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EVALUATION OF GROUNDWATER QUALITY WITH REGARD TO LIVESTOCK USE FROM SANGAMNER AREA, AHMEDNAGAR DISTRICT, MAHARASHTRA, INDIA

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ABSTRACT
Livestock is a key asset for poor people, fulfilling multiple economic, social and risk management functions. In India, smallholder farmers rely greatly for their survival on livestock keeping which is a safety valve for them. There is a need to look into the welfare of livestock such as feed, water and health etc. Health of livestock similar to human being is mainly affected by water they drink. Cows, buffaloes, bullocks, sheep, goats are common livestock in Sangamner area. These livestock and dairy serve as the major source of earning to farmers besides agriculture. Every farmer in the area maintains some kind of livestock population. It is, therefore necessary to evaluate the quality of groundwater for the consumption of livestock population. 68 groundwater samples were analyzed for various parameters such as pH, EC, TDS, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, SO_4^{2-} and NO_3^{-} during pre and post monsoon season using standard methods. It was found that the parameters like EC, total hardness and nitrate were exceeded the limit recommended for the use of water for livestock and poultry suggested by National Research Council. Higher EC were observed in low-lying area which are poorly drained and are under intensive agriculture. Wide variations in the response of livestock to saline water were observed. Some of the major factors that influence the response of livestock to saline water depend on kind of livestock, age, sex, pregnancy and lactation, intensity of work performed by the animal and climatic conditions. The cattles from some of the areas were to allowed drink the groundwater from the area, they start suffering from diseases and their pregnancy period was prolonged. Educating the farmers to adopt better farm management and better livestock care has been suggested to reduce the problem of groundwater deterioration and welfare of livestock population.
Keywords: Groundwater quality, livestock use, National Research Council, groundwater deterioration.

INTRODUCTION

Water is one of the foremost essential components and it is essentially required by all living organisms. The quality of water is of vital concern to all living beings. About 97.2% of water on earth is salty and 2.8% is present as fresh water from which about 20% constitutes groundwater[1]. Therefore determining groundwater quality is important to observe the suitability of water for particular purpose through anthropogenic and other sources like different land conditions, rain conditions, use of different chemical pesticides and different depth of bore wells[2]. Human activities and livestock farming also have a significant effect on groundwater quality.

Livestock require water for survival as water is necessary for the transport of nutrients, waste products and harmones. Often there is a belief that animals will drink any type of water but it was observed that the animals usually drink poor quality water only when there is no option. Livestock plays an important role in agricultural economy and it is absolutely essential to look into needs with respect to their water quality. Good quality water is essential for the production of livestock and poultry[3]. Some of the major factors that influence the response of livestock to saline water depend on the kind of livestock, age, sex, pregnancy, lactation, intensity of work performed by animals and climatic conditions. Water quality can affect both the total water consumption of livestock and the health of that livestock. Objectionable taste and odor will

discourage livestock water consumption, reduce useless gain. Several studies on groundwater quality with regard to livestock use have been reported [4-10].

Sangamner is in semi–arid region with low rainfall. There is greater dependence on the groundwater. Groundwater is mainly used for drinking, washing bathing, irrigation and for livestock raring in the area. However, the establishment of industrial estate by the Govt. of Maharashtra at Sangamner and growth of sugarcane and allied industries has staring deteriorating the groundwater quality in some parts of the area. Cows, buffaloes, bullocks, sheep and goats are common livestock in the area. These livestock and diary serve as the major source of earning to farmers besides agriculture. Their basis input i.e. feed has been sourced from agriculture. On an average every farmer in the area maintains some kind of livestock population. It is, therefore, necessary to evaluate the quality of water for the consumption of livestock population. In the majority part of the study area, poultry and dairy farming is the backbone of rural economy. Since the soils from the area have started deteriorating due to excess use of fertilizers, use of saline water and practicing of mono culture type of cropping pattern, the crop yield have gone down. This is in turn affected the economy of the family. Thus farmers have developed the dairy farming to a large extent. There is a large network of co-operative dairies in the area. This agro-based industry is developed due to deterioration in the quality of groundwater. Researchers have carried out an extensive work on groundwater quality for various purposes in the area [11-14]. But there is however no data available about the groundwater quality with regard to livestock use of Sangamner area. In this view, an attempt has been made to evaluate the groundwater quality of Sangamner area.

Study Area

Sangamner area is located in the northern part of the Ahmednagar district of Maharashtra State. The tahsil lies between 18°36' N to 19 ° 1'N latitude and 74 ° 1'W to 74 ° 56'W longitude. The Sangamner town is located on the confluence of the Mahalungi and the Pravara River. It is a Taluka head quarter which is at a distance of 150 km from Pune, on Pune - Nasik National Highway No. NH-50 (Fig.-1).

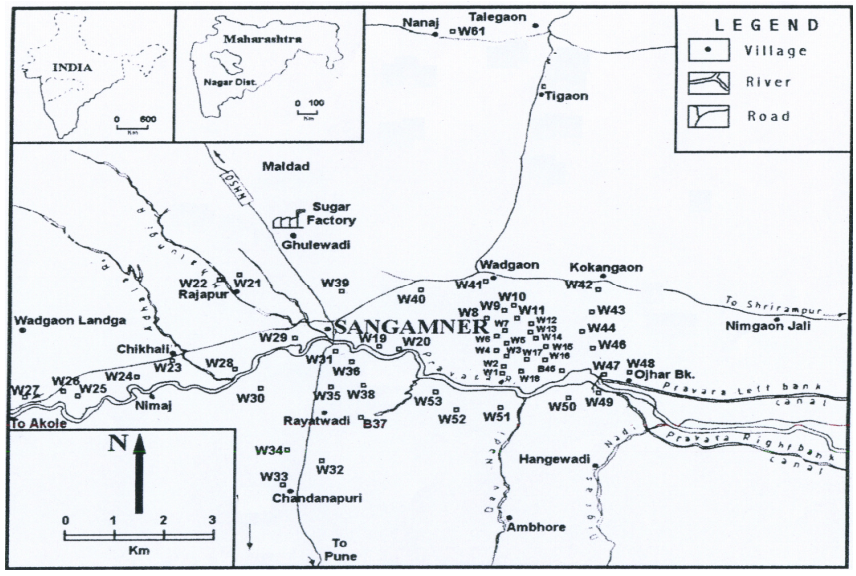

Fig.-1: Locations of ground water sampling stations in the Study area.

The area is drained by the Pravara River which is a tributary of Godavari and has its origin in the hilly region of Western Ghats. Geologically, basalt underlay the Pravara basin, which is characterized by thick alluvium (upto 35 m.). Several dams and weirs have been constructed across Pravara River. Because of construction of Bhandardara Dam in the source region of Pravara River, the valley has been brought

under intensive agriculture with sugarcane as a single dominant crop. Subsequent to the establishment of co-operative sugar mill at Sangamner in 1967, the agriculture in the area has witnessed rapid changes in the cropping pattern. In addition to sugar industry, several allied industrial units have also come up in the area. The effluents from sugar industry, with little or no treatment have been stored in lagoons and then discharged into the natural stream flowing through the agricultural area for a distance of about 8 to 9 km. This effluent stream finally meets the Pravara River at Sangamner and deteriorate the quality of water. In some remote areas, river and pond water is also used for various domestic purposes including cooking drinking and livestock raring. The medical facilities in this area are also not appropriate. Majority of the people are farmers residing in the fields along with livestock near the wells and on the bank of river.

EXPERIMENTAL

A network of 68 groundwater-sampling stations distributed over mainly the irrigated region of the Sangamner area. The samples were collected for two seasons i.e. pre monsoon (May) and Post monsoon (November). The 54 of them were from irrigated area and 14 from non-irrigated area. Sampling locations were chosen on the basis of pilot geological and hydro-geological survey of the area. The samples from dug / bore wells were collected on the basis its use for drinking / domestics purposes. The samples were collected in polyethylene bottles of one-liter capacity. The care was taken to collect samples after pumping for some time. To determine the suitability of groundwater for livestock, the parameters like pH, EC, alkalinity, hardness, chlorides, sulphate, nitrate and sodium were analysed. The pH, electrical conductivity (EC) were measured in the field. The samples were then brought to the laboratory for further chemical analysis. The analysis was carried out in the laboratory by using the procedures given by APHA, AWWA, WPCF [15]. Using titrimetric methods performed the analysis of chloride (Cl^-), total alkalinity as $CaCO_3$, Calcium (Ca^{2+}) and total hardness as $CaCO_3$ (TH). While nitrate and sulphate were analyzed by spectrophotometric methods and the alkali element sodium were detected by flame photometer (E, 850 A, Equiptronics). The results of the groundwater analysis are presented in Table-1 and 2.

Table-1: Physico-chemical data of groundwater samples from Sangamner area, Ahmednagar district, Maharashtra (Pre - monsoon).

S. No.	WT	pH	EC	TDS	Na	Ca	Mg	Cl	HCO_3	SO_4	NO_3	TH
W1	3.03	8.2	4630	3010	260	19	25	129	689	161	36	150
W2	2.12	8	4930	3205	348	27	36	184	719	156	29	210
W3	1.51	8.4	4870	3166	232	45	52	186	572	158	8	324
W4	3.63	8	5630	3660	300	42	47	194	572	168	52	296
W5	2.42	8.2	6420	4173	360	25	35	198	602	166	29	204
W6	7.57	7.8	7161	4655	376	66	80	284	673	165	58	492
W7	2.42	8	4670	3036	260	39	49	161	592	163	36	300
W8	4.54	8.2	3860	2509	216	24	41	123	490	162	49	228
W9	6.06	7.9	5760	3744	192	90	102	307	556	160	46	644
W10	7.57	7.6	5320	3458	172	116	93	272	393	164	56	672
W11	6.06	7.7	10360	6734	380	148	131	533	398	167	40	904
W12	5.75	7.7	10250	6663	380	87	146	598	536	165	72	814
W13	1.51	8	5630	3660	187	70	105	360	260	161	39	609
W14	4.54	8.2	8460	5499	340	56	103	439	587	160	70	562
W15	3.03	8	6620	4303	284	65	82	302	602	166	47	500
W16	3.93	8.3	5290	3439	210	18	27	110	550	164	30	154
W17	3.63	8.4	5160	3354	280	21	24	146	583	161	52	150
W18	2.72	8.3	6770	4401	332	38	35	216	755	159	68	238
W19	9.09	8.2	6300	4095	272	62	75	243	699	158	81	462
W20	10.6	7.8	6010	3907	232	67	81	252	694	162	58	500
W21	18.8	8.2	3780	2457	134	25	54	103	485	151	52	284

W22	15.2	7.5	7650	4973	190	112	95	289	302	153	89	670
W23	7.57	8	6690	4349	280	31	18	253	538	157	44	152
W24	9.09	7.9	7240	4706	272	44	24	193	592	153	66	208
W25	18.2	7.8	5610	3647	210	44	39	211	507	154	48	270
W26	8.18	8.1	1370	891	16	25	29	51	142	40	42	182
W27	12.1	8.5	720	468	30	13	7	14	86	28	26	62
W28	12.1	8	4870	3166	260	38	35	142	614	158	34	240
W29	12.7	8.2	3970	2581	208	28	29	107	568	149	40	188
W30	10.6	7.6	4470	2906	136	51	53	149	466	123	57	342
W31	13.6	7.4	4640	3016	68	52	109	220	252	141	62	378
W32	14.8	7.4	2860	1859	44	40	46	89	288	101	29	288
W33	15.2	8.2	2870	1866	78	35	44	85	232	118	52	270
W34	12.7	7.8	4740	3081	130	64	68	239	257	124	37	438
W35	18.1	7.8	4260	2769	118	64	66	144	369	170	28	432
W36	19.7	7.9	3650	2373	88	40	65	109	298	145	40	366
B37	-	7.8	4600	2990	124	51	69	176	339	154	44	410
W38	7.57	7.5	5700	3705	110	88	111	369	383	156	29	674
W39	22.7	8.4	2770	1801	122	20	31	105	457	76	36	176
W40	19.7	7.6	2550	1658	52	60	48	105	353	69	48	358
W41	15.2	7.8	2140	1391	72	48	56	90	364	123	46	346
W42	12.1	8	3300	2145	116	51	37	156	318	122	61	280
W43	12.1	7.6	5930	3855	126	97	113	335	453	168	57	704
W44	8.48	7.6	4500	2925	124	172	79	300	362	155	65	754
B45	-	7.6	3480	2262	212	64	35	141	525	156	37	318
W46	10.9	8.2	4050	2633	112	28	24	34	339	122	52	170
W47	9.09	8.1	1610	1047	146	33	38	100	563	155	26	238
W48	1.51	7.9	2700	1755	116	35	32	91	441	153	46	218
W49	12.1	8.6	2070	1346	224	13	7	28	565	105	36	62
W50	19.7	8	4170	2711	140	48	44	133	499	156	53	300
W51	7.57	8	7350	4778	328	49	92	298	606	167	38	500
W52	4.54	8.2	1860	1209	120	30	30	122	359	129	48	200
W53	9.09	8.2	1680	1092	126	21	57	71	436	109	36	286
W54	12.1	8	5690	3699	154	48	46	212	373	156	49	310
B55	-	8.4	830	531	28	26	14	30	140	53	29	120
W56	7.57	8.4	580	371	25	19	16	10	116	47	22	112
W57	18.1	7.9	1590	1018	76	30	30	47	205	98	34	200
W58	12.1	7.9	1240	794	26	35	29	41	167	71	46	204
W59	18.2	8.1	1390	890	56	25	22	28	172	80	56	152
W60	9.09	8.2	1150	736	52	20	25	24	132	92	59	154
W61	6.66	8	3200	2048	76	50	48	121	237	142	34	322
W62	12.1	8.2	810	5184	31.2	25	21	44	132	69	22	148
W63	6.06	8.6	640	410	36	23	17	18	80	63	15	128
W64	12.1	8.6	540	346	34.8	21	8	16	135	50	10	84
W65	9.09	8.4	760	486	37.6	16	12	13	152	54	16	90
W66	8.48	8.4	650	416	21.2	24	15	23	95	48	9	122
W67	18.2	8.1	420	269	16.4	27	13	12	132	39	0.6	120
W68	19.7	8.1	360	230	34.4	26	7	9	160	37	2.4	92

Note:
1. All values of the constituents are in ppm / mg/l, except pH and EC (µS/cm).
2. W- Dugwell, B- Borewell, TH-Total hardness.
3. Water Table (WT) depth is in meters.

Table-2: Physico-chemical data of groundwater samples from Sangamner area, Ahmednagar district, Maharashtra (Post - monsoon).

S. No.	WT	pH	EC	TDS	Na	Ca	Mg	Cl	HCO_3	SO_4	NO_3	TH
W1	1.81	8.4	890	578	144	80	12	142	235	72	26	250
W2	1.81	8.1	4500	2925	541	80	93	476	673	175	12	581
W3	1.21	8	4700	3055	532	150	148	675	651	171	9	984
W4	0.6	8.2	7905	5138	829	120	141	937	666	177	3	880
W5	0.9	8.5	4750	3087	560	138	106	582	589	169	2	781
W6	0.3	7.9	7385	4761	529	228	288	930	827	181	13	1755
W7	0.3	8.2	3620	2353	458	124	163	497	669	174	2	981
W8	1.21	8	4158	2703	527	112	167	553	640	173	27	967
W9	2.12	7.4	6610	4297	365	280	320	950	659	179	12	2016
W10	0.9	7.4	7516	4885	425	320	340	1071	689	177	3	2199
W11	2.12	8	7922	5149	648	388	321	1292	710	175	14	2290
W12	1.51	7.8	9200	5980	760	326	309	1503	753	180	38	2333
W13	0.9	7.8	7315	4755	516	216	392	1092	710	174	6	2153
W14	0.9	8.2	8826	5737	729	216	294	1262	710	178	7	1749
W15	0.9	7.9	6720	4368	540	220	248	923	735	170	14	1570
W16	1.81	8	3850	2502	578	76	102	532	657	169	11	609
W17	0.9	7.6	6610	3907	662	180	185	767	678	172	11	1211
W18	1.21	8.2	5100	3315	488	104	136	639	622	168	2	819
W19	14.5	8	5816	3780	476	202	227	717	768	172	18	1439
W20	12.7	7.9	5408	3515	495	196	235	710	737	169	19	1457
W21	7.57	8.6	3815	2480	418	100	124	667	615	144	21	761
W22	9.09	7.9	7212	4688	623	268	289	1533	457	167	33	1859
W23	4.54	8.3	7500	4875	671	234	321	1480	735	167	24	1486
W24	8.18	8.9	6411	4167	681	140	170	1235	674	166	21	1049
W25	4.84	8.3	5209	3386	495	176	216	1030	745	166	40	1328
W26	1.51	8.3	1400	910	74	100	76	198	326	38	36	563
W27	1.51	8.5	1000	650	82	80	63	85	433	42	2	460
W28	3.03	8.4	5008	3255	458	140	160	795	744	165	2	1008
W29	7.57	8.8	800	520	10	112	43	135	204	42	2	456
W30	4.54	8.1	4304	2798	318	236	241	830	566	142	28	1581
W31	2.42	8.2	4612	2998	183	288	240	950	557	131	30	1707
W32	6.96	8.4	3520	2288	147	204	214	631	562	125	11	1391
W33	9.09	8.4	5810	3776	188	304	457	1256	551	161	57	2641
W34	6.06	8.2	5080	3302	322	308	363	1285	582	118	46	2264
W35	10.6	8.3	4612	2997	199	328	214	837	533	126	38	1700
W36	7.57	8.3	3540	2301	134	134	276	695	513	144	30	1470
B37	-	8.2	4814	3129	262	178	258	1008	502	167	39	1508
W38	0.6	8.5	2913	1894	128	144	198	497	482	115	16	1175
W39	12.1	8.5	2301	1496	141	88	136	312	642	63	38	780

W40	12.1	8.5	2412	1568	37	208	152	447	482	58	40	1142
W41	9.09	8.1	2100	1365	65	182	120	319	523	112	30	948
W42	7.57	8.3	2412	1568	142	152	232	525	597	104	87	1335
W43	4.24	8	5990	3894	209	284	370	1093	528	163	52	2232
W44	4.84	8.3	2716	1765	144	441	280	1015	546	164	100	2254
B45	-	8.1	4260	2769	232	188	143	489	594	163	58	1058
W46	5.45	8.7	4698	3054	318	128	141	568	661	161	31	900
W47	3.03	8.8	1580	1030	120	96	80	113	518	90	3	569
W48	0.3	8.3	2896	1882	171	144	121	348	510	146	30	858
W49	10.6	8.7	1986	1291	297	56	20	121	673	79	3	220
W50	9.09	8.3	4164	2707	313	170	125	426	683	164	23	939
W51	4.54	8.9	5574	3623	555	128	187	717	652	167	12	1089
W52	-	8.7	2192	1425	122	148	121	334	408	131	20	868
W53	4.54	8.6	1789	1163	198	84	56	170	489	99	48	441
W54	4.54	8.1	4768	3099	295	138	223	738	732	165	51	1263
W55	-	8.6	890	579	61	98	48	122	316	39	42	442
W56	3.93	8.7	880	572	43	80	63	70	351	67	3	459
W57	7.57	8.1	3090	2009	23	100	56	78	355	50	14	480
W58	3.03	8.3	1390	904	52	124	73	174	377	55	69	610
W59	10.6	8.5	1210	787	63	102	77	114	357	67	66	572
W60	1.21	8.8	1296	843	58	88	69	97	356	62	26	504
W61	7.57	8.4	3216	2090	169	208	188	560	567	137	20	1293
W62	0.3	8.7	810	527	45	102	65	90	351	43	26	522
W63	7.57	8.7	680	442	41	80	34	102	285	47	3	340
W64	3.63	8.5	1590	1034	105	80	126	224	540	78	7	719
W65	3.03	8.6	940	611	53	88	58	91	382	41	18	459
W66	2.42	8.1	820	533	37	88	53	110	270	40	18	438
W67	7.57	8	1080	702	25	144	90	102	467	45	13	730
W68	8.18	7.9	620	403	16	110	10	69	244	19	2	316

Note: 1. All values of the constituents are in mg/l, except pH and EC (µS/cm).
2. Values of Fe are in ppb.
3. W- Dugwell, B- Borewell, TH-Total hardness.
4. Water Table (WT) depth is in meters.

RESULTS AND DISCUSSION

Total dissolved salts / electrical conductivity of groundwater with regard to livestock use

The electrical conductivity provides an indication of the total salts in the water. The electrical conductivity (EC) is expressed in µS/cm at 25^0C approximately equal to and can be substituted for TDS without introducing error in interpretation depending on type of salts present[16]. The quality requirement of livestock is more or less same as that for drinking water for human consumption. However, the higher concentration of EC / TDS can be tolerated by animals[17]. As the concentration of salt increases above 1000µS/cm, risk of health problems and reduced productivity in livestock may occur. Saline water toxicity upsets the electrolyte balance in animals and will result in symptoms similar to dehydration. At EC over 10,000 µS/cm, water will not be palatable and diarrhea and weight loss can be expected. The use of such water is not recommended for animals[16]. The EC values from study area ranges from 840 to 11350µS/cm and 620 to 9200 µS/cm during pre and post

monsoon respectively. Lowing of EC in post – monsoon could be due to dilution effect caused by rainfed recharge during monsoon season leading to higher groundwater level. The higher values of EC during pre monsoon reflect concentration effect. The groundwater from the study area is classified based on the general guide to use saline water for livestock and poultry recommended by National Academy of Sciences[18].

Table-3: Classification of groundwater on the basis of EC to the use of saline water for livestock and poultry[18] from study area.

EC (µS/cm)	No. and Locations of Samples (Pre monsoon)	No. and Locations of samples (Post - Monsoon)
Less than 1000	W26,W27,W55,W56,W63,W65 =6(8.82%)	W1,W29,B55,W56,W62,W63, W65, W66, W68 = 9 (13.23%)
1000-2999	W40,W41,W47,W49,W52,W53,W57, W58,W59,W60,W61,W62,W64,W66, W67, W68 = 16(23.52%)	W26,W27,W38,W39,W40,W41, W42,W44,W47,W48,W49,W52, W53,W58,W59,W60,W64,W67 =18(26.47%)
3000-4999	W1,W3,W7,W8,W11,W21,W29,W30, W32,W33,W34,W35,W36,W39,W42, W45,W46,W48,W50 = 19 (27.94%)	W2,W3,W5,W7,W18,W16,W21, W30,W31,W32,W35,W36,W37, W45,W46,W50,W54,W57 =19 (27.94%)
5000-6999	W2,W4,W5,W9,W10,W16,W17,W19, W20,W24,W25,W28,W31,W37,W38 = 17(25%)	W9,W15,W17,W18,W19,W20, W24,W25,W28,W33,W34,W43, W51 = 13 (19.11%)
7000-10,000	W6,W13,W14,W15,W18,W22,W23, W43,W51 = 9 (13.23%)	W4,W6,W10,W11,W12,W13, W14,W22,W23 = 9 (13.23%)
Over 10,000	W 12 = 1(1.47 %)	Nil

It is observed that 6(8.82%) samples in pre monsoon and 9(13.23%) samples in post monsoon season show less than 1000 µS/cm indicating relatively low level of salinity. Such type of groundwater is excellent for all classes of livestock and poultry as per the guidelines[18]. These lower values of EC were observed in the topographically high and well drained areas with non – irrigated agriculture. The groundwater from this area is suitable for all kinds of livestock. 16(23.52%) samples in pre monsoon and 18(26.47%) samples in post monsoon where EC is ranging from 1000-2999µS/m. This type of saline water may cause temporary and mild diarrhea in livestock not accustomed to them or watery droppings in poultry but not affecting their health or performance[18]. 19(27.94%) samples both in pre-monsoon and post-monsoon seasons in the area show EC in the range of 3000 to 4999 µS/m as per the guidelines of suitability of water to livestock. This water is satisfactory for livestock but may cause temporary diarrhea be refused at first by animals. Such type of water is poor water for poultry, often causing watery feces and increased mortality among the livestock[16]. Higher percentages 17(25%) samples in pre monsoon season belongs to higher salinity of groundwater i.e. higher EC 5000-6999 µS/m as compared to 13(19.11%) samples in post monsoon season.

This type of water should not be used for poultry but with reasonable safety can be used for dairy and beef cattle, sheep, swine and horses. It is advisable to avoid this groundwater for pregnant or lactating animals. Such type of groundwater is observed in low lying area which are poorly drained and are under intensive agriculture. 9(13.23%) samples both in pre and post monsoon seasons in the area show EC of ground water lies in between 7000-10,000µS/cm which is unfit for poultry and probably for swine. Considerable risk may exist in using these waters for pregnant or lactating cows, horses, sheep, the young of these species or for any animals subjected to have heat stress or water loss[18]. Only one sample (Sr. No. W12) in pre monsoon season show EC higher than 10000 µS/cm which is in the downstream part of river. This water is highly saline which cannot be recommended

for the use for livestock under any conditions. The cattle when allowed to drink such type of water, they start suffering from diseases and their pregnancy period is prolonged. Therefore the groundwater from this area is not suitable for poultry, pigs and dairy cattle.

Hardness of groundwater with regard to livestock use

Hardness is caused by divalent metallic cations that react both with soap to form precipitates and with certain anions to form scale. The principle hardness-causing cations are calcium, magnesium, strontium, ferrous iron and manganous ions. If the water is already high in salinity, softening the water through the exchange of divalent cations with sodium may cause problems. Hardness does not usually affect the palatability or safety of water for livestock. The hardness of livestock waters is measured in order to determine the amount of calcium and magnesium relative to other salts in the water[16]. The hardness in water is also derived largely from contact with the soil and rock formations. In general, hard waters originate in areas where the topsoil is thick and limestone formations are present. Soft water originates in areas where the topsoil is thin and limestone formations are spare or absent[19]. Water hardness is not necessarily correlated with salinity. Saline waters can be very soft if they contain low levels of calcium and magnesium. The principle cations that cause hardness are calcium and magnesium which are usually present at less than 1000 mg/L in water.

On the basis of hardness, groundwater for livestock commonly classified in terms of degree of hardness into following categories [19].

- Soft : < 75 mg/l
- Moderately Hard : 75 – 150 mg/l
- Hard : 150-300 mg/l
- Very Hard : > 300 mg/l

According to above rating the groundwater from the study area are classified. As seen from table 1 & 2, out of 68 samples 2(2.95%) samples in pre monsoon show moderately hard category of groundwater. 7 (10.20%) samples in pre monsoon season and 2(2.95%) samples in post monsoon season show hard category type of groundwater. Remaining all the samples i.e. 59 (86.76%) samples in pre - monsoon and 66 (97.05%) samples in post - monsoon show very hard category type of groundwater. Hard water has not been demonstrated to have either a positive or negative impact on poultry performance. If poultry drinking water is softened, care should be taken to balance the diet for the increased sodium content of the water[20]. Although hardness has no effect on water safety, it can result in the accumulation of scale (mostly magnesium, manganese, iron, and calcium carbonates) in water delivery equipment. The clogging of pipes and drinkers can lead to reduced water consumption and its associated problems[21].

Relationship of hardness and alkalinity of groundwater with regards to livestock use

Alkalinity in water is a combined measure of bicarbonates, carbonates and hydroxide ions. Borates, silicates and phosphates are also included, but are usually minor. pH of groundwater ranges from 7.1 to 8.8 and 7.4 to 8.9 during pre and post monsoon respectively which indicates weakly to moderately alkaline nature of groundwater. The slight increase of pH can be attributed to the higher proportion of bicarbonates. In the study area 46(67.64%) samples in post monsoon out 22(32.35%) samples in pre monsoon have alkalinities less than 500mg/l which are not harmful where as the remaining samples i.e. 22(32.35%) samples in post monsoon and 46(67.64% samples in pre monsoon have alkalinities greater than 500mg/l which can cause physiological and digestive upset in livestock[22]. The alkalinities are higher in post monsoon than in pre monsoon indicating concentration dilution effect related to climate. The higher alkalinities are observed in the areas showing rolling topography (S. No. W61, W62 and W67).

This is possibly due to rock-water interaction. Both silicate weathering of basalt and dissolution of carbonates (i.e. calcrete) present in the alluvium are potential source of bicarbonates in the groundwater. Determining both hardness and alkalinity help in interpreting the suitability of water for use by livestock. This information helps to judge what types of salts are present in the groundwater, which is important because some salts are more harmful than others[16].
When alkalinity equals hardness, salts of calcium and magnesium combined with carbonates and bicarbonates are observed. When alkalinity is less than hardness, salts of calcium and magnesium are more likely to be sulphates (instead of carbonates). Because of an interaction between sulphates and alkalinity, the laxative effects of high- sulphate water will be more pronounced as alkalinity levels increase. When alkalinity is greater than hardness, the presence of sodium and potassium salts in addition to calcium and magnesium are indicated[16].
By using this criterion, it is observed that (Table-1 and 2), the majority of the samples i.e. 65 (95.58%) samples from post monsoon season and 54(79.41%) samples from pre monsoon season show alkalinity less than hardness. It means that in the study area the presence of salts of calcium and magnesium are more likely to be sulphates instead of carbonates. 3(4.41%) samples in post monsoon and 14(20.58%) samples in pre monsoon season show alkalinity greater than hardness, indicating the presence of sodium and potassium salts in addition to calcium and magnesium. In pre monsoon season, sodium and potassium in addition to calcium and magnesium predominates while in post monsoon season, salts of calcium and magnesium are more likely to be sulphates in the area.

Sodium in groundwater with regard to livestock use
The primary symptom of sodium deficiency is loss of appetite. In very hot areas this is particularly noticeable in cattle. Reduced growth and milk production and decrease in reproduction may also result. Subsistence on water with a very high sodium content can lead to sodium ion toxicosis, which is diagnosed by high sodium concentration in plasma, cerebrospinal fluid, or brain tissue[23]. Excessive levels of sodium have a diuretic effect. Studies indicate that a sodium level of 50 mg/L is detrimental to poultry performance if the sulfate level is also 50 mg/L or higher and the chloride level is 14 mg/L or higher[20]. Sodium sulfate is a well-known laxative. By themselves, magnesium and sodium normally pose little risk to livestock, but their association with sulfate is a major concern. Water over 800 mg sodium/L can cause diarrhea and a drop in milk production in dairy cows. High levels of sodium may necessitate adjustments to rations because chlorine deficiency may result when removing or reducing salt from swine and dairy rations. In such situation the care should be taken when adjusting rations. Salt may be reduced in swine diets if the sodium in the water exceeds 400 mg/L[3,24].
The sodium content of the groundwater ranges from 21 to 490 mg/l in pre-monsoon season and 16 to 829 mg/l in post-monsoon season. On the basis of NRC[18] guidelines for sodium the groundwater from study area, it is observed from table 1 and 2 that 9 (13.23%) samples from study area both in pre and post monsoon have sodium less than 50mg/l which have little risk to poultry. These samples lies in the upstream part indicates faster circulation of groundwater attributable to physiography of the area. The remaining 59 (86.76 %) samples both in pre and post monsoon season have sodium greater than 50mg/l may affect the performance of poultry if sulphate or chloride is high. All samples except one sample (S. No. W4) from the study area have sodium content less than 800 mg/l. This sample lies in the downstream part of Pravara River. The groundwater from this area is not suitable for livestock use.

Sulphates in groundwater with regard to livestock use
Sulphates are present in groundwater in the form of sodium sulphate, calcium sulphate and magnesium sulphates. All these have a laxative effect and impart objectionable, bitter taste[16]. Many researchers studied the impact of high sulphate water on animal health and performance[25-28]. The cattle consuming water with 3000mg/l sulfates or greater during the summer at a higher risk of polioencephalomalacia (PEM)[29]. Ruminants consuming high dietary sulphur concentration in combination with high grain diet are at a particular risk for sulphur associated PEM[28]. The negative

response to high - sulphate water does not appear to be as pronounced in grazing cattle. In addition to sulphur associated PEM, high concentration of sulphates can also contribute to copper deficiencies in ruminants. Researchers have clearly demonstrated that the consumption of high sulphate water can result in a decline in liver copper stores in growing cattle. A reduction in copper status can have a negative impact on the health, growth performance and reduction function of livestock[30].

Keeping this in mind, an attempt has been made to categories sulphate of groundwater from the study area as per the guidelines to the use of groundwater containing sulphate for livestock and poultry[16]. The sulphate content of the groundwater ranges from 2.4 to 216 mg/l in pre-monsoon and in the post-monsoon it varies from 19 to 181 mg/l. It is observed from the table that entire samples in the study area are within the limit specified by National Research Council i.e. less than 250 mg/l. Therefore, the groundwater is safe for livestock use. The sulphate content above 50mg/l may affect performance if magnesium and chloride levels are high[16]. As far as study area is concerned, it is observed from the Table-1 and 2 that 9 (13.23%) samples in post – monsoon season and 13 (19.11%) samples in pre monsoon season have sulphate content less than 50mg/l. The remaining samples have sulphate content higher than 50mg/l may affect the performance of livestock. Higher sulphate level have a laxative effect. The sulphate content is higher in post monsoon may be due to action of leaching and anthropogenic activities. SO_4 is not active in summer season because it is mainly derived from fertilizer sources and farmers do not generally use fertilizer in summer.

Table-4 : Groundwater classification for livestock on the basis of nitrate concentration in the area[18].

Nitrate (mg/L)	Comment	No. and Locations of Samples (Pre monsoon)	No. and Locations of Samples (Post monsoon)
0-44	No harmful effect	W1,W2,W3,W4,W5,W6,W7, W8,W10,W13,W14,W16,W25, W26,W27,W28,W29,W30,W3 4,B37,W39,W40,W47,W49,W 51,B55, W56,W58,W60,W61,W63,W6 4,W65,W66,W67,W68 = 36 (52.44%)	W1,W2,W3,W4,W5,W6,W7,W8,W 9,W10,W11,W12,W13,W14,W15,W 16,W17,W18,W19,W20,W21,W22, W23,W24,W25,W26,W27,W28,W2 9,W30,W31,W32,W36,B37,W38,W 39,W40,W41,W46,W47,W48,W49, W50,W51,W52,B55,W56,W57,W60 ,W61,W62,W63,W64,W65,W66,W6 7,W68 = 57 (83.82%)
45-132	Safe if diet is low in nitrates and nutritionally balanced	W9,W11,W12,W16,W17,W18, W19,W20,W21,W22, W23,W24, W31,W32,W33,W35,W36,W3 8, W41,W42,W43,W44,B45,W46 , W48,W50,W52,W53,W54,W5 7, W59,W62 = 32 (47.05%)	W33,W34,W42,W43,W44,B45,W53 ,W54,W58,W59, = 11 (16.17%)
133-220	Could be harmful if consumed over a long period of time	Nil	Nil
221-660	Cattle at risk, possible death losses	Nil	Nil
661-800	Unsafe, high probability of death losses.	Nil	Nil
>800	Unsafe do not use.	Nil	Nil

Nitrates in groundwater with regard to livestock use

High concentrations of nitrate in water can poison livestock. Nitrate is almost always found in higher concentration in water supplies than the more toxic nitrite. In ruminant animals and horses (which have acecum), bacteria reduce nitrate to nitrite, which enters the bloodstream and interferes with the ability of haemoglobin to carry oxygen. Animals may die due to lack of oxygen. In poultry and hogs, which have a more simple stomach than ruminants, bacterial conversion of nitrate to nitrite occurs but is less of a problem[31]. If nitrate concentrations are high in a livestock water supply and in the animal's feed, nitrite poisoning is more likely to occur. Feeds like silage or hay cut during drought can contain high amounts of nitrate.

Symptoms of nitrate poisoning include labored breathing, a blue muzzle, trembling, lack of coordination, and an inability to stand. If the animals do not die, they can often recover completely after the nitrate source is removed. Symptoms of acute nitrate toxicity in non-ruminants include clinical signs of restlessness, frequent urination, dyspnoea and cyanosis. Advanced stage may include vomiting, ataxia, convulsions, inability to rise and death. Symptoms of methemoglobinemia include weakness, ataxia, hypersensitivity, dyspnoea, rapid pulse rate, increase in respiration and urination and cyanosis. Nitrogen – related health problems can often be attributed to a wasteful use of nitrogen fertilser. This is well documented for certain forages such as midmar ryegrass (*Lolium multiforum*) and kikuyu grass (*Pennisetum clandestinum*). Unadapted and hungry animals should not be allowed free access to highly fertilizers. Pastures[32].

In the present study, it is found that nitrate concentrations are higher in pre monsoon than in post monsoon (Table-1 and 2). The nitrate from the ground water in the study area are classified as per the guidelines of NRC[18] (Table-4). It is found that 36 samples (52.44%) and 57 (83.82%) samples in the pre monsoon and post monsoon respectively have nitrate in the range of 0-44 mg/l which has no harmful effect (Table-4) as per guidelines of National Research Council[18]. 32 samples (47.05%) in pre monsoon and 11 samples (16.17%) in post monsoon in the area show nitrate concentration in the range of 45-132 mg/l which is safe if diet is low in nitrates and nutritionally balanced for livestock (Table-4). Overall nitrate concentration in the study area is not harmful for livestock use. The high values of nitrate are observed in the irrigated area which can be attributed to excessive use of chemical fertilizers in the sugarcane cultivating tract.

The groundwater from the villages like Kanoli, Manoli, Rahimpur, Jorve have high concentration of nitrate (Fig.-1). It is also significant to note that area which is thickly populated with residential colonies and industrial sector have high nitrate concentration. The farmers from this area are informed to take care of the livestocks regarding nitrate poisoning.

Climate change and groundwater quality for livestock use

Climate change will have a substantial effect on global water availability in the future. Not only will this affect livestock drinking water resources, but it will also have a bearing on livestock feed production systems and pasture yield. As climate changes becomes more variable, niches for different species alter. This may modify animal diets and compromise the ability of small holders to manage feed deficits[33].

The climate has a profound effect on the soil formation processes as well as Chemistry of water[34]. The climate in the study area is characterized by a hot summer and general dryness during major part of the year excepting during southwest monsoon season. The maximum temperature is as high as 42^{o}C whereas the minimum temperature is as low as 10^{o}C during winter. As the area falls under the rain shadow zone of Western Ghats, it receives very low precipitations with the annual rainfall ranging from 300 to 700 mm. The annual average rainfall is 496.5mm and the distribution is mostly uneven. Therefore care is to be taken of the livestock during summer season in the area.

CONCLUSIONS

In order to evaluate the suitability of groundwater for livestock use, 68 groundwater samples from Sangamner area were analysed for pH, EC/TDS, alkalinity, hardness, chlorides, sulphates, nitrate and

sodium in pre and post monsoon. The lower values of EC/TDS were observed in the topographically high and well drained areas with non-irrigated agriculture. The groundwaters from this area are suitable for all kinds of livestock. The groundwater from the area (Table-3) with EC higher than 7000-10000µS/cm is unfit for poultry and can be used with considerable risk for pregnant or lactating cows, horses, sheep. This type of groundwater is observed in low lying areas which are poorly drained and are under intensive agriculture. Majority of the groundwater samples in the area show very hard category type of groundwater but it has not shown to have either a positive or negative impact on poultry and other livestock. But it can result in the accumulation of scale in water delivery equipments. Hardness and alkalinity of groundwater both help to determine complete interpretation of suitability of groundwater for livestock use. In the study area, the majority of the samples showed alkalinity greater than hardness indicating presence of salts of calcium and magnesium predominating sulphates instead of carbonates. The majority of the samples in the area in pre and post monsoon season have sodium greater than 50mg/l which affect the performance of poultry when sulphate and chloride is high in the groundwater. The sulphate in the study area is higher than 50mg/l in the majority of the groundwater samples which affect the performance of livestock. The sulphate found to be higher in post monsoon season than in pre monsoon. In the study area, nitrate concentration are higher in pre monsoon than in post monsoon. The nitrate in the study area is not harmful for livestock. The higher nitrate concentration is observed in the irrigated area which can be attributed to excessive use of chemical fertilizers in the sugarcane cultivating tract. The hot summer and dryness in the area is found to affect the health of livestock.

Remedial measures

Considering the importance of livestock in maintaining the rural economy of the area, the following remedial measures can be suggested.

- Frequent chlorination of wells at regular interval should be done to fight bacteriological menace and to make the water potable for human and livestock use.
- Prohibit access to cattle / livestock near the storage of water / water pumps.
- Supplying drinking water should be located, designed and constructed in such a way that the groundwater is protected from contamination and wells are used and maintained in a hygienic manner. The well construction should be improved to avoid the possibility of recharge by polluted water through the well lining.
- The education must receive due priority to farmers regarding the better use of groundwater for livestock which are the wealth of our nation.

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