Madlauda block

Madlauda, a tehsil headquarter is located at 29.4035° N latitude and 76.8057° E longitude and almost 16 km towards west from district headquarter Panipat. It is 175 km away from State capital Chandigarh. Madlauda Tehsil is surrounded by Israna Tehsil towards south, Panipat Tehsil towards east and Safidon (Jind) Tehsil towards west. Madlauda block comprise of 35 villages covering and 27,000 households over an area of 342 km^2 area.

Grid (1 km x 1 km) based sampling was done all over the Madlauda block and a total of 280 water samples were collected. Laboratory analysis revealed that the electrical conductivity (EC) of the tested water samples ranged from 0.43 dS/m (village Bhandari, 29.3504' N latitude 76.8171' E longitude) to 7.56 dS/m (village Dumiyana, 29.3378° N latitude 76.7083° E longitude) with a mean value of 1.86 dS/m (Table 16). Salinity problem was noticed in 33% of the water samples (Table 17); 28% belong to EC class 2–4 dS/m (average EC~2.75 dS/m) and 5% had EC >4 dS/m (average EC~5.10 dS/m).

The data presented in Table 16 revealed that residual alkalinity in groundwater (RSC) ranged from 0 to 15.8 me/l with an average value of 3.3 me/l. Highest RSC~15.8 me/l was recorded in village Alupur located at 29.3659° N latitude, 76.8214° E longitude. Nearly half of the collected samples had very low RSC problem (average RSC~0.5 me/l), out of which 80% had RSC <1.25 me/l (average RSC~0.20 me/l). About 49% samples were characterized with RSC >2.5 me/l (average RSC~5.5 me/l) (Table 18); 20% have RSC between 2.5–5 me/l (average RSC~3.7 me/l), 24% had RSC between 5–10 me/l (average RSC~6.8 me/l) and rest 5% with RSC > 10 me/l (average RSC~12.0 me/l).

Table 16. Range and values of water quality parameters in Madlauda block

Sl. No.	Parameters	Range	Mean
1.	EC (dS/m)	0.43–7.56	1.86
2.	pH	6.90–8.67	7.90
3.	CO_3^{2-} + HCO_3^- (me/l)	2.5–20.0	9.9
4.	Ca^{2+} + Mg^{2+} (me/l)	1.8–33.8	7.6
5.	RSC (me/l)	Nil–15.8	3.3
6.	Na^+ (me/l)	0.9–56.3	12.2
7.	SAR (m mol/l)$^{1/2}$	0.5–28.0	6.6
8.	Cl^- (me/l)	0.2–34.2	6.1
9.	$SO4^{2-}$ (me/l)	3.6–41.3	13.2
10.	PO_4^{2-} (me/l)	BDL–2.3	0.1
11.	F^- (ppm)	BDL–12.5	1.6
12.	NO_3^- (ppm)	BDL–42.8	9.0

BDL: Below Detectable Limit

The sodium adsorption ratio (SAR) ranged from 0.5 to 28.0 with a mean value of 6.6 (Table 16). The lowest SAR was observed in village Urlana Kalan (29.3812° N latitude, 76.7131° E longitude) and the highest in village Nayan (29.3321° N latitude, 76.9259° E longitude). As such, the SAR of groundwater remained <10 in 82% of the tested water samples in Madlauda block (Table 19), while only18% samples had critically higher SAR >10; 16% with SAR between 10–20 and only 2% with SAR >20.

The concentration of Na^+ increased considerably with the increase in salinity (Table 17) and alkalinity (Table 18) in groundwater, consequently imparting higher SAR problem. No definite relationship was observed between EC and RSC.

Spatial variability for EC (Fig. 8a) indicated that nearly 67% (~229 km^2) water in Madlauda block had very low problem of salinity (EC <2 dS/m). Rest 33% water was affected by salinity problem of variable nature; 32.6% (~111 km^2) had EC between 2–4 dS/m and 0.4% (1.5 km^2) with EC >4 dS/m. Most of the salinity affected area in Madlauda block was confined to border areas touching Israna and Panipat blocks. About 65% area (223 km^2) in Madlauda block was affected with RSC >2.5 me/l, the critical limit for using RSC groundwater for irrigation; 49.8% had RSC between 2.5–5 me/l and 15.6% with RSC between 5–10 me/l (Fig. 8b). RSC problem was noticed all over the Madlauda block except

Table 17. Chemical composition of groundwater samples of Madlauda block against different EC class

EC class (dS/m)	No. of samples	EC dS/m	$CO_3^{2-} + HCO_3^-$ me/l	Cl^- me/l	SO_4^{2-} me/l	$Ca^{2+} + Mg^{2+}$ me/l	Na^+ me/l	RSC me/l	F^- ppm	NO_3^- ppm	SAR (mmol/l)$^{1/2}$
<2	187	1.25	9.5	3.1	8.8	6.7	7.8	3.2	1.5	6.9	4.7
2–4	80	2.75	10.9	8.8	17.1	8.4	19.9	3.8	2.1	12.3	10.5
4–8	13	5.10	10.1	17.3	30.2	17.2	27.8	0.4	1.3	13.0	10.8
Total*	280	1.86	9.9	6.1	13.2	7.6	12.2	3.3	1.6	9.0	6.6

*represents weighted mean for each parameter

Table 18. Chemical composition of groundwater samples of Madlauda block against different RSC classes

RSC class (me/l)	No. of samples	RSC me/l	EC dS/m	$CO_3^{2-} + HCO_3^-$ me/l	Cl- me/l	SO_4^{2-} me/l	$Ca^{2+} + Mg^{2+}$ me/l	Na^+ me/l	F^- ppm	NO_3^- ppm	SAR (mmol/l)$^{1/2}$
<1.25	113	0.20	2.14	8.1	8.7	10.5	10.3	7.8	0.8	5.7	3.2
1.25–2.5	29	1.82	1.28	8.3	4.5	8.8	6.5	11.5	0.9	7.3	4.5
2.5–5	57	3.68	1.65	9.9	4.4	10.8	6.2	12.0	1.2	8.8	6.6
5–10	67	6.80	1.74	12.4	5.0	11.2	5.6	13.5	2.1	9.9	8.3
>10	14	11.97	2.20	16.1	4.5	14.4	4.2	19.6	5.1	6.9	14.6
Total*	280	3.25	1.86	9.9	6.1	13.2	7.6	12.2	1.6	9.0	6.6

*represents weighted mean for each parameter

Table 19. Chemical composition of groundwater samples of Madlauda block against different SAR class

SAR class (m mol/l)$^{1/2}$	No. of samples	SAR (mmol/l)$^{1/2}$	RSC me/l	EC dS/m	CO_3^{2-} + HCO_3^- me/l	Cl^- me/l	SO_4^{2-} me/l	Ca^{2+} + Mg^{2+} me/l	Na^+ me/l	F^- ppm	NO_3^- ppm
<10	229	4.90	2.63	1.64	9.5	5.5	11.6	8.0	9.6	0.9	8.9
10–20	45	13.05	5.62	2.74	11.6	7.6	17.8	6.3	22.2	3.8	9.4
>20	6	23.49	8.97	3.53	14.1	11.9	25.2	5.2	36.6	6.5	9.3
Total*	280	6.61	3.25	1.86	9.9	6.1	13.2	7.6	12.2	1.6	9.0

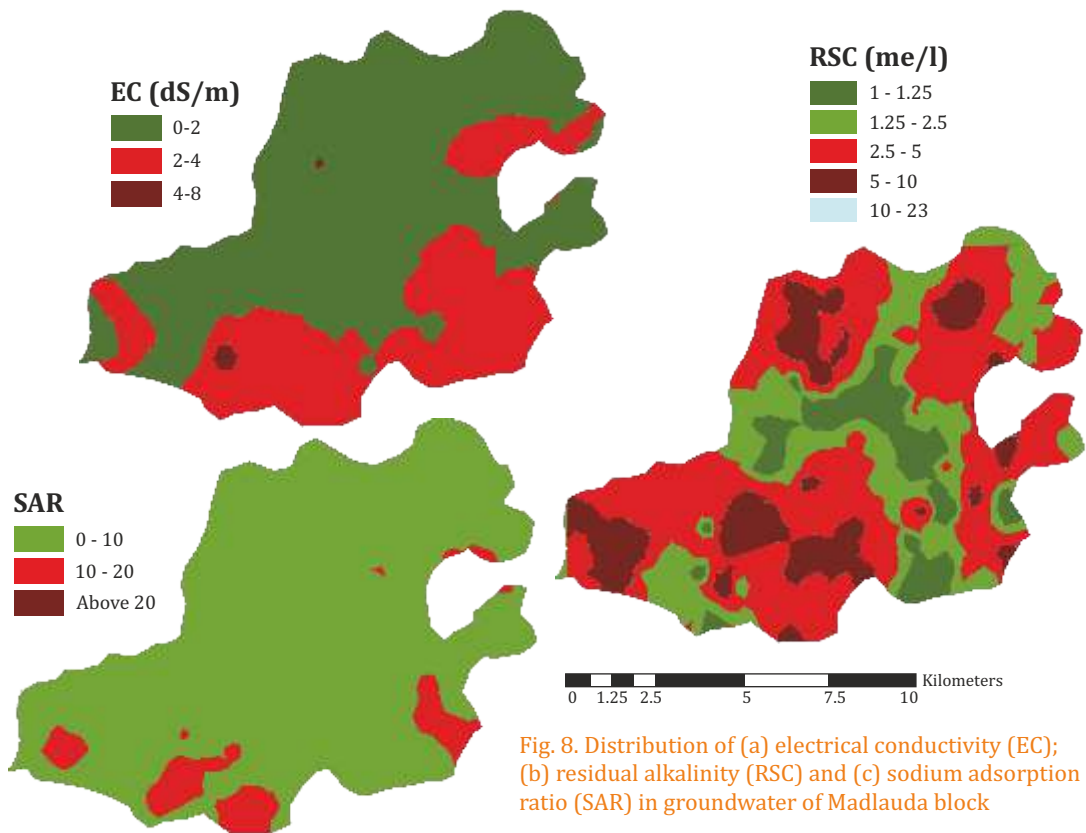*represents weighted mean for each parameter*

Fig. 8. Distribution of (a) electrical conductivity (EC); (b) residual alkalinity (RSC) and (c) sodium adsorption ratio (SAR) in groundwater of Madlauda block

the central parts. Most of the area (92%, 315 km^2) had very low problem of SAR in underground water (SAR<10). However, the SAR affected area belongs to SAR class 10–20 and was confined to border areas touching Israna block (Fig. 8c).
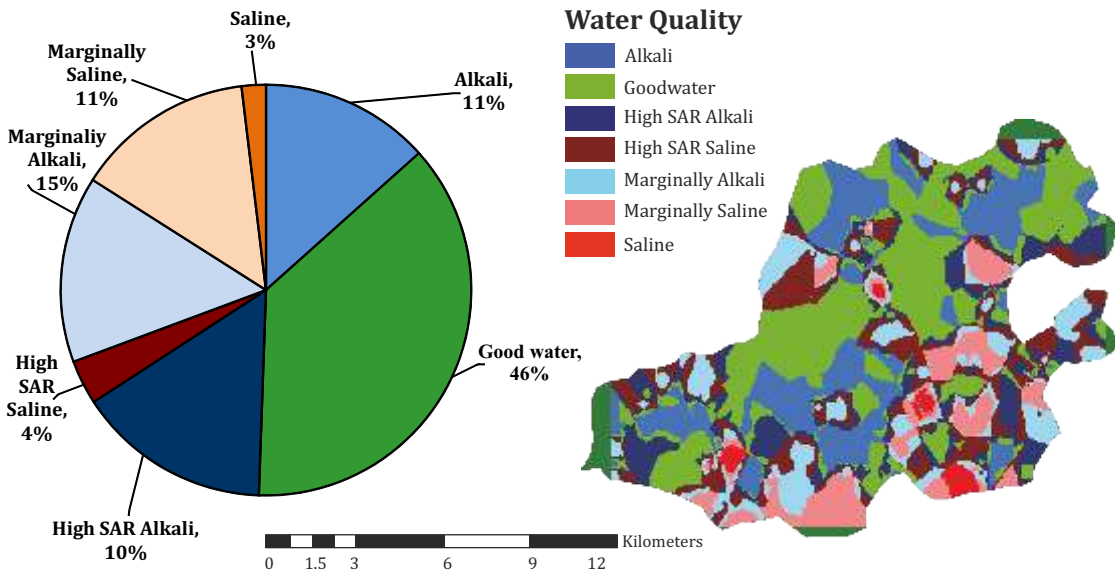
Fig. 9. Distribution and characterization of groundwater quality of Madlauda block

In Madlauda block covering 342 km^2 area, only 37% groundwater was of good quality (EC <2 dS/m, RSC <2.5 me/l, SAR <10) (Fig. 9). Problem of residual alkalanity was quite critical in 43.4% of the total area in the sequence of high SAR alkali~15.3%, marginal alkali~14.7% and alkali~13.4%. Salinity of variable nature (marginal saline~14.1%, Saline~1.9% and high SAR saline~3.5%) was observed in 19.5% water. High SAR problem was encountered in 18.8% area.