consumption of chemical pesticides in fields is still a necessity in the present scenario of agriculture in Punjab. High use of various pesticides, which enter in to the food system very easily, is expected to contribute considerably to cancer/ defective birth rate. Punjab has just 2.5 per cent area of the total agricultural land in India and it consumes nearly 20 per cent of the pesticides used in the country. The present consumption of pesticides in India is about 1 lakh Metric Ton. Significantly, Malwa, the cotton belt of the state, has the highest pesticide consumption density in the country. Bathinda consumes about 17 times the average Indian consumption. Further, the cotton belt comprises nearly 15 per cent of the area of Punjab and consumes nearly 70 per cent of the pesticides in the state, thus making the equation more dangerous.

The important point to be mentioned is that its direct exposure is much more harmful rather than thinking very complex ways of its entry in to the human genetic system. Direct exposure means – the persons spraying the pesticides do not take sufficient precautions as they are not aware of its long term effects.

Spraying of the pesticides by the field workers must be done with great caution – (a) wearing face mask covering nose, eyes and ears; and hand gloves (b) performing the job for limited hours that too spread over the day and with a gap of few days; (c) the empty pesticide containers after cleaning must be destroyed to the sufficient extent so that it cannot be used for other purpose. At present reuse of empty containers of chemicals is a frequent practice. Once the container is opened - careful storage of pesticides is another important aspect. The agricultural products treated with pesticides, Cauli flower, Bringel etc. must be properly washed before consumption. Use of pesticides at homes (close environment) – has to be done with much more care. We frequently see our Children spraying pesticides to get rid of Cockroaches and other insects etc. This act of spray should be under with utmost caution as children can get themselves affected by overdosing or inhaling the vapors. These spray bottles should be handled with care and under parental guidance only, The electronic media should educate the people about its bad affects too, which before telecasting fanciful advertisements of these sprays like

RED/BLACK HIT,FILIT,TORTOISE spray/ COILS etc, otherwise it looks very fancy to parents that kids running after these insects, cockroaches with spray bottles.

Suggestive Measures - Use of Pesticides

Spraying of the pesticides by the field workers must be done with great caution – (a) wearing face mask covering nose, eyes and ears; and hand gloves (b) performing the job for limited hours spread over the day and with a gap of few days; (c) the empty pesticide containers after cleaning must be destroyed to the sufficient extent so that it cannot be used for any other purpose.

Use of pesticide in close environment (Home) for Cockroaches etc. must be done with utmost care. Do not permit children to use it. The pregnant ladies and children – avoid direct exposure to pesticides. Vegetables like Cauliflower, Brinjel etc. must be washed before consumption.

Sale of pesticides in concentrated form should be banned or authorized agencies be permitted to use it for agriculture and other purposes

Important is - We must learn how to use scientifically evolved products. The pregnant ladies and children – avoid direct exposure to pesticides. A possible solution comes to mind is - Sale of pesticides in concentrated form should be banned and pesticide spraying may be allowed by the authorized persons (agencies) only.

(K) *Above all*

(i) The media and even the scientific community are advised not to make unsubstantiated and preposterous claims in this regard among people. The media reporting always has an important positive role in educating the people apart from bringing out the truth. The facts related to the community health must be mentioned in a clear fashion. The reporting media must be careful in this regard. Always try to link – what effects are expected at the source location.

(ii) There are efforts at various Atomic Energy Research Institutes (JAERI Takasaki Research Establishment) to extract uranium from the sea water by developing new polymer fiber adsorbent having high adsorption capacity approximately tenfold greater in comparison to the conventional titanium oxide adsorbent. Perhaps it may be economic to extract uranium from the ground waters of Malwa region too (uranium concentration = 100 ppb) rather than sea with 3.3 ppb of uranium present in it.

Acknowledgements:

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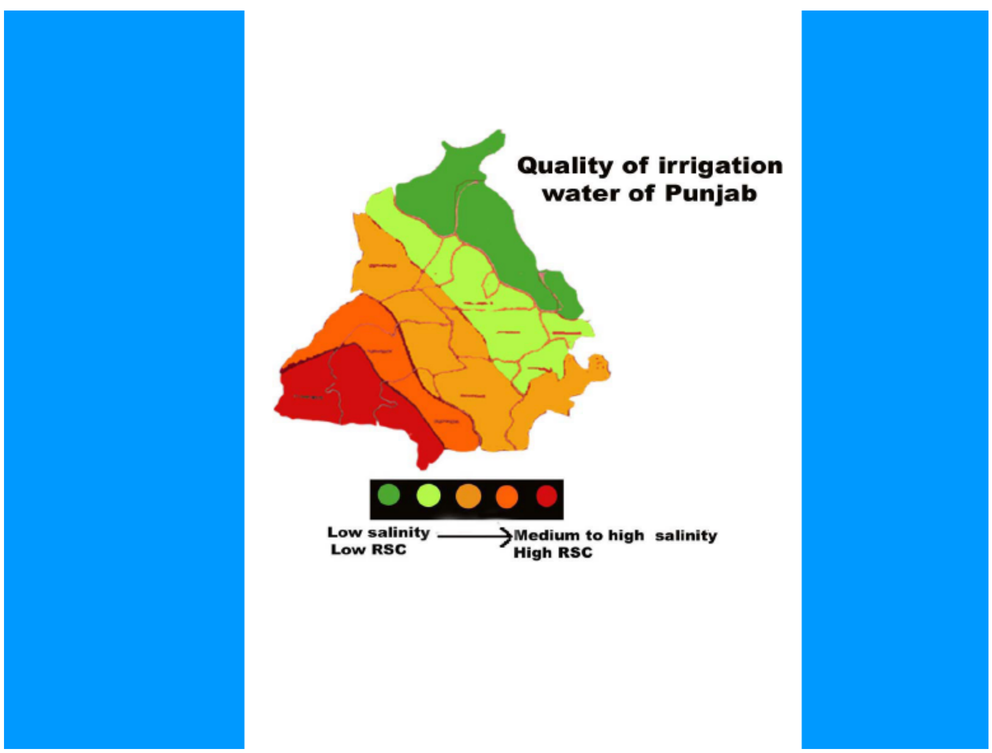
Annexure I – Relevant maps


Map of Punjab
JAMMU & KASHMIR
N
HIMACHAL PRADESH
PAKISTAN
Gurdaspur
Amritsar
Hoshiarpur
Kapurthala
Nawanshahr
Jalandhar
Ferozepur
Ludhiana
Rupnagar
CHANDIGARH (State Capital/ Union territory)
Faridkot
Moga
Fatehgarh Sahib
Patiala
Muktsar
Bathinda
Sangrur
Mansa
Map not to Scale
State Capital
District Headquarter
State Boundary
District Boundary
RAJASTHAN
HARYANA

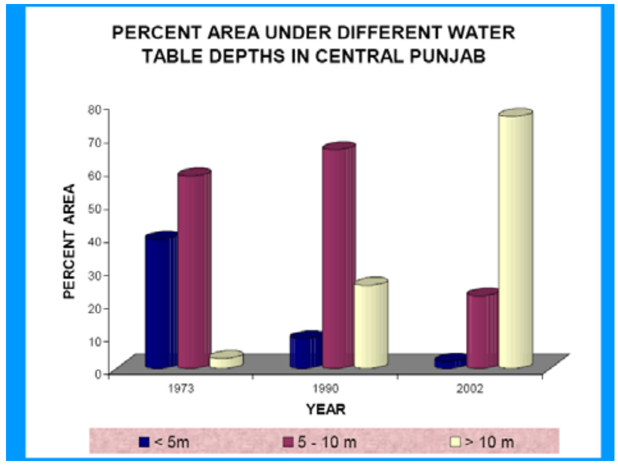

RAJASTHAN
Ganganagar
Hanumangarh
Churu
Bikaner
Jhunjhunun
Sikar
Alwar
Bharatpur
Jaisalmer
Nagaur
Dausa
Jaipur
Dhaulpur
Jodhpur
Tonk
Karauli
Ajmer
Sawai Madhopur
Barmer
A
Pali
Bhilwara
Bundi
Jalor
Rajsamand
Kota
Baran
Sirohi
Chittaurgarh
Jhalawar
Udaipur
Dungarpur
Banswara
A - Ajmer


HARYANA
Panchkula
Ambala
Yamunanagar
Kurukshetra
Kaithal
Sirsa
Fatehabad
Karnal
Jind
Panipat
Hisar
Sonipat
Rohtak
Bhiwani
Jhajjar
Gurgaon
Mahendragarh
Rewari
Faridabad



(Source – PAU report)

Fig. A1 - Quality of irrigation water of Punjab.



(Source – PAU report)

Fig. A2 – Percent area under different water table depths in central Punjab. Sharp fall in depth is observed during the last decades.

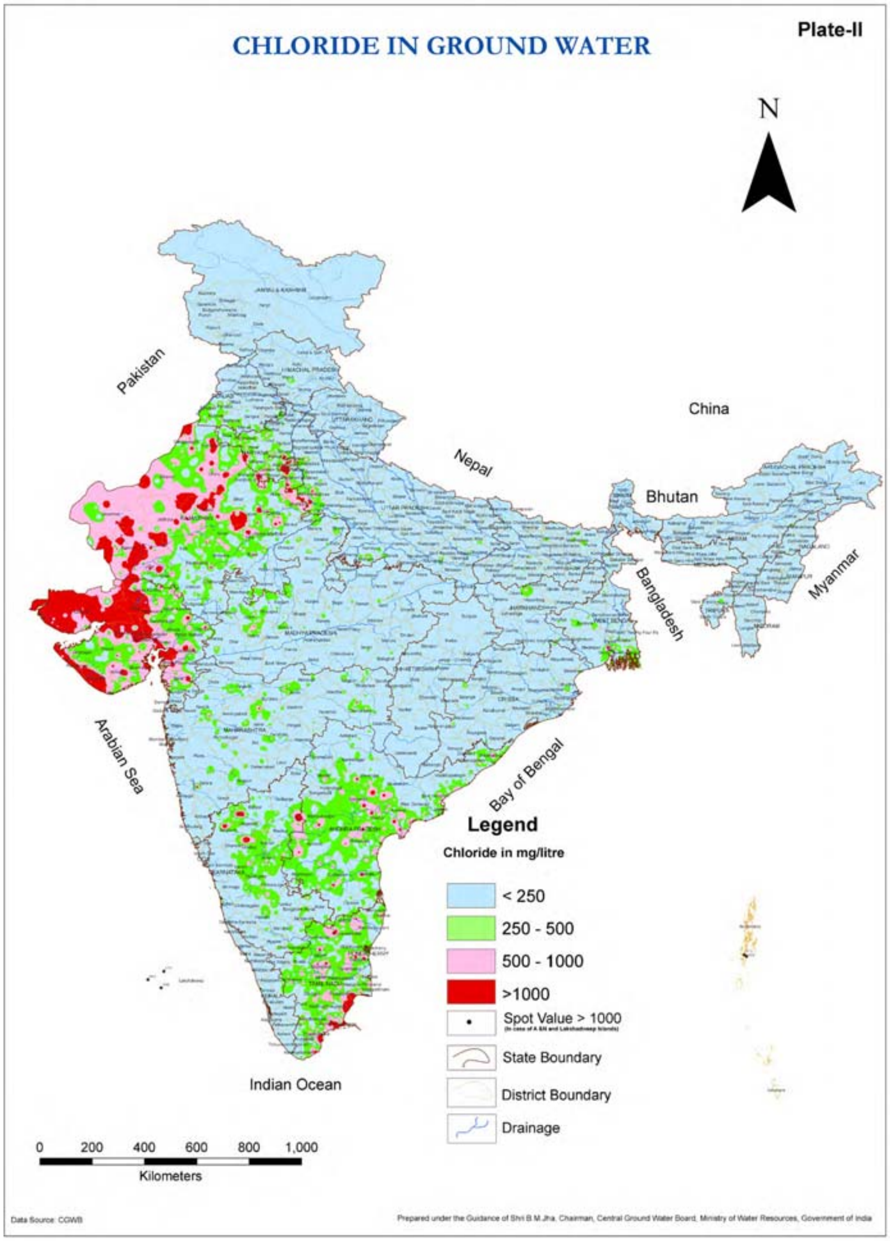


Plate-II
CHLORIDE IN GROUND WATER
N
Pakistan
China
Nepal
Bhutan
Bangladesh
Myanmar
Arabian Sea
Bay of Bengal
Indian Ocean
Legend
Chloride in mg/litre
< 250
250 - 500
500 - 1000
>1000
Spot Value > 1000
State Boundary
District Boundary
Drainage
0 200 400 600 800 1,000
Kilometers
Data Source: CGWB
Prepared under the Guidance of Shri B.M.Jha, Chairman, Central Ground Water Board, Ministry of Water Resources, Government of India

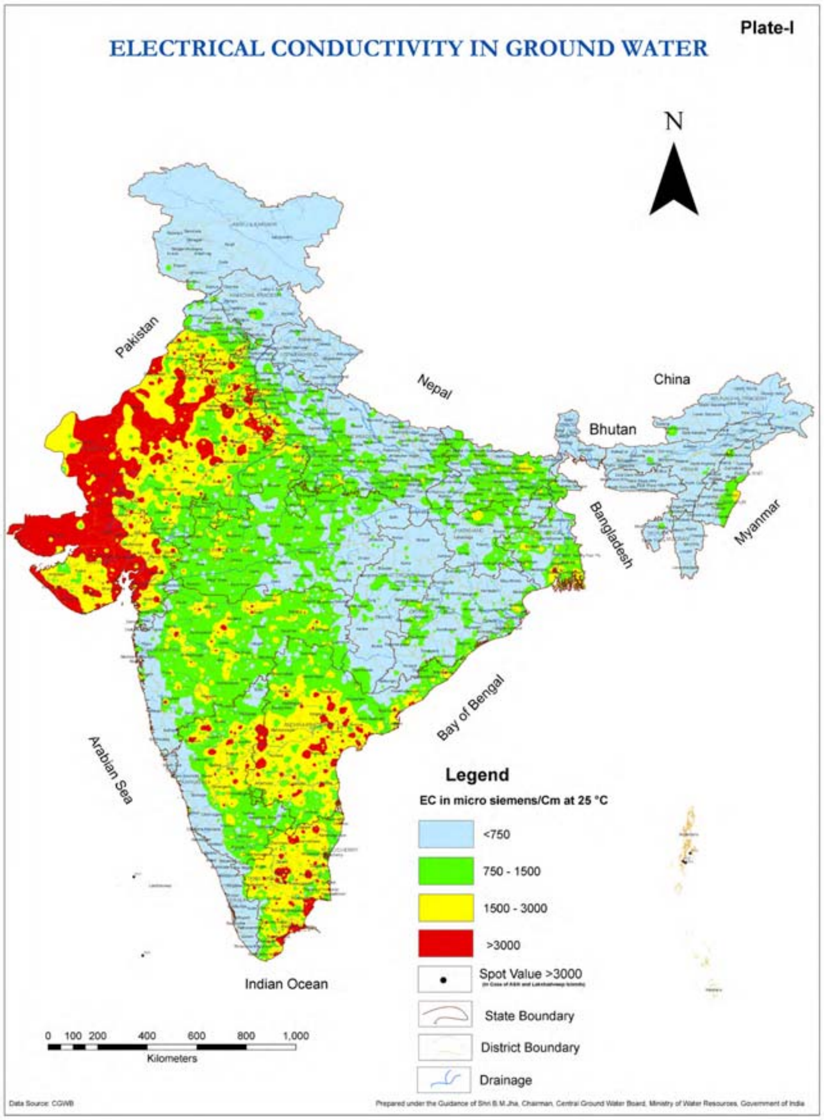


Plate-I
ELECTRICAL CONDUCTIVITY IN GROUND WATER
N
Pakistan
Nepal
China
Bhutan
Bangladesh
Myanmar
Bay of Bengal
Arabian Sea
Indian Ocean
Legend
EC in micro siemens/Cm at 25 °C
<750
750 - 1500
1500 - 3000
>3000
Spot Value >3000
State Boundary
District Boundary
Drainage
0 100 200 400 600 800 1,000
Kilometers

ANNEXURE II

Uranium concentrations reported by various research groups reported from Punjab and Himanchal Pradesh showing very high concentration of uranium is not included [Recent data from BARC and GNDU studies and Panjab Govt. Water Supply Department is not included]

Uranium Concentrations in µg/litre (PUNJAB):

Sangrur	
Tapa	13
Handiya	14
Barnala	5
Sangrur	9
Bhawanigarh	13
Dhuri	19
Dhanola	21
Sunam	20
Malerkotala	8
Faridkot	
Faridkot	10
Sadik	14
Kot Kapura	18
Khara	16
Jaiton	19
Mansa	
Budlada	18
Mansa	27
Burj Harike	43
Bhiki	14
Bareta	17

Ludhaina	
Rajkot	20
Ludhiana	21
Khanan	14
Sarhind	30
Jagraon	11
Moga	
Moga	19
Baga Purana	17
Smalsar	10
Ajitwal	6
Nihal Singh Wala	18
Patiala	
Nabha	20
Patiala	21
Samana	14
Kauli	30
Raj Pura	11

II. Uranium Concentrations in μg/litre (MALWA REGION) :

Water samples from different villages of Tarn-Taran, Amritsar, Ferozepur, Faridkot and Bathinda Districts. H. Singh et al, Indian J. Physics 83 (2009) 1039	
Budhlada	43
Bajakhana	31
Morh	30
Kot-Fateh	38
Bhikhi	18
Bathinda	30
Faridkot	17
Zira	17
Tindwan	24
Killi Bodla	13
Makhu	14
Behak Pachharian	13
Harike	11
Marhana	11
Khara	10
Ruri Wala	8
Sarhali	11
Thathia	10
N. Pannuan	1
Tarn-Taran	9
Doburji	10
Balachak	16

Comm. and Capacity development Unit of dept. of W/S and Sanitation, S.A.S., Nagar. Analysed at Panjab University	
Malkana	6
Jajjal-1	98
Jajjal-2	7
Jajjal-3	Below DL
Gyana	7
Malkana	32
Gyana	18
Malkana	42
Talwandi Sabo (Gurudwara)	- small residue
Jajjal-1	- small residue
Jajjal-2	- small residue
Jajjal-3	12
Jajjal-1A	5
Malkana-1	43
Malkana-2	Below DL
Gyana-1	16
Gyana-2	5

III. Uranium Concentrations in μg/litre (MALWA REGION) :

Water samples from different villages of Bathinda (Jajjal, Malkana, Gyana) "Naresh Kochhar et al Asian Journal of Water, Environment and Pollution 4 (2007) 107	
Gurudwara- Jajjal	113
Veterinary Hospital-Jajjal	16
Dera-Jajjal	5
Darshan Singh, Bagar Singh, Jajjal	31
Jasbir Singh, Jajjal	45
Babur Singh	47
Ban Singh (Malkanan)	9
Gurdeep Singh (Malkana)	185
Gurcharan Singh (Gyana)	63
Major Singh (Gyana)	141
Jagral Singh (Gyana)	170
Rajpal Singh(Gyana)	65
Kartar Singh (Gyana)	88
Mita Singh (Gyana)	57
Near old age home Devi Road (Takht Mal)	316
Tube well near water works (canal main line)	66
Shemsher Singh (Taruwanan)	7
Banta Singh (Taruwana)	60

IV. Uranium Concentrations in μg/litre (Himanchal):

S.No	Location	Source	Uranium Concentration
1	Kharagmangoli	Hand pump	4
2	Ramgarh	Tubewell	10
3	Billa	Tubewell	6
4	Alipur	Hand pump	20
5	Batour	Hand pump	11
6	Raipur	Tubewell	3
7	Pyarewala	Hand pump	12
8	Laha	Hand pump	2
9	Raomajra	Hand pump	1
10	Kala Amb	Tubewell	3
11	Devi Ka Bagh	Tubewell	4
12	Ambwala	Tubewell	6
13	Nahan	Tubewell	10
14	Do Sadka	Tubewell	3
15	Laadu	Natural source	5
16	Banethi	Natural source	5
17	Kanderan	Natural source	1
18	Badyal	Natural source	3
19	Morni	Natural source	2
20	Tikari	Natural source	1
21	Bhoori	Natural source	2
22	Mandana	Hand pump	2
23	Beawala	Hand pump	5

ANNEXURE III A

SUMMARY OF PAPER "EFFECTS OF GROUND WATER DEVELOPMENT IN CENTRAL VALLEY, CALIFORNIA, USA" *(Jurgens et al, Ground Water Journal; This paper is posted at DigitalCommons@University of Nebraska - Lincoln. http://digitalcommons.unl.edu/usgssta_pub/223)*

The Central Valley is one of the most productive agricultural regions in the world, with a cash value of more than $20 billion in 2007 [Fig. 1]. Seven counties within the Central Valley are among the top 10 counties in the United States for agricultural products sold. Nearly two-thirds of all groundwater withdrawals in California occur in the Central Valley, primarily for agricultural irrigation. The San Joaquin Valley makes up the southern two-thirds of the Central Valley, and most of the population and associated municipal or public groundwater use is in the eastern San Joaquin Valley (ESJV). Uranium (U) concentrations in groundwater in several parts of the eastern San Joaquin Valley, California, have exceeded federal and state drinking water standards (30 micrograms per litre) during the last 20 years [Table 1]. It has led to the removal of at least 23 public-supply wells (PSWs) from service within the last 20 years in the ESJV. **Strong correlations between U and bicarbonate suggest that U is leached from shallow sediments by high bicarbonate water, consistent with findings of previous work in Modesto, California.**

Previous studies have shown that anthropogenically introduced contaminants, such as pesticides and nitrate, have degraded the quality of groundwater within the ESJV. The spatial distribution of these contaminants in groundwater is linked to patterns of fertilizer and pesticide use and their rate of application at the surface. In contrast to these agricultural contaminants, U is naturally abundant in soils and aquifer sediments in the ESJV and is not linked to the application of fertilizers or pesticides. Groundwater from several other wells affected by high U is either blended with water containing low U or removed by ion exchange to meet regulatory requirements.

Recent work has also shown that calcium can enhance desorption of uranyl-carbonate ternary complexes and that the calcium-uranyl-carbonate complex, $Ca_2UO_2(CO_3)^0_3$, may be the dominate species of dissolved U(VI) in calcium-rich groundwater systems. **Plant root respiration and microbial oxidation of organic matter in soils produce carbon dioxide (CO_2), resulting in CO_2 partial pressures (*P*co2) in the soil zone that are greater than atmospheric pressure. Water percolating through the soil equilibrates with the soil atmosphere by dissolving CO_2 (g) to form carbonic acid. The carbonic acid participates in mineral weathering reactions that increase DIC concentrations in water, primarily in the form of bicarbonate. Increased soil zone P_{co_2} beneath irrigated lands has resulted in increased bicarbonate concentrations in groundwater, and that this bicarbonate has enhanced the mobility of U [Fig. 2, Fig. 4].**

In addition, the application of surface water and groundwater for agricultural irrigation and pumping from deep parts of the aquifer for irrigation and public supply has increased the rate of downward groundwater flow. The vertical movement of water from the water table to deeper parts of the groundwater flow system has increased by more than six fold in many parts of the valley since development and caused head gradients to be in a downward direction almost everywhere. It is also our hypothesis that these changes in groundwater flow patterns have caused U concentrations to increase in many PSWs throughout the ESJV. **Because the developed portion of the ESJV aquifer system is largely oxic, uranium is expected to remain mobile in groundwater and therefore poses a significant threat to the long-term sustainability of groundwater as a potable source.**

Uranium is naturally abundant in sediments in the ESJV, which are derived from granitic rocks of the Sierra Nevada. Aerial gamma-ray surveys of U in the ESJV show that U concentrations in surficial sediments range from 1.22 to 4.20 ppm and average about 3 ppm. In contrast, superficial sediments of the conterminous United States have an average U concentration of 1.83 ppm. However, the amount of U that may be easily mobilized is typically only a small fraction of the total U content of the sediment. This fraction is normally adsorbed to mineral surfaces on sediment grains, primarily iron oxide and oxyhydroxide coatings, and the edges of clay minerals

This paper describes the likely linkage between the development of groundwater resources in the ESJV since the 1850s and temporal increases in U concentrations in groundwater. Data collected by the U.S. Geological Survey (USGS) for the California Ground Water Ambient Monitoring and Assessment program Priority Basin Project (USGS-GAMA), data previously collected by the USGS National Water Quality Assessment (NAWQA) program and other USGS studies (USGS historical), and data compiled by the CDPH are used to demonstrate that high U concentrations are associated with shallow, modern-age groundwater that has high concentrations of bicarbonate.

Table 1

Summary of Uranium Concentrations in Groundwater from Different Well Types in Eastern San Joaquin Valley, California; U.S. Geological Survey National Water Information System (NWIS)

Well Type	Number of Wells with U Analysis	Uranium (μg/L) Minimum	Uranium (μg/L) Median	Uranium (μg/L) Maximum	Number of Wells with U > 30 μg/L	Range in Depth below Water Table to Top of Uppermost Perforated Interval (feet)	Median Screen Length
Observation	98	0.09	18.0	2500	31 (32%)	0.66–307 [55]	5
Domestic	122	0.04	8.7	503	30 (25%)	9.6–454 [82]	20.5
Public supply	121	0.04	1.8	41.3	3 (2.5%)	7.0–917 [140]	211
Irrigation	9	0.20	7.8	91.9	1 (11%)	42–557 [160]	175
All USGS data[1]	350	0.04	6.7	2500	65 (19%)	0.66–917 [98]	50

Notes: Percent of wells in parentheses. Median in brackets. [1]Uranium was not detected in six wells.

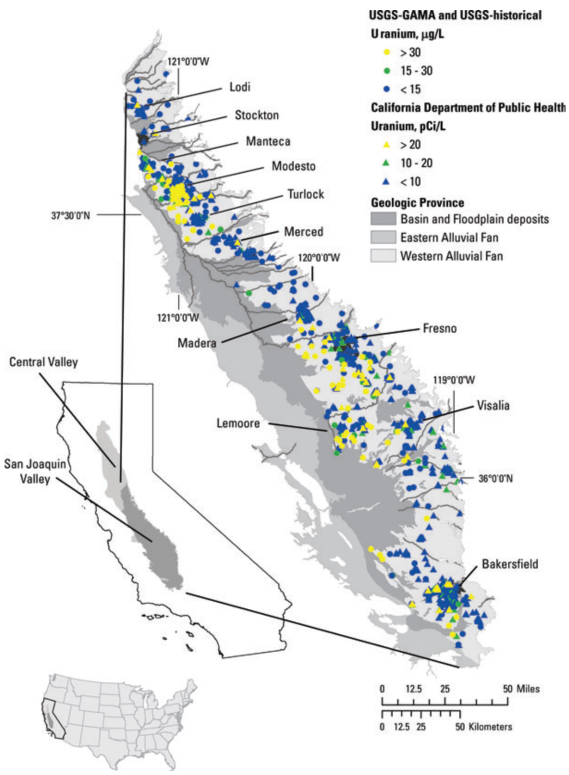


Figure 1. Location, physiographic features, and concentration of uranium in groundwater in the eastern San Joaquin Valley, California.

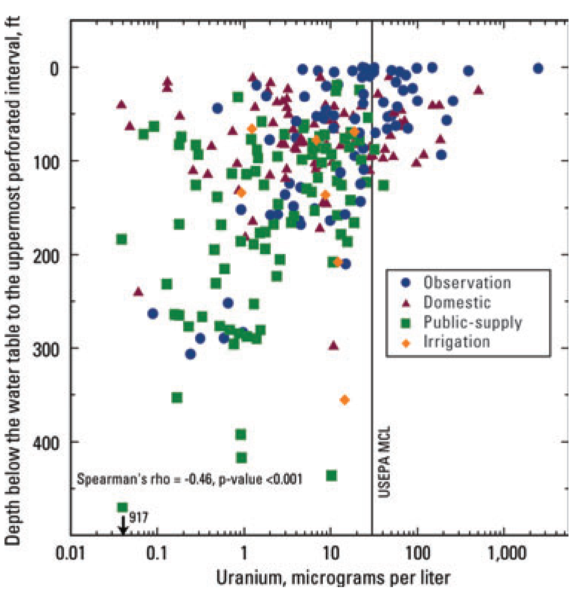


Figure 2. Relation between uranium in groundwater and depth below the water table to the uppermost perforated interval among well types in the eastern San Joaquin Valley, California.

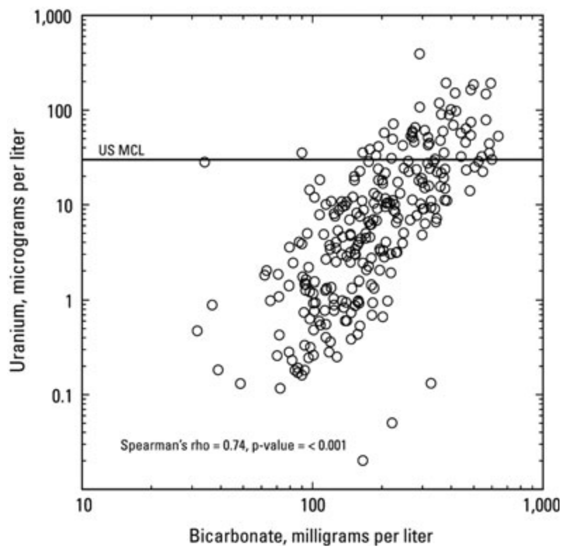


Figure 3. Relation between uranium and bicarbonate in oxic groundwater in the eastern San Joaquin Valley, California.

$$UO_2^{+2} + 2Ca^{+2} + 3HCO_3^{-} \leftrightarrow Ca_2UO_2(CO_3)_3^0 + 3H^+ \quad \log K = -0.29 \text{(modified from Dong and Brooks [2006])}$$

ANNEXURE III B

Uranium extraction from Phosphate rocks – a byproduct of Fertiliser industry

Reference [Fathi Habashi, Department of Mining, Metallurgical and Material engineering, Canada]

Phosphate fertilizers are mainly produced from Phosphate rocks; which exist mainly in the form of hydroxy- and fluoroapatite, $Ca_{10}(PO_4)_6(OH)_2$ and $Ca_{10}(PO_4)6F_2$, respectively, or a mixture of both. 85% of the phosphate rock for the industry is of sedimentary type. It contains 100-200 ppm of uranium, 2-20 ppm thorium and about 0.5% lanthanides. Florida and North Africa phosphates are typical of this category. The remaining 15% are of *Igneous* type and contain < 10 ppm uranium but contain appreciable amount of thorium and lanthanides. Kola phosphate which is mined in Russia is typical of this category. Uranium is present mainly in the tetravalent state in isomorphous substitution with calcium ion; the ionic radius of U^{4+} which is 0.97Å being very near to that of Ca^{2+} which is 0.99Å.

The presence of uranium in phosphates was known since 1908 but it became important only during the 1940's because of the need for uranium in the USA in connection with the Manhattan Project to produce an atomic bomb. No local uranium deposits were known at that time. Current world phosphate rock production is about 170 million tons annually, which represents a potential source of about 17,000 tons of uranium per year. Different processes have been applied to extract uranium from phosphoric acid produced by H_2SO_4 acidulation of phosphate rock. Uranium can be extracted as a by-product of making fertilisers. Some 20,000 tonnes of uranium has been obtained by US from the rock phosphate deposits. About 20 % of US uranium came from central Florida's phosphate deposits to 1990s, as a byproduct. At present, the process is not economically viable. With the discovery of rich uranium ores, the recovery from phosphate became uneconomical. With shortages in uranium supplies, many fertilizer plants remain engaged in the recovery of uranium from the phosphate rocks.

At present there are two principal routes for treating the rock to produce fertilizers: sulfuric acid route which is the major route, and nitric acid route, a minor route.

SULFURIC ACID ROUTE

Phosphoric acid is produced by this process as an intermediate product:

$$Ca_{10}(PO_4)_6F_2 + 10H_2SO_4 + 20H_2O \rightarrow 6H_3PO_4 + 10CaSO_4.2H_2O + 2HF$$

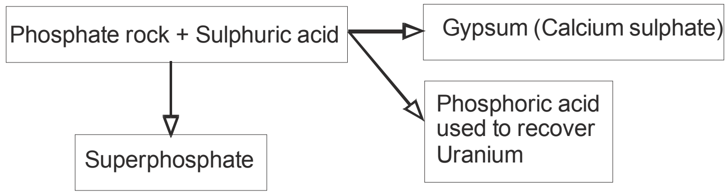
The phosphoric acid is then concentrated by evaporation, and then neutralized with ammonia to produce mono- or diammonium phosphates fertilizers, which typically contain 52% and 46% P_2O_5, respectively.

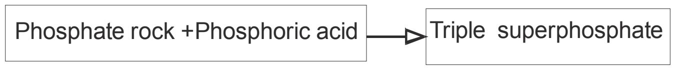
$H_3PO_4 + NH_3 \rightarrow NH_4.H_2PO_4$ at pH 4

$H_3PO_4 + NH_3 \rightarrow NH_4.H_2PO_4$ at pH 6.2

During this treatment, uranium goes in the phosphoric acid while the lanthanides remain in the gypsum residue. It suffers from the disadvantage of producing enormous quantities of gypsum contaminated with radium. For each ton rock treated about 1.5 tons gypsum is produced.

Production of Single and Triple super phosphate fertilisers:





Uranium was recovered from phosphoric acid by precipitation methods but mainly by extraction with organic solvents without interfering with the manufacture of fertilizers.

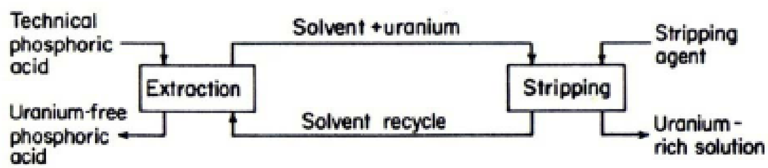
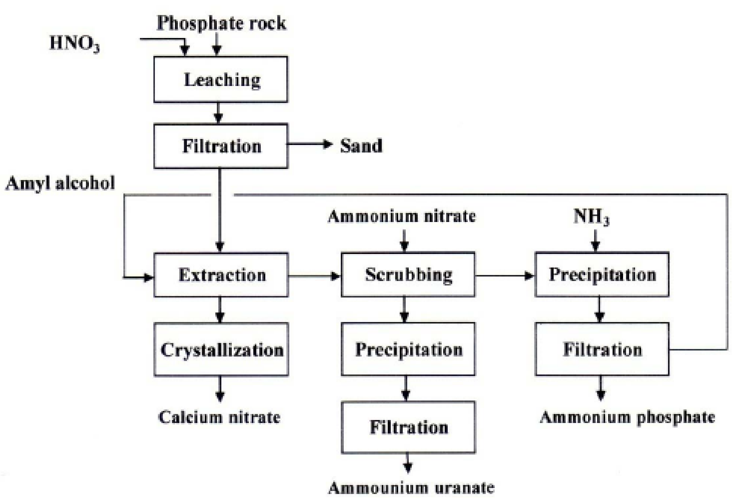


Fig. - Typical solvent extraction process for uranium from phosphoric acid

Nitric acid Route :

$Ca_{10}(PO_4)_6 F_2 + 20\ HNO_3 \rightarrow 6\ H_3PO_4 + 10\ Ca\ (NO_3)_2 + 2HF$



ANNEXRE-IIIC

FERTILISER CONSUMPTION IN INDIA

Food grain production = 240 million tonnes;

Food grain yield = 1.74 tonnes/hectare.

Net sown area = 140 million hectare.

Fertiliser consumption = 27 million tonnes

India is the second largest consumer of fertilisers in the world after china, consuming about 27 million tonnes. However, the average intensity of fertiliser use in India is much lower than most of the countries in the world but it is highly skewed, with wider inter-regional, inter-state and inter-districts variations. The consumption is expected to be 40 million tonnes by 2020.

Share of Phosphorus primary nutrient is ~ 25 %., that for Nitrogen is 63 % and K is12 %.

By 2020, fertilizer demand is expected to increase to 42 million MTs – 23 million MTs of N, 11 million MTs of P and 7.1 million MTs of K.

Percentage share of fertilizer consumption is 15 %, 25 %, 25 % and 35 % for the eastern, southern, western and northern parts of India.

Per hectare fertilizer use by states (2009-10)

Punjab, Andhra Pradesh, Tamilnadu, Haryana	200-225 kg/hactare
Bihar, U.P., West Bengal	150-200 kg/hactare
Gujrat, Karnataka Maharasthtra	100-150 kg/hactare
J & K, Kerala, M.P., Assam, Orissa, H.P., Rajasthan	50-100 kg/hactare
India	~100 kg/hactare

In the TE2009-10, 112 out of 538 districts (20.8%) consumed more than 200 kg per hectare, 76 districts between 150-200 kg, 105 districts between 100-150 kg and 127 districts between 50-100 kg/ha.

Share of various fertilizers to nutrients N,P and K

Share of Urea in total nitrogen	~80 %
Share of DAP in total phosphorus	~63 %
Share of SSP in total phosphorus	~ 7 %
Share of Complex fertilisers in total Phosphorus	~ 30 %
Share of MOP in total potassium	~ 70 %

Punjab state consumption of Fertilizers (2009-10)

Rabi crop	0.50 million MTs of Diammonium Phosphate fertilizer
	1.50 million MTs of Urea
	0.25 million MTs of Single Super Phosophate
Kharif crop	0.40 million MTs of Diammonium phosphate fertilizer
	1.25 million MTs of Urea
	0.25 million MTs of Single Super Phosophate

FERTILISER CONSUMPTION FOR VARIOUS COUNTRIES
SOURCE: World Resources Institute

http://www.nationmaster.com/red/graph/agr_fer_use-agriculture-fertilizer

DEFINITION: Average fertilizer use (kg per ha of cropland 2000). Fertilizer use, kilograms per hectare, is calculated by WRI by dividing the total fertilizer consumption, measured in kilograms of plant nutrient, by the total hectares of arable and permanent cropland. The measure of fertilizer consumption is an aggregate of nitrogenous, phosphate and potash fertilizers. The Food and Agriculture Organization of the United Nations (FAO) collects data on fertilizer use through surveys distributed to participating governments. In addition, the Ad Hoc Working Party on Fertilizer Statistics works to improve geographic coverage of the data. Hectares of arable and permanent cropland are determined through a variety of means, including self-reporting from governments and FAO estimation methods.

Rank	Countries	Amount	Rank	Countries	Amount	Rank	Countries	Amount
# 1	Ireland	594.5	# 21	Italy	159.4 kg	# 41	El Salvador	103
# 2	Netherlands	450.2	# 22	Bangladesh	156.3	# 42	India	98.6
# 3	Egypt:	385.8	# 23	Austria	151.7	# 43	Hungary	98.2
# 4	Costa Rica	385	# 24	Uzbekistan	149.9	# 44	Uruguay	94.9
# 5	Slovenia	369.4	# 25	Colombia	144.8	# 45	Czech Repb	90.4
# 6	Japan	301	# 26	UAE	142.1	# 46	Suriname	86.6
# 7	UK	285.8	# 27	Finland	140.6	# 47	Thailand	86.1
# 8	Vietnam	285.3	# 28	Croatia	139.8	# 48	Portugal	84.3
# 9	Israel	256	# 29	Pakistan	135.1	# 49	Jamaica	81.8
# 10	China	255.6	# 30	Sri Lanka	128.9	# 50	Turkey	78.3
# 11	New Zealand	255.5	# 31	Belarus	128.7	# 53	Indonesia	73.8
# 12	Switzerland	233.4	# 32	Honduras	126.5	# 54	Philippines	73.1
# 13	Germany	228.2	# 33	Greece	118.7	# 55	Belize	69
# 14	Norway	222	# 34	Spain	118	# 56	Mexico	67.1
# 15	Chile	212.9	# 35	Brazil	114	# 57	Iraq	67
# 16	France	211.7	# 36	Guatemala	111.1	# 66	Canada	54.2 kg
# 17	Lebanon	199.6	# 37	Poland	106	# 72	South Africa	48.2 kg
# 18	Malaysia	187.8	# 38	Saudi Arabia	104.6	# 101	Ukraine	13.1 kg
# 19	Korea, North	175.5	# 39	Sweden	103.5	# 106	Russia	11.2 kg
# 20	Denmark	159.9	# 40	United States	103.4	Weighted average		82.4 kg

ANNEXURE IV

Mission to Indus by Dr. Roger Revelle

New Scientist 326 (1963) 340.

http://books.google.co.in/books?id=EjSplwV4XmUC&pg=PA341&lpg=PA341&dq=Sea,+salinity+in+Punjab&source=bl&ots=RxWmBx6PYy&sig=mBvTfP4shOY10NoRVIplKq8b-1c&hl=en&ei=OjC4Tb-TNMrXrQeKg9jnDQ&sa=X&oi=book_result&ct=result&resnum=5&ved=0CD4Q6AEwBA#v=onepage&q=Sea%2C%20salinity%20in%20Punjab&f=false

One of the most remarkable exercises in International cooperation in science has been the work of a panel of American scientists who have studied the irrigation system in West Pakistan and came up with far-reaching proposals for improving the agriculture of that country.

In 1961, President Ayub Khan of Pakistan asked President Kennedy to send a group of scientists to study the problem of waterlogging and salinity in West Pakistan.

The flood plain of the Indus and its five great tributaries – the Jhelum, the Chenab, the Ravi, the Beas and the Sutlej bearing the melted snow and monsoon rains from the Himalayas - to water green ribbon of flood land, was naturally a place where farmers would settle and which conquerors would cover. The last of these the Britishers worked a transformation of the land. There had been great irrigation work before but nothing compared with the barrages and 10,000 miles of canals which, beginning in the century in the mid-19th century, the British engineers created in the Punjab and the Sind. British administrators encouraged hundreds of thousands of farmers and their families to immigrate into the newly watered lands: each farmers was allocated 50 acres, and a grid like pattern of villages was built to house the new "canal colonies".

The development of irrigation is continuing today. Under the Indus settlement between Pakistan and India, the entire flow of the Sutlej and the Ravi rivers will be diverted to India. The area previously irrigated from these rivers will be provided with water by new barrages and canals which will carry some of the flow of Indus, Jhelum and Chenab to the eastward.

In 1963, the canals in west Pakistan water 23 million acres (1 million acre = 40 miles square) of land – which by far the largest single irrigated regions on earth.

One obvious problem seen by the Pakistan Government was the damage to the cultivated land by water logging and the accumulation of salt – twin evils responsible for affecting the ancient and modern irrigation schemes.

It is usual to suspect inadequate drainage in an irrigation scheme as the chief cause of waterlogging and salinity – which is justified for the case of Punjab. It is to be noted that most of salt in the soils of many areas was there before irrigation began.

The hydrology of the Indus plain is dominated by the great size and flatness of the area. **In the 700 miles from Lahore to the Arabian sea, the drop is only 700 feet. Drainage is therefore extremely difficult, even if one is conscious of the problem and prepared to spend money, there is nowhere for the water to go.**

The hydrological regime can be divided into two parts – The Punjab has in its northern part 10 – 20 inch of rain fall a year; it has an immense amount of underground sea of fresh water, equivalent in volume to ten years of flow of Indus system, a resource of immense potential importance. The lower Indus plain has much less rainfall (less than 5 inch in Sind) and underground water is salty.

What has happened to the Punjab in the past 60 years. Most of the underground water is fresh in the sense that it is quite suitable for irrigation waters in the arid regions, it contains some dissolved salts. The underground water table formerly came close to the surface only near the rivers; otherwise it lay as much as 100 feet underground. **The construction of canals from which about 40 % of the water percolated into the ground gradually brought the water table very close to the surface over large regions of the plain. When this happens the low-lying areas will become water logged drowning the crops, in other places the water creeps to the surface continuously from water table by capillary action and evaporates leaving its dissolved salts behind. These salts accumulate in the top few feet of soil and poison the crops.** Only a part of the soil salt has accumulated in this way. A part of it has resulted from evaporation of irrigation waters which is customarily spread so thinly over the fields that non is left for leaching.

At present, in the irrigated regions 1.5 feet of water is used on average each year for irrigation whereas twice this amount is need to allow sufficiently downward percolation to prevent salt accumulation.

The only way to get rid of salt from soils is to wash it out and at the same time lower the water table. **The horizontal drainage would be extremely costly as chief means of tackling this problem because of the insignificant slope of the ground. The vertical drainage is the solution which will increase evaporation and at the same time allow some of the water to percolate downward from the surface, carrying dissolved salts back to the ground.** A network of deep tube wells can be sunk into the underlying waters, which is then pumped to the surface for irrigation purposes using electricity generated from natural gas and hydroelectric works. Some of the waters seeps back underground leaching away the salt in the process, but some of it evaporates. In this way the level of underground water is lowered.

To achieve substantial lowering of the water table we have to exploit the geometry, especially the fact that, with increasing size of a surface, the area increases more rapidly than its perimeter. our calculations show that only when we deal with an area of about one million acres (roughly 40 square miles) is the perimeter across which seepage will occur, small enough compared to the pumped area to permit the elimination of water logging with in year or two. We have therefore, proposed to the Pakistan Govt that it should divide the irrigated regions of the northern Indus plain into areas of roughly a million acres and proceed with tubewell programmes. Our primary conclusion, however, is that the proposed million-acre tracts for tubewells schemes must be energetically developed in other ways; otherwise the projects are doubtful economic or social values.

In the major part of the Sind, where underground water is salty ,a combination of tubewell and conveyance channels to carry the salty water back to Indus is the probably the most economical solution. Here the size of drainage areas is not so critical, but other reasons call for reclamation over large areas.

We have urged that careful budgeting for all the Indus water. Maps of the mechanical composition, salt content and cation-exchange characteristics of soils are needed, not only as basis for determining cropping patterns but also for planning capital expenditure for development.

All aspects of the programmes rest on agricultural extension and vigorous education programmes to guide farmers in carrying out this task. Corrosion resistant tubewells are needed to pump the highly saline under groundwater.

ANNEXURE V

TABLE I ELEMENTAL ANALYSIS OF COAL AND FLYASH SAMPLE FROM GNDTP – Only one time sampling was done on 27 Jan. 2010.

Guru Nanak Dev Thermal Power Plant (GNDTP)	Fe (%)	Rb (ppm)	Sr (ppm)	Y (ppm)	Zr (ppm)	Mo (ppm)	Pb (ppm)	Th (ppm)	U (ppm)
Pulverized coal being used	**1.4 %**	**11**	**38**	**30**	**175**	**< 10**	**~7**	**3**	**<1**
Dry flyash generated by	**2.8 %**	**24**	**117**	**78**	**330**	**< 10**	**20**	**7**	**<2**
Other elements in Flyash – Ti, Mn, Cu, Zn, Ga, As, Nb………(below 50 ppm)									

TABLE II Elemental analysis of the samples collected by the team of Punjab Pollution Control Board, Patiala, Punjab Pollution Control Board, Bathinda, and EDXRF lab., Physics Department, Panjab University. The samples were collected and brought to Panjab University in the sealed form by the members of EDXRF lab. The analysis was done for the elements in the range Z=19 to Z=47 and Z=78 to Z=92.

Water sample location	Residue (mg/litre)	Elemental concentration (ppb)				
		U	Mo	Sr	Br	Fe
Guru Nanak Dev Thermal Power Plant, Bathinda						
Ash slurry samples from ash dykes	324	<3	28	266	6	1427
Ash slurry sample coming out from pipe	350	<3	21	281	<2	677
Standing water on the dykes	450	<3	227	341	7	869
Bathinda branch canal running along ash	93	<2	<2	103	3	537
Lake water	289	<3	23	239	9	1425
Hand Pump, Near ash dykes (GNDTPP)	602	3	9	1024	58	905
Hand pump in between the ash dykes and	108	3	4	268	2	1918
Private Tube well 100 m away from ash	1225	45	152	916	212	1762
Private Tube well 150 m away from ash	491	5	50	255	114	739
Hand pump opposite GNDTPP	247	18	5	1210	16	691
National Fertilisers Limited, Bathinda						
Distributory of Bathinda canal branch near	100	<2	<2	93	8	267
Hand pump near carbon slurry dykes of	985	70	262	757	159	3386
Hand pump near NFL	95	<2	<2	75	<1	122
Hand pump near APEX Carbonics Pvt.	123	<3	8	543	7	370
Hand pump in between GNDTPP and APEX	1693	25	131	1219	399	1090

Hand Pump near NFL township	268	<3	<2	309	<2	604
Tap water at the guest house of NFL	74	<3	<2	59	2	566
Villages around Bathinda city						
Hand pump, Jajjal village	3467	98	27	1650	994	210
Hand pump, Giana village	998	18	40	720	780	140
Hand pump, Malkana village	1242	6	5	970	1248	110
Hand pump, bus stand, Gill Patti village	3130	36	27	2428	1085	<20
Private Tube well , Gurudwara, Gill Patti	1000	22	2	793	198	<10
Hand Pump, Railways crossing,	2552	78	45	3044	1043	<20
Handpump, Main road side, Baluana	4750	212	-	6165	4432	1140
Guru HarGobind Thermal Power Plant, Lehra Mohabat, Bathinda						
Hand Pump water, at G.T. Road opposite	694	14	15	842	241	<10
Hand pump near main gate of GHTPP	656	19	47	1061	201	916
Hand pump near wagon tripler near GHTPP	236	22	5	822	58	456
Hand pump near ash dykes of GHTPP	320	11	5	280	45	254
Hand Pump at G.T. Road near Lehra	230	<3	54	144	7	667

Other elements Ca, Ni, Cu, Zn, As, Rb, Pb were also observed at some places. The values of As and Pb are not alarming.

TABLE III

Elemental analysis of the samples collected by the team of Punjab Pollution Control Board, Patiala, Punjab Pollution Control Board, Ludhiana, and EDXRF lab., Physics Department, Panjab University. The samples were collected and brought to Panjab University in the sealed form. The analysis was done for the elements in the range Z=19 to Z=47 and Z=78 to Z=92.

Table – Analysis of water samples for limited elements – Concentrations in Microgm/L

27-9-2010	**Sample collxn – Budha Nala**	Water residue	Ca	Cr	Mn	Fe	Co	Cu	Zn	As	Pb	Br	Rb	U	Sr
NBN1	Point Source Budha Nallah at Bhamain Kalan	573	125858	DL	214	3036	DL	413	786	3	6	DL	9	2	208
NBN2	Point Source Budha Nallah Near Shamshan Ghat	1033	165202	662	DL	21888	DL	796	1077	7	38	DL	12	12	447
NBN3	Point Source Budha Nallah Near Chand Cinema	1506	231659	1534	DL	30443	212	908	1075	1	52	DL	18	22	473
NBN4	Point Source Budha Nallah Village Wallipur	610	123334	421	108	14573	98	524	586	2	21	DL	9	5	171
NBN5	River Satluj u/s Budha Nallah	270	46910	202	64	4992	24	168	48	1	4	DL	2	DL	36
NBN6	River Satluj d/s Budha Nallah at Wallipur	237	40877	54	99	3381	DL	172	36	2	3	DL	1	DL	35

DL – below detection limit

Table III – Analysis of water samples for limited elements – Concentrations in Microgm/L

SAMPLE LABEL	SATLUJ	Water residue	Ca	Cr	Mn	Fe	Co	Cu	Zn	As	Pb	Br	Rb	U	Sr
NC1A	Up Stream East Bein before the mixing of Phagwara Drian	420	66247	DL	DL	7377	35	168	65	39	6	49	4	2	206
NC2A	Point Source Phagwara Drain	747	90899	DL	DL	1839	DL	81	28	DL	DL	89	6	2	513
NC3A	Down Stream East Bein after mixing of Phagwara Drain	577	90312	DL	DL	6858	DL	72	463	17	DL	64	9	6	396
NC4A	Up Stream East Bein before the mixing of Garha Drain	333	92682	190	DL	2977	DL	61	25	10	DL	6	4	1	95
NC5A	Point Source Garha Drain	600	132385	239	DL	2890	DL	110	358	16	DL	73	12	DL	415
NC6A	Down Stream East Bein after mixing of Garha Drain	460	94788	DL	127	2254	DL	58	22	24	DL	277	DL	DL	350
NC7A	Up Stream East Bein before the mixing of Kala Singha Drain	940	106193	DL	DL	2632	DL	DL	DL	DL	DL	90	11	DL	279

SAMPLE LABEL	SATLUJ	Water residue	Ca	Cr	Mn	Fe	Co	Cu	Zn	As	Pb	Br	Rb	U	Sr
NC8A	Point Source Kala Singha Drain	1283	139485	DL	DL	2702	DL	DL	32	8	DL	183	12	DL	310
NC9A	Down Stream East Bein after mixing of Kala Singha Drain	853	146344	DL	DL	3312	DL	64	64	1	9	495	15	4	288
NC10A	Up Stream of Satluj before the mixing of East Bein	573	101949	DL	DL	3439	36	94	27	22	DL	73	6	7	298
NC11A	Point Source East Bein	257	68800	DL	DL	3029	DL	52	29	9	DL	12	DL	DL	148
NC12A	Down Stream of Satluj after mixing of East Bein	407	89562	281	DL	3680	43	67	DL	12	DL	30	3	DL	201
NC13A	Kali-Bein (Additional sample)	270	88892	219	DL	2733	20	27	6	15	DL	30	2	2	151

DL – below detection limit

CONCLUSIONS – NONE OF THE INDUSTRIAL OR HUMAN WASTE IN BUDHA NALA AND OTHER BEINS SHOWED SIGNIFICANT CONCENTRATIONS OF URANIUM.

ANNEXURE VI

See websites –https://canceratlasindia.org/chapter4_1.htm, https://canceratlasindia.org/map.htm

Chapter 1

The cancer registries under the National Cancer Registry Programme (NCRP) have provided since 1982 an idea of the magnitude and patterns of cancer in selected urban centres including one in a rural sector. However, extensive areas remain essentially uncovered and therefore the picture of cancer in several urban centres and rural regions remain largely unknown. India is a vast country with populations having varied cultures, customs and habits. The environment differs and so does dietary practices, and socio-economic status. Important differences exist in the ways of living of the urban and rural populations. Geographic differences in patterns of cancer have already been observed among the different registries under the NCRP. For example, cancer of the gall bladder has a comparatively higher incidence in the population based cancer registries (PBCRs) of Delhi and Bhopal, while cancer of the stomach has been the consistent leading site of cancer among males in Chennai and Bangalore. The incidence rates of some sites of cancer like female breast has shown an increase over the years in some registries, whereas others like cancer of the cervix and oral cavity have recorded a decline. (NCRP, Reports 1985 to 2002). Therefore, the broad purpose was to develop an atlas of cancer for the whole of India. Setting up of new registries throughout the country as in some Western countries would involve enormous and probably prohibitive cost in establishing and maintaining the same. The data of the NCRP has shown microscopy as the basis of diagnosis in over 80-85% of registered cases of cancer. The basic and critical principle in the working of this project, therefore, was that the Department of Pathology (in medical colleges and hospitals) constituted the nodal point for obtaining data on cancer.

Modern electronic information technology has been used to capture information on cancer cases as and when they are microscopically diagnosed and reported. The collaborating centres transmit the required information (mainly patient identification details including area of living, and site and morphology of tumour) on all malignant cases on-line through a web-site. The project was commenced with the following main objectives:

(i) to obtain an overview of patterns of cancer in different parts of the country;

(ii) to calculate estimates of cancer incidence wherever feasible.

The overall aim of the study was to get to know the similarities and differences in patterns of cancer across the country in a relatively cost-effective way using recent advances in computer and information technology transmission. Knowing patterns of cancer across the country would provide important leads in undertaking aetiological research, in targeting cancer control measures and in examining clinical outcomes. Certain subsidiary outcomes that emerged out of this exercise were: (a) Strengthening of departments of pathology in medical colleges and other hospitals with personal computers and internet connection; (b) Orientation/training in cancer registration and epidemiology to pathologists as well as other interested clinicians. Though the thrust of the project was to gear up pathologists to collaborate and contribute, several clinical oncologists have actively collaborated.

See websites –https://canceratlasindia.org/chapter4_1.htm,

FIGURE 4.1(a) : Districtwise Comparisons of MAAR with that of PBCRs under NCRP
All Sites (ICD-10:C00-C96) **- Males**

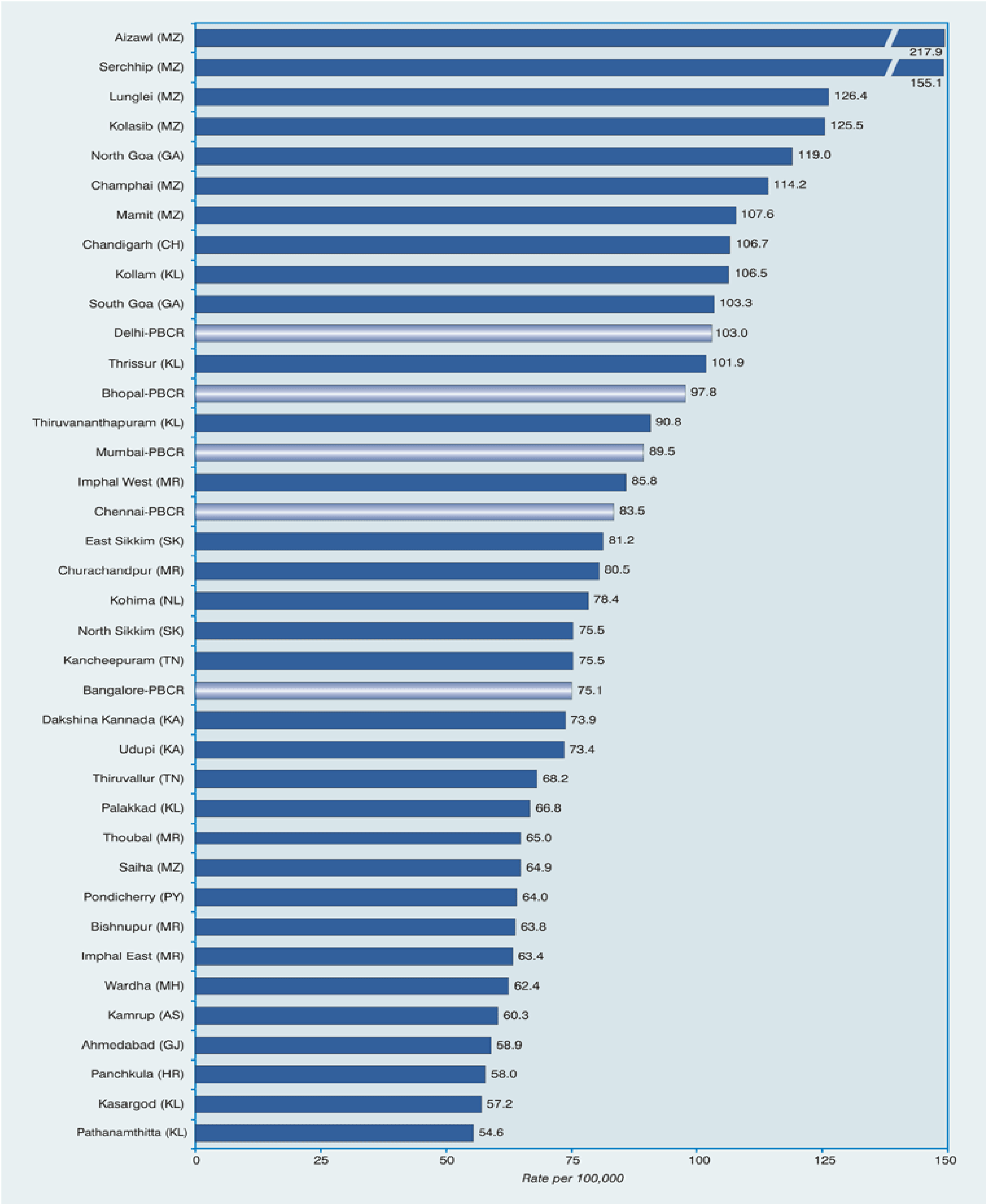


FIGURE 4.1(a) : Districtwise Comparisons of MAAR with that of PBCRs under NCRP

All Sites (ICD-10:C00-C96) **- Males - (Contd...)**

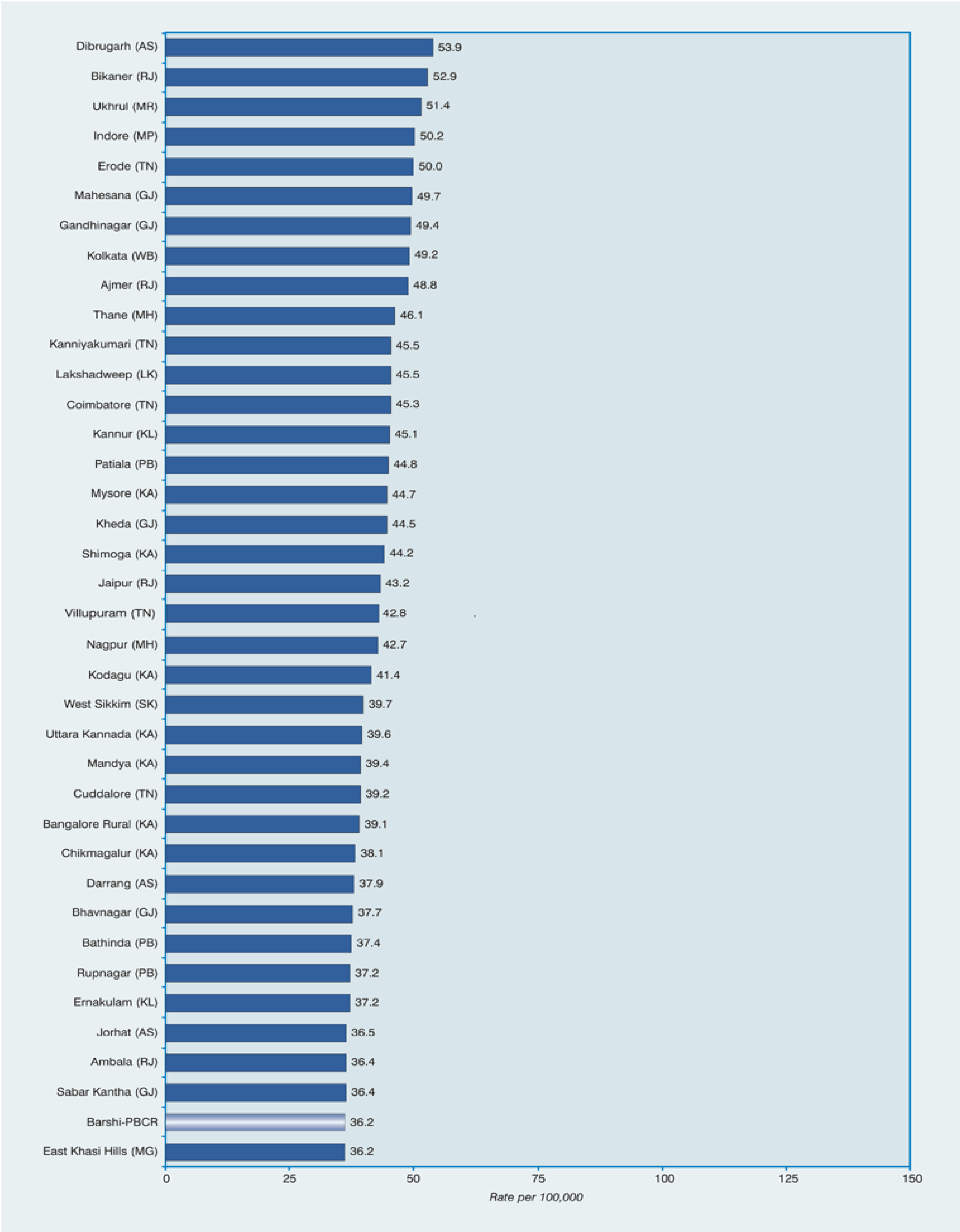


FIGURE 4.1(a) : Districtwise Comparisons of MAAR with that of PBCRs under NCRP
All Sites (ICD-10:C00-C96) **- Females**

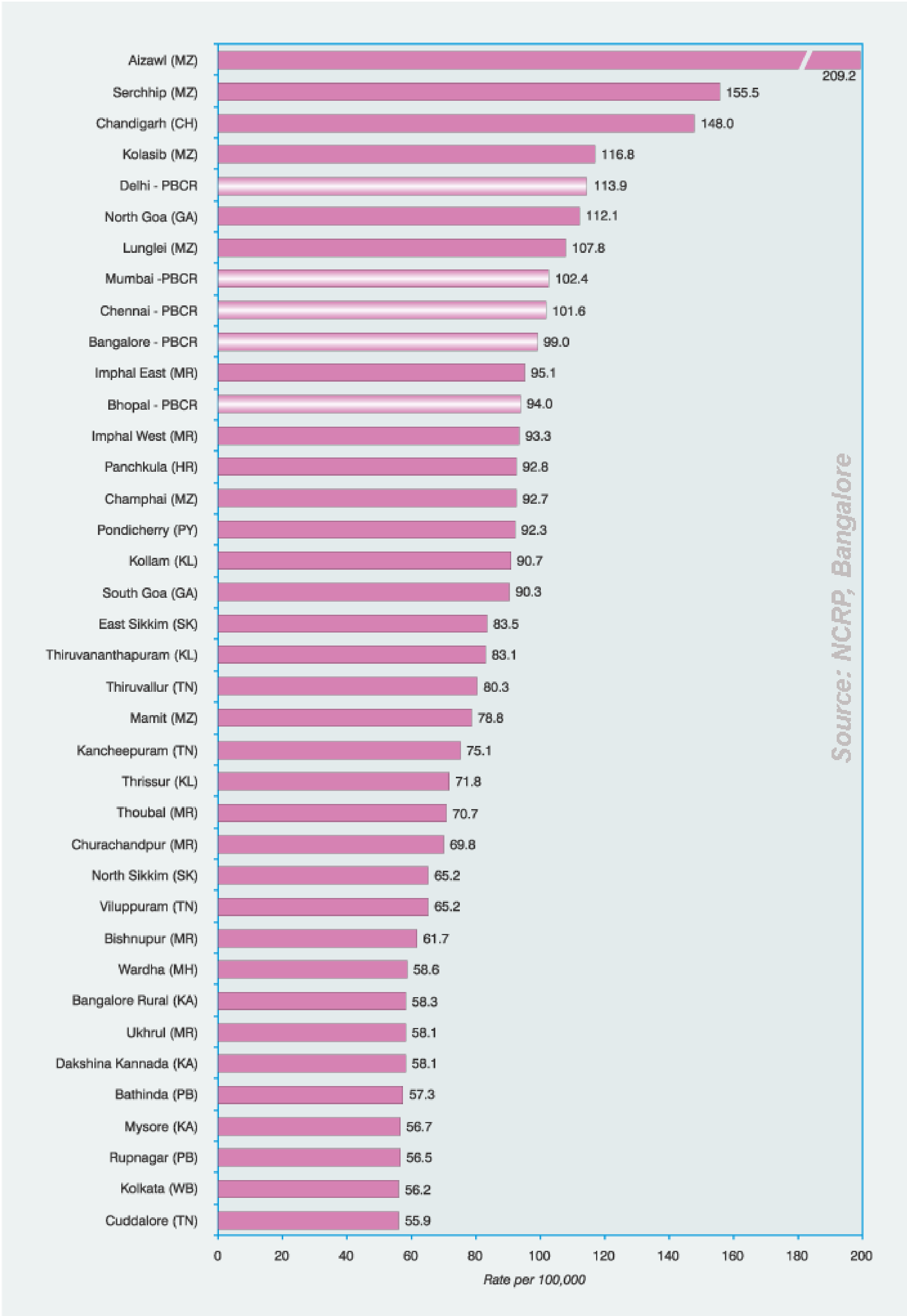


FIGURE 4.1(b) : Districtwise Comparisons of MAAR with that of PBCRs under NCRP
All Sites (ICD-10:C00-C96) **- Females - (Contd...)**

Chapter 7

PROFILE OF CANCERS IN COLLABORATING CENTRES

This chapter gives a summarized account of each of the centres that have collaborated and contributed information on cancer cases.

In all, 105 centres contributed information on 2,17,174 cases for the two year period 2001-2002 (1,03,081 for 2001 and 1,14,093 cases for 2002). The checks on data, inclusion and exclusion criteria, and the basis for grouping to look at leading sites etc, are all given in Chapter 2 on `Overall Plan and Methods'.

Format of Presentation

Overall, the following order of sequence has been followed in arranging the write-up and tabulations of each centre. Broadly the centres consist of the following:

1. Centres with Hospital Based Cancer Registries (HBCRs) under the National Cancer Registry Programme (NCRP);
2. Centres with functioning HBCRs, other than those in the NCRP network;
3. Population Based Cancer Registries (PBCRs) under the NCRP;
4. Functioning PBCRs other than those in the NCRP network;
5. All other centres - mainly, these consist of Regional Cancer Centres other than those covered in 1 - 4 above, private cancer centres, government and private medical college hospitals, non-teaching government and private hospitals and private pathology laboratories.

Under these five broad groups, the profile and summary tables and figure of each centre is arranged in the descending order of the number of cancers (for the combined years 2001 and 2002) on which information was provided towards the project.

Moreover, the contribution of information on cancers by the PBCRs is that of persons other than those residing in the respective PBCR area.Further, no such charts or district-wise distribution of tables are given for centres where the numbers of cancers are relatively small (by and large less than two hundred cases or where counts for leading sites got into single digits).

Summary of Cancer Patterns

There are several limitations in describing patterns of cancer in individual centres especially in the context of geographical distribution. The leading sites of cancer in a given institution are dependent on a number of factors, such as, the popularity of a particular department and/or treating physician, the availability of a particular diagnostic or treatment facility, the affordability of the patients and so on. In some centres one could be dealing with small numbers of cancers. Thus, either the order of leading sites or fluctuation of the same between the years provides little meaning. Still, the patterns observed in most of the cancer centres that function as referral institutions for care of cancer patients do reflect the predominant cancers in the region. Further they give an indication of the magnitude and burden of cancer in the specific institution.

The foregoing points have to be kept in mind while interpreting the description (given below) of the patterns of cancer based on the leading anatomical sites of cancer, by individual institution.

Leading Sites of Cancer in Males (relative proportion (%) of all cancers given in parentheses)

Among males cancers of sites associated with use of tobacco were the most important. These cancers were generally referred as Tobacco Related Cancers (TRCs). Among the TRCs the prominent ones seen in the collaborating centres are mouth, lung, tongue, oesophagus and hypopharynx. They were seen uniformly in all centres regardless of geographical location and were among the five leading sites of cancer in many of the centres. Cancer of the mouth was the leading site of cancer in several centres and constituted nearly 27% of cancers of all sites at the A.H. Regional Cancer Centre in Cuttack, Orissa State. Cancer of the lung was also the leading site of cancer in many centres and in the two major institutions in Kolkata - Chittaranjan National Cancer Institute and Cancer Centre and Welfare Home it forms 13.8 and 13.6% of cancers respectively. Cancer of the tongue was the leading site of cancer in the two collaborating institutions from Gujarat State (Gujarat Cancer and Research Institute and Pramukhswami Medical College - 11.1 and 19.0% of cancers) and in

Kuppuswamy Naidu Memorial Hospital (9.1%) in Coimbatore, Tamil Nadu State. Cancer of the oesophagus was the leading site in the Karnatak Cancer Therapy Institute (15.7%) in Hubli, Bharat Hospital (12.7%), Mysore and in Kidwai Memorial Institute of Oncology (9.7%), Bangalore - all in Karnataka State. It was also the leading site at Government Medical College (11.4%), Patiala, Punjab State. Cancer of the hypopharynx was the leading site of cancer in Dr B.B. Barooah Cancer Institute constituting 18.2% of all cancers. Cancer of the larynx, which is also a TRC site was the leading cancer in several centres. Some of these centres included PGIMR (Histology) (13.7%), Chandigarh, Jawaharlal Nehru Medical College (13.5%), Aligarh, Uttar Pradesh State and Government Medical College (11.0%), Nagpur, Maharashtra State.

Cancer of the stomach was prominent among the leading sites in the centres at Civil Hospital (29.1%), Aizawl, Mizoram State, Regional Institute of Medical Sciences (15.2%), Imphal, Manipur State. It was also the first or second leading site of cancer in three collaborating institutions (Sudharma Laboratory - 19.7%; Government Medical College - 14.5%; Amala Cancer Hospital and Research Centre - 10.4%) in Thrissur, Kerala State.

Cancer of the penis, was observed as a leading site of cancer at Rangaraya Medical College (second leading site - 11.0% of all cancers), Kakinada, Andhra Pradesh State; JIPMER (fourth leading site - 7.6% of all cancers), Pondicherry and in the Sai Subramaniam Pathology Laboratory (sixth leading site - 5.2% of all cancers) in Coimbatore, Tamil Nadu State.

The anatomical site - termed as 'Other Skin' that excludes melanoma of the skin was seen to be a major site of cancer in some centres. This was not observed in the hospital cancer registries under the NCRP.

It was the second leading site of cancer at S.N. Medical College (7.6%) Jodhpur in Rajasthan State; at Mahatma Gandhi Institute of Medical Sciences (6.2%), Wardha, Maharashtra State, Tirunelveli Medical College (6.1%), Tirunelveli, Tamil Nadu State, and at JIPMER (5.1%), Pondicherry.

The leukaemias and Non-Hodgkin's lymphomas constituted a major leading site of cancer in most centres. Cancer of the prostate was also one of ten leading sites in several centres. Apart from these, other sites that appeared as the first or second leading site of cancer were more likely due to the biases indicated above including the small numbers of cases reported from that institution than due to any reflection of geographic patterns.

Leading Sites of Cancer in Females (relative proportion (%) of all cancers given in parentheses)

Cancer of the cervix was the leading site of cancer in many institutions. The relative proportion was highest (77.6%) at the MNJ Institute of Oncology, Hyderabad, Andhra Pradesh State. The relative proportion was also high at JIPMER (55.1%), Pondicherry and at Karnatak Cancer Therapy Institute (43.2%) in Hubli, Karnataka State.

Cancer of the breast was also the leading site of cancer in various institutions. At Apollo Hospital, Hyderabad, Andhra Pradesh State it formed 36% of all cancers in females. The relative proportion of cancer of the breast was higher than 30% in many centres, notably, Government Medical College (32.7%), Patiala, Punjab State; Bhagwan Mahaveer Cancer and Research Centre (32.2%), Jaipur, Rajasthan State; Goa Medical College (31.9%), Goa State.

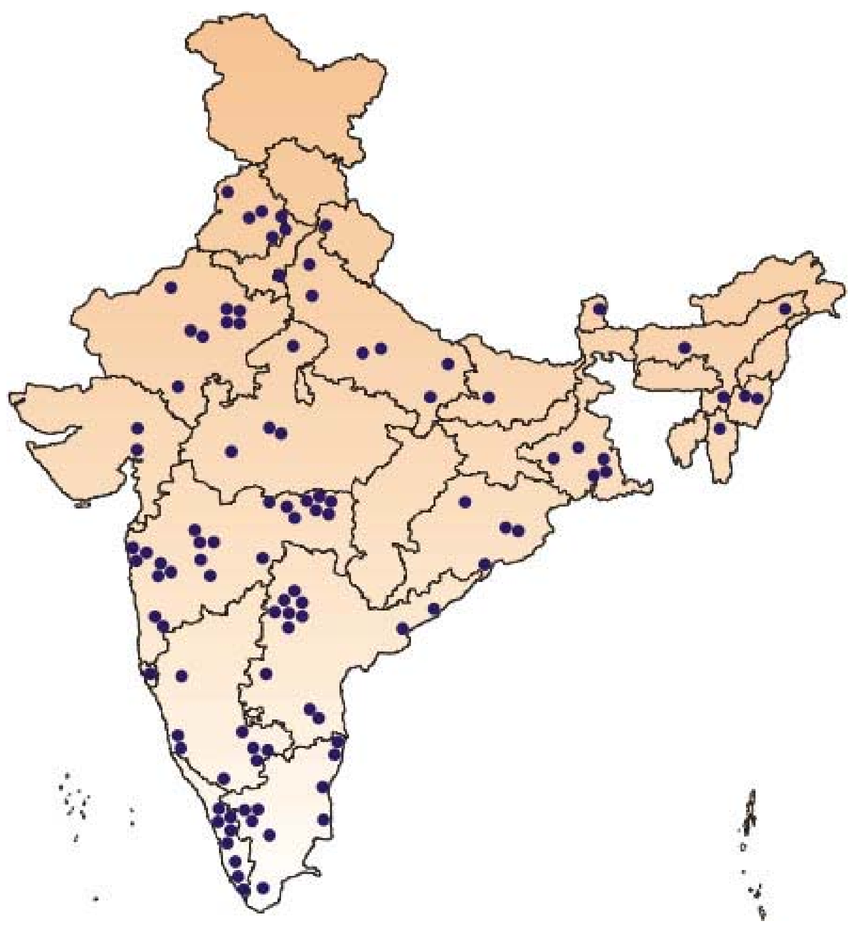
Cancer of the ovary was an important site of cancer constituting 9% of cancers in Government Medical College, Thrissur, Kerala State, 7.2% at PGIMER (Cytology), Chandigarh and 6.8% at Government Medical College, Nagpur, Maharashtra State.

Nine percent of cancers in females reported at the Regional Cancer Centre, Thiruvananthapuram, Kerala State, were cancers of the thyroid. The relative proportion of this site of cancer was 5.0% at Kasturba Medical College, Manipal and 4.9% at Kasturba Medical College, Mangalore, both in Karnataka State.

Cancer of the gall bladder accounted for 9.6% of all cancers in females at the Mahaveer Cancer Sansthan in Patna, Bihar State and was the third leading site of cancer. Both the major institutions in Kolkata - Cancer Centre Welfare Home and Chittaranjan National Cancer Institute recorded this site of cancer to be 6.0% and 5.8% of all cancers, being the third and fourth leading sites respectively.

In females also, cancer of the stomach was an important leading site in the institutions in the states of Mizoram and Manipur. In the Civil Hospital in Aizawl, Mizoram State, it formed 14.4% of all cancers and was the second leading site of cancer. Similarly, in the Regional Institute of Medical Sciences, Imphal, Manipur State, stomach cancer constituted 8.6% of all malignancies in females and was the fourth leading site of cancer. Cancer of the stomach was also one of five leading sites in the centres at Thrissur, Kerala State (Sudharma Laboratory - second leading site and 9.9% of all cancers; Government Medical College - fifth leading site and 5.0% of all cancers; Amala Cancer Hospital and Research Centre - fifth leading site and 4.5% of all cancers).

Cancers of the mouth and oesophagus were among the important and leading TRCs in females. Cancer of the mouth was the second leading site at A.H. Regional Cancer Centre (15.5%), Cuttack, Orissa State. In JIPMER (8.1%) and in Dr B.B. Barooah Cancer Institute (8.2%) it was the second and fourth leading site of cancer respectively. In the latter institution, cancer of the oesophagus was the third leading site forming 12.6% of all cancers. Cancer of the oesophagus was also the third leading site in the Karnatak Cancer Therapy Centre (9.7%), in Hubli, Karnataka State, at the Acharya Tulsi Regional Cancer Treatment Centre (7.6%) in Bikaner, and at Santokba Durlabhji Memorial Hospital (7.4%) at Jaipur in Rajasthan State. Two institutions in the North Eastern states - Regional Institute of Medical Sciences (9.9%), Imphal, Manipur State and Civil Hospital (10.3%), Aizawl, Mizoram State had cancer of lung as the third and fourth leading site of cancer respectively.



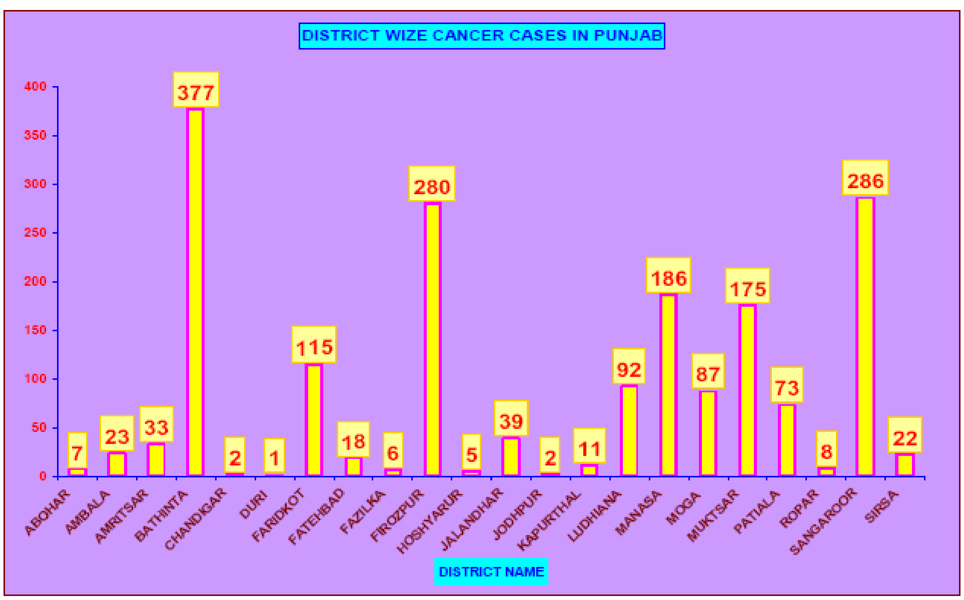
A part of report on Cancer Patients at Acharya Tulsi cancer hospital and Regional Research Center, Bikaner by Dr. A.V.Ratnam

http://cheminova.dk/download/Indien/cancer_study_report.pdf

The data of the cancer patients who were treated at the Bikaner hospital

Data of Punjab district wize 2005

SINO	DISTRICT NAME	NO OF CANCER CASES
1	ABOHAR	7
2	AMBALA	23
3	AMRITSAR	33
4	BATHINDA	377
5	CHANDIGAR	2
6	DURI	1
7	FARIDKOT	115
8	FATEHBAD	18
9	FAZILKA	6
10	FIROZPUR	280
11	HOSHYARUR	5
12	JALANDHAR	39
13	JODHPUR	2
14	KAPURTHAL	11
15	LUDHIANA	92
16	MANASA	186
17	MOGA	87
18	MUKTSAR	175
19	PATIALA	73
20	ROPAR	8
21	SANGAROOR	286
22	SIRSA	22
	TOTAL	**1848**



Data of Rajasthan district wize 2005

SLNO	DISTRICT NAME	NO OF CANCER CASES
1	AJMER	10
2	ALWAR	9
3	BANSWADA	1
4	BARAN	4
5	BARMER	4
6	BHARATPUR	2
7	BHILWARA	4
8	BIKANEER	951
9	BUNDI	1
10	CHITORGARH	4
11	CHURU	424
12	HANUMANGARH	412
13	JAIPUR	7
14	JAISALMER	7
15	JALORE	1
16	JHALAWAR	9
17	JHUNJHANU	155
18	JODHPUR	38
19	KARAULI	1
20	KOTA	7
21	NAGAUR	183
22	PALI	19
23	SIKAR	88
24	SRIGANGAN	528
25	UDAIPUR	1
	TOTAL	**2870**