WATER-LOGGING SCENARIO IN MUKTSAR DISTRICT, PUNJAB STATE, INDIA.

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Abstract: Muktsar area forms a part of Punjab state in India and lies in the south-west portion of the state. It experiences medium-low rainfall and falls in a semi-arid climate zone. It is a part of vast Indo-Gangetic alluvial plains. The groundwater is the backbone of the agriculture in the area and is known for cotton growing. As compared to the north-eastern and central parts of the state which experience depletion of water levels, the studied area in south-west part experienced rise in the water level since last 100 years. Water levels have increased to a level as high as 0.95 meters in some areas in the last 12 years. Water levels are rising since 24 years at rate of 21 cm/year. Rise of water levels has led to the problem of waterlogging and salinity, with depth of water ranging up to 2 meters in the critical areas, making them water logged . High rate of evaporation due to semi arid climate leads to capillary rise of salts to the ground surface making the soils saline and alkaline. The major reason for high levels of groundwater is less pumpage of water due to its chemical quality constraints which makes it unfit for normal usage. An attempt has been made to study the latest field scenario of the problem based upon field trips undertaken during pre and post monsoon periods. The waterlogged areas having depth to water up to 2 mbgl have been found to exist in Alamwala, Jabewali, Mehn-Bhader, Malout, Muktsar, Rupna, Karniwala, Middu-Khera, Panni wala areas of district Muktsar. Remedial measures to control the problem such as construction of drains, subsurface drains, vertical drainage, biodrainage and conjunctive use of surface and groundwater are suggested.

INTRODUCTION:

Water logging is one of the most serious geoenviornmental phenomenon, not only in Punjab state but also around the world causing grave damages to the agricultural land thus affecting the economic status. Water logging literally means saturated with water. Practically it refers to the state of land on which the ground water table is permanently or even temporarily located at or near the soil surface with the result the yield of crops commonly grown is reduced well below the normal for the land, or if the land is not cultivated, it cannot be put to its normal use because of high sub soil water table. The national commission on agriculture (1946) defines an area as water logged when the water table rises to such a level that the soil pores in the root zone of a crop gets saturated resulting in the restriction of normal circulation of air, decline in the level of oxygen and increase in the level of carbon dioxide. In such areas the water table rises to such a level that the soil get saturated resulting in severe damage to the crops. Depending on types of crops, soil condition and ground water quality a water table ranging from 1 to 2 m, of sometimes 2.5m from the ground surface may be damaging to plant growth. On the average a depth of 1.5m is considered as harmful, therefore areas having depth to groundwater within 2m should be considered as water logged as has been done in the present case. Areas where ground water has generally high total dissolved solids content and high sodium content, increased evaporation from high water table and rise of salts by capillary action to the ground surface contribute to the progressive accumulation of soluble salts in the soil rendering them saline, alkaline and unfit for cultivation of non salt resistant crops. Waterlogged and saline soils are found naturally in many regions, but inappropriate irrigation also causes these problems, resulting in economic losses when crop yields are reduced by high water tables and soil salinity (Szabolcs, 1987; Rhoades, 1990; Smedema, 1990; Dregne, 1991; Scherr and Yadav, 1996; Abdel-Dayem, 1997). An important chemical effect of waterlogging is the reduction of pE by the action of the pores in the root zone of a crop organic reducing agents acting through bacterial catalysis. The soil becomes more reducing which results in reduction of MnO_2 and Fe_2O_3 to soluble Mn(II) and Fe(II), the latter being toxic to plants at high level (Anil K.De, Environmental chemistry).

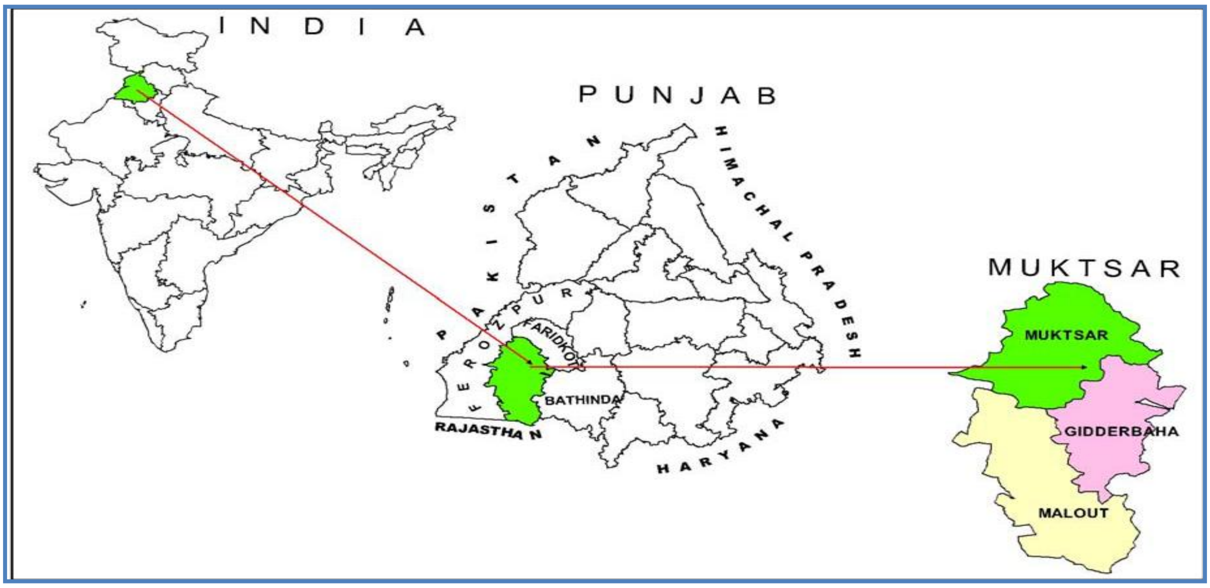
$MnO_2 + 4H^+ + 2 \rightarrow Mn^{2+} + 2H_2O$

$Fe_2O_3 + 6H^+ + 2e \rightarrow 2Fe^{2+} + 3H_2O$

The study area is suffering from very high levels of water i.e. up to 2 meters. This is mainly due to the non utilization of the groundwater. The groundwater in the area is mainly saline and unfit for agricultural processes. Moreover there are 2 major canal networks Sirhind feeder and Rajasthan feeder in the area which indirectly contributes to the waterlogging. The main objective of this study is to understand the areas suffering from the problem of waterlogging in the Muktsar district of Punjab state and suggest some remedial measures to control this problem in future.

LOCATION: Muktsar district lies in south-west part of Punjab state (N290°54’20” and E30°40’20”. Overall it covers an area of 2630 km^2. Muktsar district is divided into four blocks namely Kotbhai, Lambi, Malout and Muktsar. (Fig1)

Fig.1 location of the study area



Rainfall and climate: In this area the monsoon sets in last week of June and withdraws towards the end of September. The rainiest months are July and August. Overall 79% of rainfall is observed in monsoon and rest 21% occurs during non-monsoon period. The climate of the district is semi-arid and hot which remains dry throughout the year except in the rainy months.

Geomorphology: The area forms a part of Satluj sub basin and Indus basin alluvial plains. Topographically the area is almost flat with an average elevation of 200 m above main sea level and slopes gently towards south and southwest. A numbers of sand dunes are present in the area which are of varying detentions and does not show any preferred alignment

Soils: The soils in this area are divided into two types Sierozem soil and desert soil. Sierozem soils are found in whole of the Muktsar district. It is characterised by light yellow to pale brown in colour . These soils are deficient of nitrogen, phosphors and potash. They are calcareous and usually have kankar at depth of 0.75 m to 1.25 m. Desert soils are light brown and are found mainly in southern and western part of malout and lambi block. At places the area is associated with development of highly saline area in form of salt pans. Salt encrustrations are also a common phenomenon in this area (fig 2,3&4)

Fig.2 location Jabewali

Fig.3 location Panni wala fatta

Fig 4 location Karniwala

Canal system: There is an intense network of canals in the area. two major canals Sirhind feeder and Rajasthan feeder are the main source of water supply. These canals are further divided into various distributaries and minors. About 96% of the district is being irrigated by canal irrigation and only 4% area is irrigated by tube well (CGWB,2007)

HYDROGEOLOGY OF THE AREA

The area is a vast stretch of old and recent alluvium of Quaternary and is modified by orogenic processes associated with fluviatile action. The Quaternary sediments has both unconfined and confined aquifer. In general unconfined conditions exist only up to 30m depth. The proportion of permeable beds at deeper depth is generally low. The area is underlain by unconsolidated formation comprising sand silt clays etc. In the district the ground water is generally saline at all levels except at local patches. There is wide lateral variation in the chemical quality depending upon the proximity of the area to the surface irrigation channels. In whole of the district water for irrigation is based on both canal and tube well supplies. The main stress is on canal water because the shallow ground water of the district is alkaline in nature and is moderate to highly saline. Comparing the concentration values of major ions with the recommended desirable and permissible concentration limits for drinking water (Bureau of Indian Standards) it is found that 60% ground water is not suitable for drinking purposes mainly due to nitrate that exceeds the recommended limit of 45mg/l.(CGWB, 2007)

FIELD OBSERVATIONS

A field reconnaissance was conducted to find out the extent of waterlogging in the study area. Depth of water levels was measured along with collection of water and soil samples. Areas like Alamwala, Jabewali, Mehn-Bhader, Malout, Muktsar, Mohini Khera Karniwala, Middu-Khera, Panni wala, Wangal, were found to be critically waterlogged with water levels as high as 2 meters.

Table 1.1 shows the locations and depth of water level in meters.

VILLAGE location	**JUNE_10**	**OCT_10**	**JUNE_11**	**OCT_11**	**JUNE_12**
ASSA BUTTER	5.01	4.05	5.03	2.40	4.20
CHOTIAN			NA	8.86	9.40
DHULKOT			NA	6.84	7.37
DODA	5.30	3.90	5.10	3.15	4.90
FAQUARSAR	2.50	1.90	2.30	1.90	2.80
GAGGA	2.40	0.96	1.20	0.75	1.40
HUSNAR			NA	3.55	3.90
KARNI WALA	0.95	0.75	0.60	0.90	1.65
KHIRKIAN WALA			NA	0.65	1.77
KOT BHAI	5.30	4.90	4.80	4.45	5.10
KOT BHAI	NA	5.07	5.32	4.65	4.82
SHEKH			NA	2.61	3.10
ABUL KHURANA			NA	1.78	2.40
BADAL	3.18	2.38	2.68	1.23	2.33
BANWALA (ANNU)			NA	2.00	2.65
BARIND KHERA	7.13	6.13	5.83	5.06	5.23
BHITIWALA			NA	1.77	2.50
KILLIAN WALI			NA	6.40	6.90
LAL BHAI	2.99	1.59	2.49	1.29	2.74

MANN	3.16	2.13	2.23		
MEHNA	6.40	3.60	3.75	3.23	3.90
MEHNA	3.72	2.90	3.14	2.63	2.80
MIDDU KHERA	1.40	0.70	0.85	0.25	0.90
ALAMWALA	2.17	1.97	2.28	1.37	2.82
ALAMWALA	3.29	1.52	2.28	1.05	2.27
BHUNDER	1.04	0.60	1.30	FILLED	
JHURAR	2.52	1.90	2.50	1.35	2.40
MALOUT	2.65	2.02	2.75	1.80	
MALOUT PIND	1.75	1.90	1.80	0.60	2.15
MOHNI KHERA	1.95	1.90	1.90	1.03	2.10
PANNIWALA FATTA	1.00	0.90	0.90	0.85	1.35
BURA GUJJAR	2.62	2.75	2.95	2.10	2.98
JHABELWALI	1.65	1.00	1.40	0.90	1.45
MEHN BHADER	1.75	1.00	1.45	0.90	1.55
MUKATSAR	3.40	2.40	3.10	1.70	3.10
MURAR KALAN	2.77	2.40	2.65	1.35	2.37
NANDHGARH	3.20	3.05	3.10	2.50	3.20
SANGHO DHAM	1.28	0.38	0.78	0.33	1.23
SOHIWAL	3.80	1.85	2.95	0.70	3.01
WANGAL	1.70	1.60	1.60	1.30	1.20

Through this study it was found that the main reasons for waterlogging in this area was leakage from canal and poor water quality.

To determine the quality of groundwater, samples were collected from various locations for geochemical analysis. The water samples were collected in clear polythene bottles, and then they were labelled and sent in the geochemistry laboratory for analysis. Table 2 shows the results of major elements.

Table.2 study area locations and its chemical parameters (all values are in mg/l except for EC which is in µmohs/cm at 25°C)

S. No	**Village name**	**Ph**	**ECE**	**TDS**	**Ca**	**Mg**	**Na**	**K**	**Co3**	**Hco3**	**So4**	**Cl**	**No3**	**F**
1	**Sarai Naga**	6.90	544	348	23.24	1.27	53.4	103.5	0	225	0.21	42.6	10.42	-
2	**Wrring**	6.45	28	16	323.	28.1	199	473.	0	585	1.39	2272	11.22	-

			7	12	84	1		4						
3	**Chwarwli**	7.00	636	186	22.44	33.015	31.4	10.1	0	135	0.21	63.9	10.60	-
4	**Jhabelwali**	7.05	1247	413	23.24	41.11	35.2	10.9	0	370	0.09	35.5	10.20	-
5	**Ude karan**	7.26	1967	803	16.03	39.234	225	9.5	0	385	0.63	99.4	10.07	-
6	**Bura gujjar**	6.82	3974	1435	384.76	79.71	425.7	16.5	0	335	1.25	802.3	10.68	-
7	**Jasseana**	6.64	3974	1572	133.8	31.41	184.5	220.5	0	525	1.44	1491	14.63	-
8	**Muktsar**	7.32	456	296	6.412	49.321	27.2	11.3	0	755	0.30	78.1	10.21	-
9	**Ruddia**	6.73	1468	963	80.96	17.66	126.8	10.7	0	410	0.64	333.7	10.66	-
10	**Chakduhewala**	7.24	1958	1418	24.84	61.231	80	9.8	0	585	1.21	639	10.63	-
11	**Karaiwala**	6.67	1444	940	80.96	18.213	49.1	40.6	0	285	0.73	319.5	11.30	-
12	**Malout**	7.02	1931	1368	86.57	7.26	473.4	9.6	0	510	1.22	575.1	10.45	-
13	**Harike kalan**	7.25	1394	901	10.42	12.101	302.4	11.7	0	770	0.41	113.6	10.20	1.20
14	**Kotli**	7.15	486	315	48.09	1.944	9.4	3.9	0	950	1.32	85.2	1.02	0.92
15	**Wrring**	6.46	222	144	9.6	0.48	7.8	1.2	0	50	1.00	99.4	0.012	0.29
16	**Duhewal**	6.90	9900	1812	367.13	21.82	490.5	64.6	0	295	2.92	2087.4	35.72	0.31
17	**Khunnan khurd**	6.81	7712	178	60.12	17.1	171	51	0	260	2.67	1536.5	12.22	1.31
18	**Hussner**	7.12	1797	1789	86.57	13.7	273	86.6	0	305	2.48	1216	13.47	1.29
19	**Gidderbaha**	7.09	1101	1220	16.83	17.8	50	11.2	0	170	1.90	276.9	11.11	2.30
20	**Gagha**	6.95	34	70	58.5	3.5	20.2	20.8	0	235	1.55	92.3	11.11	1.2

			80	4										3
21	**Karamgarh**	6.99	1243	1670	16.83	1.7	154.5	10	0	480	2.41	489.9	11.51	1.69
22	**Kabranwala**	6.68	2848	803	9.6	2.62	53.2	12.1	0	270	1.46	241.4	10.25	1.72
23	**Karniwala**	6.48	1833	922	37.67	5.8	139.5	11.1	0	205	2.31	461.5	8.84	1.27
24	**Rupana**	6.50	1678	122	28.05	3	34.2	9.3	0	195	1.76	390.5	10.94	1.65
25	**Muktsar**	6.75	1987	1111	68.13	2.6	98.4	10.3	0	201	1.88	320.1	2.06	0.77
26	**Balamgarh**	7.12	1431	1395	34.46	5.6	96.2	11.9	0	260	1.85	347	1.58	0.88
27	**Chak mahn badher**	6.33	3668	932	16.83	1.9	60.4	5.6		165	1.55	298.2	12.3	0.89
28	**Chibrawali**	6.89	1127	3320	53.45	56.3	1829	56.4	1.5	5.4	2.29	11.4	1.28	2.30
29	**Bam**	7.03	1483	753	9.88	8.69	262	78.5	3	3.8	1.26	1.6	1.03	2.30
30	**Pani wala fatta**	6.98	1834	1004	78.95	65.65	71.65	58.4	1.6	5.3	1.38	3	4.28	1.38
31	**Alamwala**	6.74	561	3421	371.2	488.1	5020	54.6	0	7.1	2.7699	39	2.49	2.30
32	**Abulkhurana**	7.10	2490	368	34.5	24.44	116.1	43.75	0	4.3	1.12	1	1.11	1.26
33	**Danewala**	6.88	1880	1532	110.1	91.4	801.3	31.61	0	15.1	1.34	2	4.80	2.15
34	**Hussnar**	6.37	1265	2408	124.9	175.2	2929	4.67	0	14.4	2.52	19.2	1.74	2.19
35	**Madir**	7.34	1794	850	30.82	34.46	3499	0.95	1.8	15.6	2.56	16.1	1.06	2.30
36	**Faquarsar**	7.11	1018	1297	96.21	48.81	540.2	14.15	0	9.9	1.24	0.5	1.14	2.24
37	**Cherewan**	6.98	1432	668	102.3	52.9	349	44.1	0	9.3	1.50	3.2	2.02	1.0

38	**Marar kalan**	6.59	13 21	97 5	70.4 5	46.3	16.9 7	74.7	0	6.5	1.23	1.1	2.90	1.0 3

After chemical analysis it was found that the groundwater quality of the area was not suitable for irrigation purpose. Irrigation water quality classification as given by Richards (1954) showed that out of 38 samples only 1 sample fell under the category of excellent category (table3) water class for salinity hazard whereas 24 were fair/medium and 8 samples fell under poor/bad water class. On the other hand when sodium absorption ratio was calculated it was found that 4 samples fell under poor/bad

Table 3. Irrigation water quality classification (after Richards 1954).

Water class	**Salinity hazard**		**Alkali hazard**	
	EC(µs/cm)	**No. of samples**	**SAR(epm)**	**No of samples**
Excellent	Upto 250	1	Upto 10	32
Good	250-750	6	10-18	3
Fair/medium	750-2250	24	18-26	0
Poor/Bad	<2250	8	>26	4

Using Wilcox classification (1995) for groundwater irrigation, percent sodium was calculated, and it was found that 34 samples were unfit for irrigation.(Table 4)

Table:4 Suitability of groundwater for irrigation according to Wilcox Classification (1995) in the study area

% Sodium	**Water class**	**No of samples**
<20	Excellent	1
20-40	Good	1
40-60	Permissible	1
60-80	Doubtful	2
>80	Unsuitable	34

Hence it was quite evident that the quality of groundwater in the area was unfit for irrigational practices thus left groundwater unused. This eventually led to rise of groundwater levels.

With development of the study area, intensive irrigation network increased the recharge into groundwater reservoir.

Development of railways, road network, embankments and canals hindered seriously the natural runoff, resulting in larger area remaining submerged for a loner time span thus leading to an increase in seepage of water underground. The canal network in Muktsar has played an important role in water table. Following two factors has been the main reasons for positive water balance.

- Excessive recharge due to seepage from irrigation canals
- Inadequate drainage system causing recharge due to blockade of surface run off.

Figure 5,6 & 7 shows waterlogged locations in the study area

Fig:5 Waterlogging at Karniwala

Fig:6 Waterlogging at Chakduhewal

Fig:7 Waterlogging at Jhabelwali

SUGGESTED SHORT AND LONG TERM MEASURES

Various remedial measures should aim at reducing the groundwater inflow components and increasing the outflow components. Under the prevailing hydrogeological/hydrochemical conditions, the waterlogged areas can be grouped in the following three categories for better perception:

- Areas with fresh groundwater.
- Areas with 15-20 thick fresh water layer over the saline native water.
- Areas with fresh saline native water with negligible fresh water cover.

Keeping in view of complex and seriousness of the problem, the remedial measures can be grouped into short and long term measures which are described below:

SHORT TERM MEASURES

The following short term measures should be taken:

- Excavation of surface drains should be given top priority and whatever possible, the seepage water should also be drained out through them. The low lying pockets should be connected with main drains so that the standing water could be cleared by gravity to the extent possible.
- Existing drainage system, especially in outfall reaches, should be kept clean throughout year. The reconditioning of the drains should be a continuous process where there is excessive growth of weed due to standing water.
- Toe drains should be constructed along the Rajasthan canal and Sirhind Feeder to arrest the seepage from them as much as possible.

- Draft can be increased through vertical drainage by installing shallow tubewells in the area where vertical drainage is feasible without causing upconing of saline waters. Shallow tubewells should be installed where water is fit for irrigation.
- Afforestration measures should be taken up. The vegetation especially deep rooted and high water consuming trees contributes to increased groundwater draft. A closed spaced plantation of canopy trees can remove more than 1000 mm of water per year from soil profile and up to 66 mm during dry season. Thereby, to control the rise of water table in potential waterlogged areas, afforestrartion along field boundaries or waste lands should be encouraged.

LONG TERM MEASURES

The following long term measures are suggested:

- A great deal of research and experimentation needs to be undertaken and farm extension services strengthened by the agricultural Universities and State Departments to educate the farmers on optimum water requirements and use for various crops. The field considerations are:
  - Conjunctive use if fresh and saline water for efficient crop production
  - Development and evaluation of improved irrigation practices.
  - Evaluation of production of various crops under limited water supply conditions.
  - Precise scheduling of irrigation for various crops.
  - Use of sprinkler and drip irrigation.
  - Evaluation of high salt tolerant crops.
  - A few of the measures listed above will reduce percolation while others will consume poor quality water. Based on these studies canal water supplies and allowances can be modified to prevent/ restrict waterlogging.
- Determination of quality of water at various depths in the entire tract to locate sweet water layers so that groundwater pumpage can be increased. In fresh water areas, the increased pumpage will eliminate the problem of waterlogging. However, in areas where fresh water overlies the native saline water or groundwater is generally saline except in local patches, detailed investigations are essential before practical solution is evolved. However, in the saline water areas the basic problem of disposal of pumped saline groundwater. In view of the complex nature of groundwater conditions existing in saline tract, with isolated fresh water lenses, additional studies are essential to get the following information

- Depth wise aquifer zones above the saline water interface.
- Possibility of developing the acceptable quality aquifers.
- Realistic calculations of recharge components from canals and return inflow from irrigation and also the component of recharge from precipitation.

- Water quality and aquifer zones can be mapped depth wise by putting hand bores down to 20 m or more on a grid of about 3 km and also across canal alignment. This interval can be reduced or gaps can be filled by undertaking electrical resistivity surveys. Lithological logs and water samples at 2 m or lesser intervals for demarcation of aquifers and useable quality water zones may be collected.
- Pumping of fresh water lenses should be investigated to avoid upconing of underlying saline water. Detailed pumping tests should be done to evolve a suitable design of skimming wells. Other investigations should include number of wells feasible, their design and pumping schedule for eradicating waterlogging.
- Options for disposal of saline water should be studied. For a permanent solution, the poor quality water has to be pumped or gravity drained to the sea or evaporated in pits to recover salt. The following options are however, available as an interim solution:

  - **<u>Blending Of Fresh saline water:</u>**
    The pumped water could be blended with canal water and used for irrigation. Conjunctive use of fresh and saline water can also achieve the same result.
  - Saline water pumped can be stored on ponds with sealed bottoms to promote development of fisheries. Some varieties of fishes can be developed in saline water.

- Mathematical modeling studies should be carried out to know the behavior of water level under existing conditions and under remedial measures, if adopted. Accordingly, recommendations can be modified and priority can be fixed to certain remedial measures.
- Waterlogging and associated salinity patterns should be regularly monitored. Remote sensing techniques can be used to monitor the waterlogging and salinity as it may reduce the cost of monitoring operations.

CONCLUSIONS

Hydrochemistry of the area plays a vital role in making water unfit for any usage. Thus creating a positive water balance. Also seepage from canal lining contributes to water rise, thus causing waterlogging. It is the need of the hour to tackle this problem. The short term and long term measures suggested here if followed can help solving this problem to a very large extent. Most of the parts of Muktsar district are either waterlogged or will be waterlogged soon in the coming years. As Muktsar district has a large area under cultivable land, waterlogging can pose serious threats to the productivity of the area. Hence it becomes necessary to take some action regarding this.

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