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Assessment of Groundwater Quality in Salem Taluk, Tamil Nadu, India Using GIS Mapping

Arulmozhi.S[1], Dr.Prince Arulraj.G[2] and Dr.Vennila.G[3]
[1]Department of Civil Engineering, Excel College of Technology, Komarapalayam – 637303, Tamil Nadu
[2] Director (Engineering & Technology), Karunya University, Coimbatore - 641114 , Tamil Nadu
[3] Professor & HOD, Department of Civil Engineering, KSR College of Technology, Tiruchengode – 637215, Tamil Nadu
*Corresponding E-mail: arul3345@gmail.com

Abstract

The quality of water is most important factor than the quantity. The quality of groundwater has become a serious concern in the world due to highly pollution risks. The quality of groundwater is affected by different parameters such as geology, soil, discharge of effluents from the industries and the disposal of sewage. The main objective of the study is to evaluate the quality of groundwater in Salem Taluk to check its suitability for drinking purpose and domestic use. Fifty one groundwater samples were collected during the postmonsoon period in December 2012 and premonsoon period in March 2013. The Samples were analyzed for the physico chemical parameters such as pH, Electrical Conductivity, Total Dissolved Solids (TDS), Carbonate (CO_3^-), Bicarbonate (HCO_3^-), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Potassium (K^+), Chloride (Cl^-), Sulphate (SO_4^{2-}) and Fluoride (F^-). The results were compared with the WHO standards. It is found that most of the samples fall into the category of “fit for drinking”.

Key words: Groundwater quality, physic chemical parameter, Drinking Water Standards

Introduction

Water is a natural solvent for most of the biochemical and biological processes. Some of the geochemical processes that take place in the ground water system are evaporation, weathering of minerals, Ion exchange, dissolution, and decomposition. These processes will alter the spatial and seasonal variations in groundwater chemistry. The important factor that governs the use of ground water for irrigation, domestic and industrial uses depends on the geochemistry of ground water, hence monitoring and protecting this natural resource is essential.

The dependence of ground water for industrial, domestic and agricultural activities lead to the over exploitation of ground water resources and the shortage of rainfall has led to water scarcity problems. The discharge of effluent from the industries and the leaching of fertilizers from the agricultural activities will deteriorate the quality of groundwater. Before evaluating the suitability of ground water for various purposes, it is necessary to understand the chemical composition of ground water. Ground water contains seven major chemical elements in dissolved state. They are Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, Na^+, K^+ and SO_4^{2-}. Once the ground water is contaminated, it is difficult to restore its quality. Hence, maintenance of the ground water quality is essential for the protection and management of water resource.

Study Area

Salem is a geological paradise, surrounded by hills and landscape dotted with hillocks. Salem District Consists of 9 Taluks namely Salem, Yercaud, Attur, Omalur, Mettur, Sankari, Gangavalli, Vazhapadi and Idappadi. The study is in Salem Taluk which is a part of Salem District, Tamil Nadu. This Taluk is bound by Omalur and Yeracud Taluk on the Northern side, Tiruchengode Taluk of Namakkal District on the southern side, Vazhapadi Taluk on the Eastern side and Sankari Taluk on the Western Side. Salem Taluk has an area of 978.15km^2 and lies between the longitudes 78^{o}00’00’’E to 78^{o}20’22’’E and latitudes 11^{o}30’00’’N to 11^{o}50’00’’N. Most of the study area consists of plain area 744.53km^2 (76%) and the remaining area is surrounded by hill and forest 233.62 km^2 (24%). The study area is extracted from toposheets 58E/14, 581/1, 581/2, 581/5 and 581/6 issued by the Survey of India (SOI) with a scale of 1:50000. The location of the study area is shown in Figure 1.

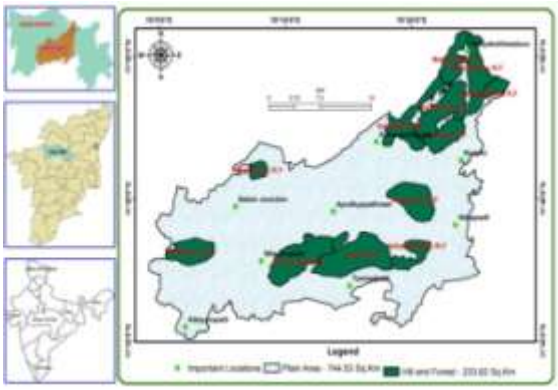

Figure 1 Study Area

Soil Type

The soil is a product that occurs due to the weathering of the rock materials. Groundwater mostly occurs in the weathered as well as in the fractured zones. Soil plays a major role in the hydro geochemistry of the mineral constituents present in the soil gets dissolved to some extent in the groundwater. The study area consists of four different types of soil viz. Brown Soil, Red soil, Red Loamy Soil and Brown Loamy Soil. The large part of the area has brown soil which is rich in nutrients and is more fertile, favorable for the growth of winter crops. The spatial distribution of the soils is shown in Figure 2.

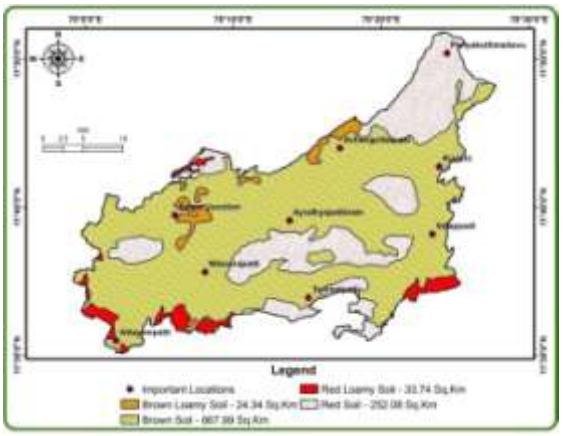

Figure 2 Type of Soils in the Study area

Land Use and Land Cover

Mapping of land use land cover is important for planning and management of water resources. Infiltration of rainwater during rainfall is the major source of groundwater recharge. The surface area available for the rain water percolation can be estimated by mapping the land use / land cover. The anthropogenic activities such as disposal of solid wastes on the open land, leachate formed from the landfills will infilter into the soil and will lead to groundwater pollution.

Most part of the study area (i.e) around 43.2% is used for the cultivation of crop varieties and 23.27% is the reserved forest where the rainfalls get infiltered. The spatial distribution of land use and land cover is shown in Figure 3.

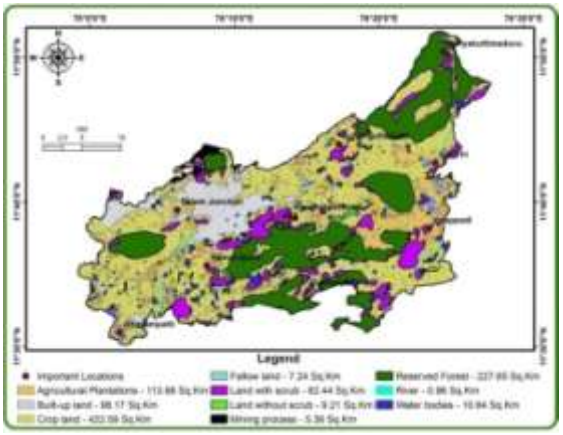

Figure 3 Land use and Land cover of the Study area

Methodology

The groundwater samples from 51 locations during the premonsoon and postmonsoon season were collected in clean polythene bottles and were analyzed for the physico-chemical parameters by employing the standard procedure prescribed by American Public Health Association (APHA, 2012).

The water quality standards prescribed by WHO, 2004 has been followed for assessing the suitability of water for drinking during premonsoon and postmonsoon seasons and is summarized in Table 1.

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Table 1 Water Quality Standards prescribed by WHO, 2004

S.No	Water Quality Parameters	Unit	WHO Standard (2004)	
			Highest Desirable	Maximum Permissible
1	pH	-	7 – 8.5	6.5 – 9.5
2	EC	µS/cm	-	1500
3	Total Dissolved Solids (TDS)	mg/l	500	1500
4	Bicarbonate (HCO_3^-)	mg/l	-	300
5	Total Hardness (TH)	mg/l	100	500
6	Calcium (Ca^{2+})	mg/l	75	200
7	Magnesium (Mg^{2+})	mg/l	50	150
8	Sodium (Na^+)	mg/l	-	200
9	Potassium (K^+)	mg/l	-	12
10	Chloride (Cl^-)	mg/l	200	600
11	Sulphate (SO_4^{2-})	mg/l	200	400
12	Fluoride (F^-)	mg/l	-	1.5

Results and Discussion

The quality of water analyzed for the premonsoon and postmonsoon season is given in Table 2 and 3 and the spatial distribution of the overall water quality is shown in Figure 4 and 5. The Suitability of groundwater for drinking purpose is presented in Table 4.

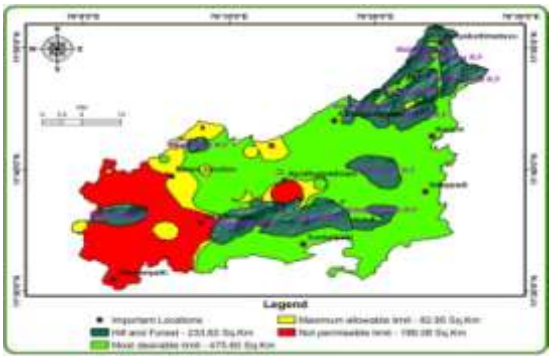

Figure 4 Spatial distribution of the Water Quality during Premonsoon Season

The spatial distribution of water quality during premonsoon season shows that that the groundwater samples taken in an area of 475.60 sq.km (48.62%) is within the most desirable limit, groundwater samples taken in an area of 82.85 sq.km (8.47%) falls within the maximum allowable limit and groundwater samples taken in an area of 186.08 sq.km (19.02%) is in the not permissible limit. From the Figure 4, it can be seen that the water in the west and south-west part of the area is highly polluted due to high fluoride levels.

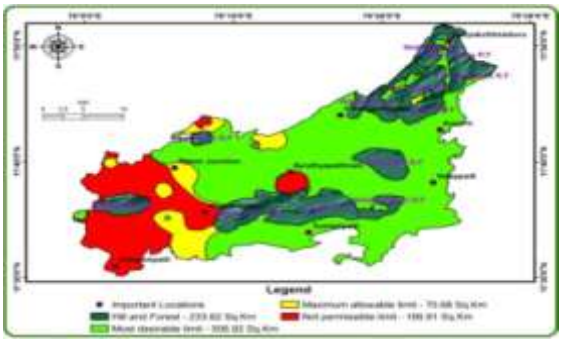

Figure 5 Spatial distribution of the Water Quality during Postmonsoon Season

The spatial distribution of water quality during postmonsoon season shows that the groundwater samples taken in an area of 506.92 sq.km (51.82%) is within the most desirable limit, groundwater samples taken in an area of 70.68 sq.km (7.23%) falls within the maximum allowable limit and groundwater samples taken in an area of 166.91 sq.km (17.06%) is in the not permissible limit. From the Figure 5, it can be seen that the water in the west and south- west part of the area is highly polluted due to high fluoride levels.

Table 2 Groundwater Quality Characteristics during Premonsoon season

Sample No	Water Sample Locations	pH	EC	TDS	TH	CO_3	HCO_3	Ca	Mg	Na	K	Cl	SO_4	F
S1	Kankattala	7.54	1100	588	327	0	299	88	26	100	2	177	48	1.12
S2	Pungamaduvu	7.61	1900	1026	645	0	549	100	96	130	9	293	129	1.28
S3	Kurichi	7.38	2400	1300	711	0	452	100	112	219	7	443	198	1.24
S4	Periyakuttimaduvu	7.81	1600	849	577	0	275	40	116	100	3	266	189	1.53
S5	Pelappadi	7.55	2900	1599	930	0	574	160	129	224	22	443	339	1.22
S6	Belur	7.45	1000	518	446	21	183	60	72	10	12	133	120	1.23
S7	Chandrapillaivalasai	7.97	1400	746	525	0	506	184	16	75	3	142	78	1.26
S8	Pudupalayam	7.42	1900	956	846	0	610	128	128	41	9	222	129	1.22
S9	Tekkalpatti	7.21	2300	1222	727	0	549	90	122	188	9	355	189	1.37
S10	Sirumalai	7.80	1000	511	469	0	342	102	52	11	2	98	78	1.48
S11	Velampatti	7.47	2600	1456	524	0	574	124	52	351	3	426	219	1.22
S12	Aramanur	7.37	1700	910	583	21	268	128	64	119	4	363	78	1.17
S13	Kuppanur	7.84	1700	929	471	0	299	60	78	170	5	310	159	1.25
S14	Palapatti	7.66	1300	697	512	0	354	162	26	58	5	184	88	1.16
S15	Pallipatti	7.80	1400	771	414	0	342	90	46	125	5	186	150	1.21
S16	Kollattukombai	7.93	1000	487	429	12	354	40	80	22	10	89	60	1.17
S17	Eripudur	7.56	1500	786	658	0	354	130	81	36	5	222	138	1.20
S18	Jembuttumalai	7.41	1100	608	360	0	214	80	39	85	2	177	120	1.14
S19	Vellalakundam	7.37	2400	1366	481	0	372	112	49	328	6	470	219	1.30
S20	Veppilaipatti	7.46	1500	818	454	0	476	106	46	115	32	177	108	1.39
S21	Perumalpalayam	7.80	1700	945	468	0	342	128	36	170	3	301	138	1.27
S22	Somampatti	7.51	2000	1076	800	0	445	190	79	85	3	301	198	1.24
S23	Valappadi	7.86	1300	698	478	0	415	160	19	75	3	177	60	1.43
S24	Kammalapatti	7.46	1100	563	484	0	317	90	63	19	3	133	99	1.27
S25	Kuralnattam	7.31	2200	1152	843	0	543	140	120	100	12	355	150	1.22
S26	Tadagapatti	7.46	800	417	358	0	177	104	24	8	1	133	60	1.37
S27	Panamarattupatti	7.31	1300	694	519	0	458	160	29	55	3	113	108	1.21
S28	Sambakuttaipatti	8.14	2000	1082	776	0	409	192	72	101	3	355	159	1.44
S29	Mukkuttipalayam	7.83	3200	1738	863	0	464	110	143	328	10	709	210	1.32
S30	Nilavarapatti	8.25	5300	2854	1219	0	763	134	215	650	13	1330	138	1.52
S31	Senaippalaiyam	7.84	3100	1746	840	0	580	297	24	315	16	621	189	1.78
S32	Palampatti	7.84	7300	3844	3231	0	561	615	412	170	25	2046	300	1.21
S33	Attayampatti	7.58	3900	2148	989	0	574	180	131	426	24	887	219	1.25
S34	Agraharapulaveri	7.85	2300	1244	316	0	915	44	50	374	17	202	108	1.25

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S35	Ilampillai	7.67	2000	1036	634	0	781	94	97	156	20	177	108	1.87
S36	Tirumalagiri	7.69	3600	2010	526	0	708	102	66	575	16	754	150	1.38
S37	Keeraipappambadi	7.18	3200	1777	634	0	744	178	46	426	18	576	168	1.48
S38	Laguvampatti	7.37	7100	3805	2388	36	812	513	269	520	26	1950	129	2.87
S39	Kandampatti	7.51	2800	1552	472	0	580	44	88	426	3	443	228	2.91
S40	Kamanaykkanpatti	7.65	1400	688	641	0	433	44	129	14	21	177	90	2.73
S41	Neikkarapatti Puttur	7.71	3000	1521	1310	0	610	144	231	81	13	594	159	2.91
S42	Chettichavadi	7.31	3600	1860	1349	0	635	120	255	201	8	745	219	2.97
S43	Hasthampatti	8.76	1500	791	575	0	366	110	73	78	3	239	108	2.73
S44	Ayyamperumalpatti	7.48	1100	571	446	0	268	70	66	45	3	177	78	2.81
S45	Pallappatti	7.52	2600	1353	942	12	549	84	178	162	7	443	210	2.89
S46	Ammapettai	7.37	1400	733	521	0	427	108	61	75	12	177	78	2.13
S47	Thatampatti	7.72	700	353	300	0	275	56	39	18	5	62	38	3.24
S48	Ayodhyapattinam	7.19	3100	1699	701	0	647	134	89	374	16	621	138	3.03
S49	Perumal palayam	7.71	2900	1546	1148	0	549	206	154	121	23	532	240	2.86
S50	Chinnanur	7.37	1900	1026	744	0	519	204	57	90	5	241	174	2.66
S51	Karipatti	7.59	1400	708	549	0	415	60	97	60	11	186	90	2.16

Table 3 Groundwater Quality Characteristics during Postmonsoon season

Sample No	Water Sample Locations	pH	EC	TDS	TH	CO_3	HCO_3	Ca	Mg	Na	K	Cl	SO_4	F
S1	Kankattala	7.60	888	622	288	0	253	77	23	105	2	171	56	1.07
S2	Pungamaduvu	6.90	1326	928	573	0	465	88	86	136	11	283	150	1.22
S3	Kurichi	6.90	1600	1120	632	0	383	88	100	229	9	428	230	1.19
S4	Periyakuttimaduvu	7.30	1149	804	515	0	233	35	104	105	4	257	220	1.46
S5	Pelappadi	7.59	1899	1329	826	0	486	140	116	234	27	428	394	1.17
S6	Belur	6.98	818	573	397	20	155	53	65	10	15	128	139	1.18
S7	Chandrapillaivalasai	7.50	1046	732	462	0	428	161	14	78	4	137	91	1.21
S8	Pudupalayam	7.57	1256	879	752	0	516	112	115	43	11	214	150	1.17
S9	Tekkalpatti	7.61	1522	1065	647	0	465	79	109	197	11	343	220	1.31
S10	Sirumalai	7.32	811	568	415	0	289	89	47	12	2	95	91	1.42
S11	Velampatti	7.61	1756	1229	463	0	486	109	47	367	4	411	254	1.17
S12	Aramanur	7.61	1210	847	516	20	227	112	57	124	5	350	91	1.12
S13	Kuppanur	7.74	1229	860	419	0	253	53	70	178	6	299	185	1.20
S14	Palapatti	7.57	997	698	450	0	300	142	23	61	6	178	102	1.11
S15	Pallipatti	7.51	1071	750	367	0	289	79	41	131	6	180	174	1.16
S16	Kollattukombai	7.74	787	551	383	11	300	35	72	23	12	86	70	1.12
S17	Eripudur	7.40	1086	760	583	0	300	114	73	38	6	214	160	1.15
S18	Jembuttumalai	7.45	908	636	319	0	181	70	35	89	2	171	139	1.09
S19	Vellalakundam	7.45	1666	1166	426	0	315	98	44	343	7	454	254	1.24

S20	Veppilaipatti	7.00	1118	783	402	0	403	93	41	120	40	171	125	1.33
S21	Perumalpalayam	7.44	1245	872	413	0	289	112	32	178	4	291	160	1.21
S22	Somampatti	7.45	1376	963	707	0	377	166	71	89	4	291	230	1.19
S23	Valappadi	7.11	998	699	420	0	351	140	17	78	4	171	70	1.37
S24	Kammalapatti	7.46	863	604	429	0	268	79	56	20	4	128	115	1.21
S25	Kuralnattam	7.51	1452	1016	749	0	460	123	108	105	15	343	174	1.17
S26	Tadagapatti	7.44	717	502	316	0	150	91	22	8	1	128	70	1.31
S27	Panamarattupatti	7.57	994	696	457	0	388	140	26	58	4	109	125	1.16
S28	Sambakuttaipatti	7.84	1382	967	686	0	346	168	65	106	4	343	185	1.38
S29	Mukkuttipalayam	7.47	2038	1427	768	0	393	96	128	343	12	685	244	1.26
S30	Nilavarapatti	7.41	3154	2208	1086	0	646	117	193	680	16	1284	160	1.45
S31	Senaippalaiyam	7.10	2046	1432	738	0	491	260	22	329	20	600	220	1.70
S32	Palampatti	6.38	4144	2901	2865	0	475	539	369	178	31	1975	349	1.16
S33	Attayampatti	7.81	2448	1714	877	0	486	158	117	446	30	856	254	1.20
S34	Agraharapulaveri	6.90	1544	1081	281	0	774	39	45	391	21	195	125	1.20
S35	Ilampillai	7.43	1336	935	563	0	661	82	87	163	25	171	125	1.79
S36	Tirumalagiri	7.39	2310	1617	467	0	599	89	59	601	20	728	174	1.32
S37	Keeraipappambadi	8.32	2077	1454	559	0	630	156	41	446	22	556	195	1.42
S38	Laguvampatti	7.00	4105	2874	2115	34	687	449	241	544	32	1883	150	2.75
S39	Kandampatti	7.65	1852	1296	421	0	491	39	79	446	4	428	265	2.78
S40	Kamanaykkanpatti	7.09	988	692	572	0	366	39	116	15	26	171	105	2.61
S41	Neikkarapatti Puttur	7.09	1821	1275	1167	0	516	126	207	85	16	574	185	2.78
S42	Chettichavadi	7.11	2160	1512	1203	0	537	105	229	210	10	719	254	2.84
S43	Hasthampatti	7.40	1091	764	510	0	310	96	65	82	4	231	125	2.61
S44	Ayyamperumalpatti	6.97	871	610	397	0	227	61	59	47	4	171	91	2.69
S45	Pallappatti	7.15	1653	1157	840	11	465	74	160	169	9	428	244	2.76
S46	Ammapettai	7.46	1033	723	461	0	361	95	55	78	15	171	91	2.04
S47	Thatampatti	7.20	653	457	266	0	233	49	35	19	6	60	44	3.10
S48	Ayodhyapattinam	6.97	1999	1399	621	0	548	117	80	391	20	600	160	2.90
S49	Perumal palayam	7.81	1846	1292	1019	0	465	180	138	127	29	514	279	2.74
S50	Chinnanur	7.23	1326	928	657	0	439	179	51	94	6	233	202	2.54
S51	Karipatti	7.05	1008	706	489	0	351	53	87	63	14	180	105	2.07

Table 4 Suitability of groundwater for drinking purpose

		Premonsoon		Postmonsoon		
S.No	**Parameters**	**No of Samples exceeding the Most Desirable Limit**	**Percentage of Samples exceeding the Most Desirable Limit**	**No of Samples exceeding the Most Desirable Limit**	**Percentage of Samples exceeding the Most Desirable Limit**	**Representing Samples exceeding the most permissible limit in both the seasons**

1	pH	1	1.96	Nil	-	-
2	EC	31	60.78	20	39.22	S3, S5, S9, S11, S19, S29, S30, S31, S32, S33, S34, S36, S37, S38, S39, S41, S42, S45, S48, S49
3	TDS	48	94.18	50	98.04	S30, S32, S33, S36, S38, S42
4	TH	34	66.67	27	52.94	S2, S3, S4, S5, S8, S9, S12, S17, S22, S25, S28, S29, S30, S31, S32, S33, S35, S37, S38, S40, S41, S42, S43, S45, S48, S49, S50
5	Ca	41	80.39	39	76.47	S31, S32, S38
6	Mg	37	75.55	34	66.67	S30, S32, S38, S41, S42, S45
7	Na	15	29.41	15	29.41	S3, S5, S11, S19, S29, S30, S31, S33, S34, S36, S37, S38, S39, S42, S48
8	K	19	37.25	24	47.06	S5, S6, S20, S25, S30, S31, S32, S33, S34, S35, S36, S37, S38, S40, S41, S46, S48, S49, S51
9	Cl	32	62.74	31	60.78	S29, S30, S32, S33, S36, S38, S42
10	SO_4	Nil	Nil	Nil	Nil	Nil
11	F	18	35.29	16	31.37	S31, S35, S38, S39, S40, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51

Conclusions

From the Study, it is found that the quality of groundwater in most of the study area is within the permissible limit of WHO standards for drinking. The Western Parts of areas such as Neikkarapatti, Puttur, Chettichavadi, Hasthampatti, Ayyamperumalpatti, Pallappatti, Ammapettai, Thatampatti, Ayodhyapattinam, Perumalpalayam, Chinnanur and Karipatti on the western part of the study area is found to be polluted by the dissolution of minerals under the soil and also due to local anthropogenic activities. The TDS value of almost all the samples in both the seasons falls under very hard to extremely hard category. The overall quality of groundwater in Salem Taluk in Eastern, Northern and Southern part is found to be suitable for drinking purpose except under TDS criteria. The Western part of the study area has to be treated before use.

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