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A report on Groundwater quality studies in Malwa region of Punjab, MUKTSAR

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Abstract
Punjab is the most cultivated state in India with the highest consumption of fertilizers. Muktsar district is one of them. Economy of the district is based on the Agriculture crops and 80% population of the district is engaged in Agriculture. Sri Muktsar Sahib is situated in the cotton belt of Punjab. Paddy, Wheat, Sugarcane, Oilseeds, Pulses and vegetables are also cultivated in this area. This paper highlights the analysis of groundwater quality parameters and compares its suitability for irrigation and drinking purpose. Water samples were collected from hand-pumps at different depth in October 2010. . Water samples were analysed for almost all major cations, anions, dissolved heavy metals and turbidity. parameters like total hardness, EC, magnesium ratio, were calculated on the basis of chemical data. A questionnaire was also used to investigate perception of villagers on taste and odour. The heavy metals studied in industrial area of Muktsar were Mercury, arsenic and lead. Comparison of the concentration of the chemical constituents with WHO (world health organization) drinking water standards of 2004 , ICMR limits and various classifications show that present status of groundwater in Muktsar is not suitable for drinking. Higher totalhardness (TH) and total dissolved solids at numerous places indicate the unsuitability of groundwater for drinking and irrigation. Results obtained in this forms baseline data for the utility of groundwater. No clear correlation between the quality parameters studied here and perceived quality in terms of satisfactory taste response were obtained at electrical conductivity values higher than the threshold minimum acceptable value.
Keywords: Groundwater, Malwa region, Muktsar, Punjab.

I. Introduction

South-western region of Punjab (Muktsar) in India is known for its brackish water and high fluoride content in underground water (Sharma et al., 1995) . The current study attempts to understand some of the underlying issues related to the livelihood of the affected farmers in Muktsar district. The assessment of groundwater quality and livelihood impact studies have been carried out in this region (Muktsar, Malout and Gidderbaha).

The quality of groundwater is deteriorating leading to High TDS, due to industrial and agricultural activities especially in district of Muktsar. Punjab consumes about 17% of pesticides used in India (Tiwana et al., 2007; Singh, 2002; Agnihotri, 2000). Organic carbon content has been reduced to very low and inadequate levels in the state, because of very low or limited application of organic manures and non-recycling of crop residues (Johl et al., 2002). Partial factor productivity of NPK in Punjab has also dropped from 80.9 in 1966-67 to 16.0 in 2003-04, leading to negative balance of nutrients (Benbi et.al., 2006). Hence, farmers in the state have been applying higher and higher doses of major nutrients, especially nitrogen for sustaining adequate production levels. More than 80% of paddy straw and almost 50% wheat straw produced in the state is being burnt in fields every year (Badarinath et al., 2006; Gupta et al., 2004). Apart from air pollution it is affecting the soil fertility heavily. The major location specific problems identified in Punjab are given in Table-1 and Table-2 (Sharma et al., 2011) .

Table1: Problems identified at blocks of Punjab

Problem	Affected blocks
Waterlogging	Jalalabad & Guru Har Sahai (Ferozepur district); Mukatsar, Malout, Kot Bhai & Lambi (Muktsar district).
Salinization of the Groundwater	Mansa Bhikki, Jhunir, Sardulgarh and Budlada (Mansa district); Bathinda, Nathana, Talwandi Sabo, Phul, Rampura, & Maur (Bathinda district); Moga I, Moga II, Bagha Purana (Moga district), Faridkot & Kotkapura (Faridkot district); Muktsar, Malout, Kot Bhai & Lambi (Muktsar district); Abohar, Guru Har Sahai, Khuyan Sarwar, Jallalabad, & Fazilka (Ferozepur district).
Brackish Water	Jhunir, Bathinda, Nathana, Talwandi Sabo, Phul Rampur, Faridkot, Nadala, Patti, Khara Majha and Bhikkiwind blocks.
Depletion of water Level	The groundwater resources of the Punjab are depleting at an alarming rate of 21cms per year.
Micronutrient Deficiency	Patiala, Ludhiana, Amritsar & Muktsar districts

Table 2: Ground Water Quality Problems in Punjab

Contaminants	Districts affected (in part)
Salinity (EC > 3000 µS/cm at 25°C)	Firozepur, Faridkot, Bhathinda, Mansa, Muktsar, Sangrur
Fluoride (>1.5 mg/l)	Amritsar, Bhatinda, Faridkot, fatehgarh Sahib, Firozepur, Gurdaspur, Mansa, Moga, Muktsar, Patiala, Sangrur
Chloride (> 1000 mg/l)	Firozepur, Muktsar
Iron (>1.0 mg/l)	Bhathinda, Faridkot, Fatehgarh Sahib, Firozepur, Gurdaspur, Hoshiarpur, Mansa, Rupnagar, Sangrur

Muktsar is the agricultural dominated district of Punjab located in south-west of the state. The SWOT analysis of data showed that the block wise cropping intensity varied from 179% to 183%. The maximum cropping intensity was in Sri Muktsar Sahib (183%) followed by Malout (182%) whereas minimum was in Lambi Block (178%) which was closely followed by Gidderbaha Block (179%). This was because the soils of Sri Muktsar Sahib and Malout were relatively more fertile with higher percentage of good quality underground water. Gidderbaha and Lambi Blocks had moderate quality of water which led to decline in cropping intensity. Among the agricultural crops during kharif, cotton was the prominent crop which occupied 105000 ha area in this district which was about 17.6% of the state's area under cotton. The next major Kharif crop was paddy with an area of 98000 ha which was 3.7% of the area of the state under paddy. The average yield of different crops varied from block to block. Horticulture and vegetables had occupied 1.5% area while Kinnow, Ber & Gauva were the other fruit crops grown in this district (The govt. official website).

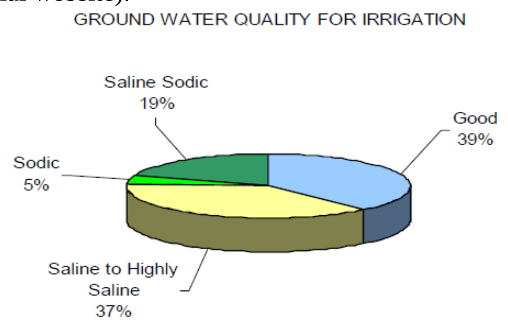

Figure 1. Area under different ground water quality zones in Muktsar district.

II. Materials and Methods

2.1 Profile of the study site

Muktsar District is located in South Western Zone of Punjab. It lies between 30˚69' and 29˚87' latitude and 74˚21' and 74˚86' longitude. It is bounded by States of Rajasthan and Haryana in the South, district Faridkot in North, Firozpur in West and Bathinda in the East (Fig. 2). Muktsar District was carved out of Faridkot district on 7.11.1995 with its headquarter at Muktsar city. There are 234 villages constituting three tehsils (Muktsar, Malout and Gidderbaha) and four blocks (Muktsar, Malout, Lambi and Kot Bhai at Gidderbaha). Water samples were collected from 15 locations from the above blocks shown in table 3. Groundwater is the only source for both drinking and irrigation purpose. Commercial crops grown in the area are cotton and paddy etc. Cotton is one of the major principal crops in this area. The water is extracted by using hand pumps, electrical compressor pumps and from wells.

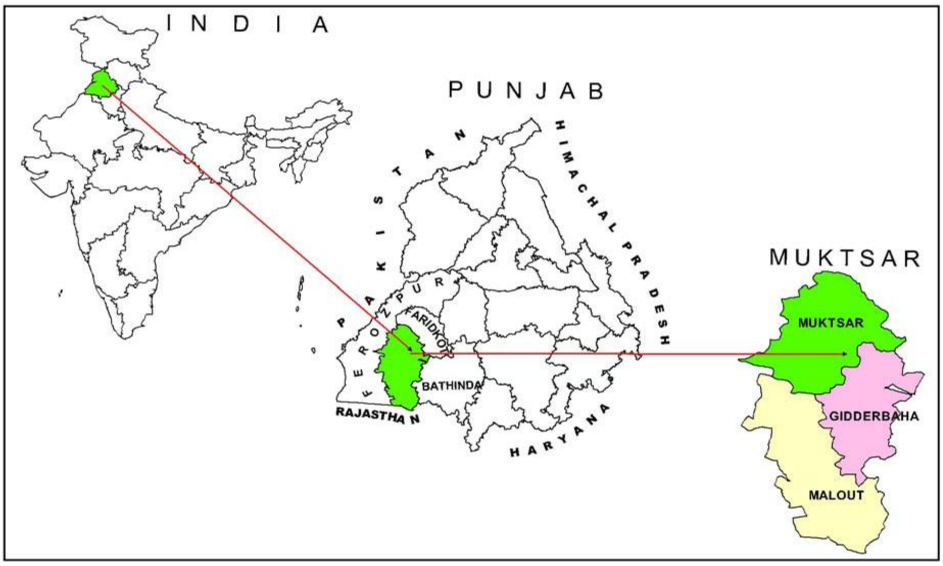

Figure 2. Location of the study area.

Table 3. Sampling locations

Sampling Place	Sampling Point number
Abohar Road side, Muktsar	1
Bus Stand, Muktsar	2
Rupana Setia Paper Industry, Muktsar	3
Mehraj Bus Stand, Muktsar	4
Mehraj, Mohalla Majbi Sikh, Muktsar	5
Aulakh, Muktsar-Malout Raod	6
Malout	7
Bansi Vaishno Dhaba, Malout	8
Dannewala	9
Kario Raod, Malout	10
Husnar	11
Opposite SDM Office, Gidderbaha	12
Bus Stand, Gidderbaha	13
Doula	14
Behman Diwana	15

2.2 Sample collection

A total of 15 samples of groundwater used for drinking purpose were collected from hand pumps at different locations of the blocks of Muktsar, Malout and Gidderbaha during the month of October, 2010. This month was selected because in this month often contamination increases due to low dilution and this tends to the accumulation of ions. Before sampling, the water left to run from the source for few minutes. Then water samples collected in pre-cleaned, sterilized polyethylene bottles of 1 L capacity.

2.3 Methodology

The samples were analyzed to assess various physicochemical parameters according to APHA (2007). Turbidity of a water sample was determined by handheld turbidity meter which is calibrated before taking the reading ((Common Water Measurements, from USGS Water Science for Schools). TDS of water sample were measured using gravimetric method.

The fluoride concentration in the samples were measured by using Fluoride Ion-Selective Electrode Method. The calorimetric and electrode method are the most satisfactory at the present time (Bhatia et al., 1992). The apparatus used in this method were Ion selective meter, Fluoride Electrode, Magnetic stirrer and the reagent used were Fluoride Standards of various ranges (0.2-20ppm) Fluoride buffer (TISAB-Total ionic strength adjustment buffer). In this Ion-Selective Electrode Method, Firstly calibrate the instrument by taking 10ml sample in a beaker at 10ml buffer solution. Put stirring bar into the beaker immerse electrode and start the magnet stirrer and wait until reading is constant withdrawal electrode rinse with distilled water. According to WHO, permissible limit for Fluoride in drinking water is 1.5mg/L (WHO, 1970).

Total alkalinity and total hardness were measured by titrimetric method using standard sulfuric acid and standard EDTA solutions, respectively. The cation calcium was assessed using titrimetric method, whereas anion like chloride was determined using spectrophotometric method respectively. To detect mercury in water sample, cold vapour AAS method was used with a detection limit of 0.05 μg/litre (APHA et al., 1995). Atomic absorption spectrophotometry with vapour generation assembly (AAS-VGA) was used for the trace analysis of arsenic (Behari JR, Prakash R, 2006). Analytical grade chemicals were used throughout the study without further purification. To prepare all reagents and calibration standards, double distilled water was used. All the experiments were carried out in triplicate. After the analysis, the results of all parameters were discussed and correlated.

III. Results and Discussion

3.1 General Parameters

Various physicochemical parameters like PH, total alkalinity, total hardness, turbidity, total dissolved solids, specific conductance or electrical as well as calcium, magnesium, chloride were analyzed with the determination of fluoride concentrations. The heavy metals studied in industrial area of muktsar were Iron Mercury, arsenic and lead. In general, the ground water had no colour, odour and turbidity except few samples. Many of the water samples had slightly salty in nature. The findings and their comparison with WHO health based drinking water guide lines (2008) are presented in Table 5. The data revealed a considerable variation in the water samples with respect to their chemical composition. The pH values greater than 7.5, indicates that the nature of ground water in that region is alkaline.

Many samples having electrical conductivity more than the prescribed limit of WHO standards for drinking water shown that the water is not suitable for drinking as well as irrigation purposes .The WHO acceptable limit for alkalinity in drinking water is 200 mg/l, but from the data record, the total alkalinity was higher than the acceptable limit. According to Durfor and Becker's (1964) classification of total hardness, water was very hard at all the locations (Table 4) (cited in Meenakshi et al., 2004). Except eleven panchayats, the calcium content in water samples was present above the acceptable limit. Also the mag nesium amount lower than the calcium levels in water samples and having the lower and higher values 28mg/L and 90 mg/L respectively.

The chloride concentration was ranged from 208mg/L to 926 mg/L. Except the sample having location no.11, the chloride content in that region faced the WHO acceptable limit appreciably. TheTDS value was ranged from 517mg/L to 4640mg/L which is found to be above the permissible limit of WHO standards.

Table 4: Classification of the water samples based on total hardness

S.No.	Description	Hardness(mg/L)	No. of Samples
1	Soft	0-60	---
2	Moderately	61-120	---
3	Hard	121-180	1
4	Very Hard	>180	14

Table 5. Physio-chemical parameters of sampled waters

Sampling Points →		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Permissible limit**	**Max. Permissible Limit**
Sr.No.	**Parameters ↓**																	
1.	Turbidity (JTU)	1.96	1.56	1.74	1.66	1.74	1.66	1.70	2.12	1.84	1.84	1.96	1.14	2.12	1.68	2.66	2.5	10.00
2.	PH	7.88	7.72	7.88	7.86	8.37	7.54	7.58	7.99	7.67	7.66	8.02	8.06	7.63	7.49	7.88	7.00-8.5	<6.5-9.2
3.	TDS mg/l	3560	1914	1560	1592	868	1340	1162	1060	1540	1692	586	517	1340	1892	4640	500	2000
4.	Total Alkalinity (as Caco3)mg/l	552	472	492	456	492	328	356	642	638	874	318	402	518	568	756	200	600
5.	Total Hardness (as Caco3)mg/l	584	526	732	442	226	724	518	348	492	652	324	168	590	640	724	200	600
6.	Calcium (as Ca) mg/l	176	182	256	178	98	256	204	114	194	318	162	66	192	296	318	75	200
7.	Magnesium (as Mg) mg/l	72	68	108	84	36	118	86	72	82	114	48	28	76	118	190	30	50
8.	Chlorides (as Cl)mg/l	924	424	418	506	218	326	396	518	408	602	208	302	482	624	926	200	1000
9.	Fluorides (as F) mg/l	3.80	2.90	1.60	1.25	1.80	1.10	1.10	4.65	0.70	1.85	2.90	5.45	1.10	1.35	2.85	1.00	1.50
10.	Iron (as Fe) mg/l	0.18	0.12	0.09	0.12	0.16	0.08	0.07	0.14	0.10	0.14	0.08	0.22	0.14	0.12	0.18	0.10	1.00
11	Specific Conductances, micromhos/cm	7224	3880	3126	3190	1764	2740	2340	2070	2840	3164	1080	1020	2590	3680	8960	300	No Relaxation

The permissible limt given by ISI (1991) for mercury in drinking water is 0.001 mg/litre but the concentration of mercury in water sample no. 3 is beyond the desirable limit shown in the table given below. Similarly the value of lead ,iron and arsenic in water sample taken from industrial area is found to be beyond the prescribed limit which is the main cause for various diseases among the people of the Malwa region, Muktsar (Table 6 & 7).

Table: 6 Heavy Metal Analysis of Sample No. 3 (Muktsar)

Sr. No.	**Parameters**	**Results**	**Permissible limit**	**Max. Permissible Limit**
1.	Lead	1.8 μg/l	0.5 μg/l	No Relaxation
2.	Arsenic	1.8 μg/l	0.5 μg/l	No Relaxation
3.	Mercury	0.25 μg/l	0.001 μg/l	No Relaxation

3.2 Fluoride

The fluoride concentration was ranged from 0.70mg/L - 5.45mg/L Fluoride content of water varied within the district and for such variations; there could be various causes such as use of phosphate fertilizers, different geo-chemical conditions. Moreover, fluoride concentrations were also reported to increase with salinity (WHO, 2002).

In the present study, high fluoride concentration was recorded in water samples of Giddarbaha block (5.45mg/L) of the district whereas 4.65mg/L of fluoride concentration was recorded in Malout block. In Muktsar block, 3.80mg/L fluoride concentration was recorded (fig 3) . Intake of fluoride from water led to high fluoride in the human body of the region.

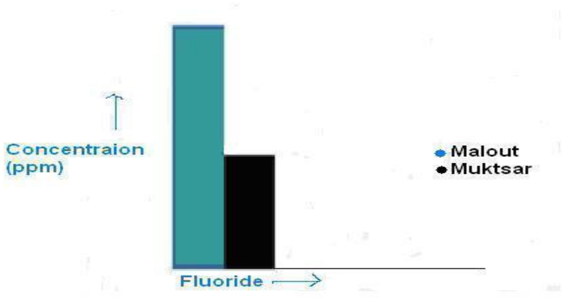

Fig.3 Water Fluoride levels in Malout and Muktsar districts.

In India almost 60–65 million people drink fluoride contaminated ground water and the number affected by fluorosis is estimated at 2.5–3 million (Athavale & Das 1999). Its deficiency (<0.6 mg/l) causes dental caries and excess causes skeletal fluorosis (Susheela et al. 1999). Children are particularly susceptible to this disease and the damage caused is medically irreversible. Continuous ingestion of excessive amounts of fluoride during tooth development causes dental fluorosis. High oral intake of fluoride results in physiological disorders, skeletal and dental fluorosis in human beings and high fluoride levels inhibit germination, reduce productivity, and inflict physiological and biochemical disorders on plants (Suma Latha et al. 1999).

Table 7. Health effects of chemical parameters

Parameters	Potential health effects	Reference
Fluoride	Dental & skeletal fluorosis; non-skeketal manifesatations	Ref.22,23 and 24
Iron	Genetic disorder, gastrointestinal obstruction, abdominal pain, nausea, blood sains vomiting,loose motion	Ref 29, 30
Mercury	Neurological and renal disturbances	Ref. 25
Lead	Damage to brain, kidneys, nervous system & RBC	Ref. 26
Arsenic	Lung & skin cancer, muscular pain, diarrhea	Ref. 27 and 28

IV. Conclusion

South-western region of Punjab in India is known for its brackish water and high fluoride content in underground water (Sharma et al., 1995). Fluoride content of water varied within the district and for such variations; there could be various causes such as use of phosphate fertilizers, different geo-chemical conditions. Moreover, fluoride concentrations were also reported to increase with salinity (WHO, 2002). Several project sare sanctioned by various national and international agencies to supply safe drinking water to the fluoride-affected villages in the country.

The groundwater of the Muktsar district is tested for its chemical composition and suitability for drinking. Most of the water samples do not meet the water quality standards for fluoride concentration and many other quality parameters and at risk from a potential fluorosis and some other diseases like cancer, gastro-intestinal obstraction, damage to brain, kidneys, nervous system & RBC etc. Hence, it is not suitable for consumption without any prior treatment.

V. Recommended Research

As noted above, gaps in the information on fluoride prevented the committee from making some judgments about the safety or the risks of fluoride at concentrations between 2 and 4 mg/L and below. The report makes several recommendations for future research to fill those gaps, as well as recommendations to pursue lines of evidence on other potential health risk (e.g.endocrine effects and brain function). Recommendations include exposure assessment at the individual level rather than the community level; population studies of moderate and severe enamel fluorosis in relation to tooth decay and to psychological, behavioral, or social effects; studies designed to clarify the relationship between fluoride ingestion, fluoride concentration in bone, and clinical symptoms of skeletal fluorosis; and more studies of bone fracture rates in people exposed to high concentrations of fluoride in drinking water.Remadial measures (use of Reverse Osmosis) should be promoted as it remove harmful contents such as fluoride , lead, arsenic and mercury in groundwater which is often high and responsible for bone and joint problems observed in the local population (singh and Kishore, 2010).

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