EVALUATION OF GROUNDWATER QUALITY USED FOR AGRICULTURE IN ANKARA-GOLBASI SPECIAL ENVIRONMENTAL PROTECTION AREA

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ABSTRACT

Gölbaşı district, located at 20 km south of Ankara city is one of the special environmental protection areas (SEPA) of Turkey. The water resources of Gölbaşı district are under the pressure of urbanization and agricultural activities. In recent years, the demand for groundwater has increased, however availability is limited to the quantity and quality of water, where the latter is subjected to salinity and boron contamination. Therefore, there is a need to figure out the current status of water quality in the district for agricultural use. In this study, 41 groundwater samples (mostly existing wells and fountains) from 11 villages were collected and analyzed for relevant parameters to assess their conformity with irrigation and livestock drinking standards. Salinity class of 13 samples were determined as C3 (high salinity) and 6 samples were classified as C4 (very high salinity). Boron concentrations were not too high, such that 59-88% of samples were Class 1 for sensitive, moderately sensitive and resistant plants, respectively. On the other hand, only 5-10% of samples were Class 5 for plants. The results showed that groundwaters were either not suitable or should be used with attention for irrigation and livestock drinking at a ratio of 40% and 32%, respectively.

1. INTRODUCTION

Turkey is under the risk of becoming a water-poor country by 2030 due to limited water resources and expected adverse impacts of population increase and climate change. As a candidate country to the European Union (EU), Turkey has to adopt the environmental policy of EU and transpose the related legislation such as the Water Framework Directive (WFD) (2000/EC/60). The WFD promotes integrated management of water resources to reduce problems associated with excessive water abstraction, pollution, floods and droughts. Therefore, Turkey has to use her water resources wisely to minimize water stress in the future.

Gölbaşı Special Environmental Protection Area (SEPA) is located at a distance of 20 km south of Ankara city, the capital of Turkey. Ankara is in the Central Anatolia Region and gets an average of 400 mm precipitation per year, which is less than the country average of about 600 mm. So, Golbasi SEPA suffers from water scarcity and depends on groundwater resources for agricultural activities. In addition, groundwaters are naturally contaminated with boron and salinity. In Turkish regulations, the boron limit is reported as 1 mg/L in drinking water. In the case of mammalians, boron induces male reproductive impediments and several teratogenic effects. Boron concentration in irrigation water, even when slightly higher than permissible level, affects plant growth which is expressed as 'boron poisoning effect' -appearance of yellow spots on leaves and fruit. Some plants are more sensitive to boron than others. Sensitive plants can tolerate irrigation waters up to 0.3 mg/L boron, while resistant plants may be able to survive up to 4 mg/L boron in irrigation water (Table 1) [1]. For animals, the effect of boron has not been determined so explicitly. It was shown that boron is the essential element in the human diet, however its specific biochemical function has not been identified yet [2]. For livestock, the desired limit of boron has been reported as 5 mg/l [3, 4]. Table 2 shows residual sodium carbonate limits and Table 3 shows salinity and alkalinity classes for irrigation waters. This study aims at evaluating the quality of groundwater in Golbasi district in terms of boron and salinity contamination.

Table 1. *Boron classes for plants*

Boron class	Sensitive plants (ppm)	Moderately sensitive plants (ppm)	Resistant plants (ppm)
1	< 0.33	< 0.67	< 1.00
2	0.33 – 0.67	0.67 – 1.33	1.00 – 2.00
3	0.67 – 1.00	1.33 – 2.00	2.00 – 3.00
4	1.00 – 1.25	2.00 – 2.50	3.00 – 3.75
5	> 1.25	> 2.5	> 3.75

Table 2. *Residual sodium carbonate limits for irrigation waters*

Residual sodium carbonate	Remark
More than 2.5 me/l	can not be used for irrigation
1.25 – 2.5 me/l	might be harmful
Less than 1.25 me/l	can be safely used for irrigation

Table 3. *Salinity and alkalinity classes for irrigation waters*

Salinity	Alkalinity
C1 Low salinity	S1 Low sodium
C2 Moderate salinity	S2 Moderate sodium
C3 High salinity	S3 High sodium
C4 Very high salinity	S4 Very high sodium

2. MATERIALS AND METHODS

In Golbasi SEPA, 11 villages were visited in May 2012 (irrigation season) (Figure 1). Water resources used for irrigation and livestock drinking were identified. 41 samples were collected from several resources such as wells, lagoons and fountains. Water samples were analyzed for quality parameters shown in Table 4. Samples were analyzed by the Irrigation Water Quality Analysis Laboratory of Central Research Institute of Soil Fertilizer and Water Resources (Ministry of Food Agriculture and Livestock). Table 5 shows the water resources sampled in each village. USA Salinity Lab class was determined for each sample by depicting sodium adsorption ratio (SAR; calculated from sodium, calcium and magnesium data) versus electrical conductivity (EC).

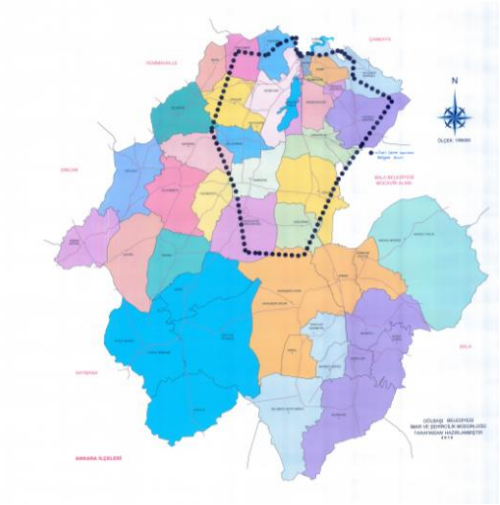

Figure 1. *Golbasi district with borders of SEPA*

Table 4. *Water quality parameters measured*

Parameter	Unit
Electrical Conductivity (EC)	(µmhos/cm)
Sodium	(me/l)
Calcium	(me/l)
Magnesium	(me/l)
Carbonate	(me/l)
Bicarbonate	(me/l)
Boron	(mg/l)

3. RESULTS AND DISCUSSION

Table 5 shows the assessment results of samples for agricultural use. Among 41 samples, 13 samples are used for irrigation and 9 of them are taken from existing drilling wells with depths up to 200 m. As seen from Table 5, the quality of 17 samples out of 41 samples does not meet irrigation water standards and 7 of these samples are currently used for irrigation. The evaluation of results revealed that 17 water resources given in Table 6 can only be used with special precautions or cannot be used at all for irrigation. This corresponds to 41% of all samples (17/41) collected in the region, which is a significant ratio indicating the severe quality problems in the water resources of Golbasi SEPA. Currently, 7 of these samples are being used for irrigation; which means 41% of samples (7/17) used for irrigation do not have the required quality.

USA salinity lab class was determined for all samples (Figure 2). As seen, sodium adsorption ratio (SAR) is less than 10 for most samples; however it is around 60 for two samples (HA-1; used for irrigation and YC-3; not used currently). Electrical conductivity (EC) varies between 400-4000 µmhos/cm; therefore salinity and alkalinity classes are generally in the region of C2-S1, C3-S1, C4-S1 and C4-S2. Only two samples are C4-S4 (HA-1 and YC-3).

Table 6. Water resources to be handled with special attention

Sample	Remark
BP-2 OB-2 OB-6	These water resources should not be used for irrigation. In very special cases, for example when water is abundant and used frequently, then they can be used for growing plants that are resistant to salinity such as barley and wheat.
GP-1 HH-2 KO-1 OB-5	These water resources should be used with special attention. In very special cases, for example when water is abundant and used frequently, then they can be used for growing plants that are resistant to salinity such as barley and wheat. Extra washing water can be given to soil to avoid problems.
HA-1 YC-3	These water resources cannot be used. Even if used once or twice, it may cause permanent hazard on soil and lead to reclamation problems that are costly.
OB-1 OB-7 OB-8 ÖR-3 YP-2 YP-5	This water resource should be used with special attention. In very special cases, for example when water is abundant and used frequently, then it can be used for growing all types of plants except those sensitive to salinity. Extra water can be given to soil to avoid problems.
YP-3 YC-1	These water resources should not be used for irrigation. In very special cases, for example when water is abundant and used frequently, then they can be used for growing plants that are resistant to salinity such as barley and wheat. Even resistant plants are used, washing must be applied. In the long term, there is the risk of causing reclamation problem. Lime can be applied to soil to help minimize these problems.

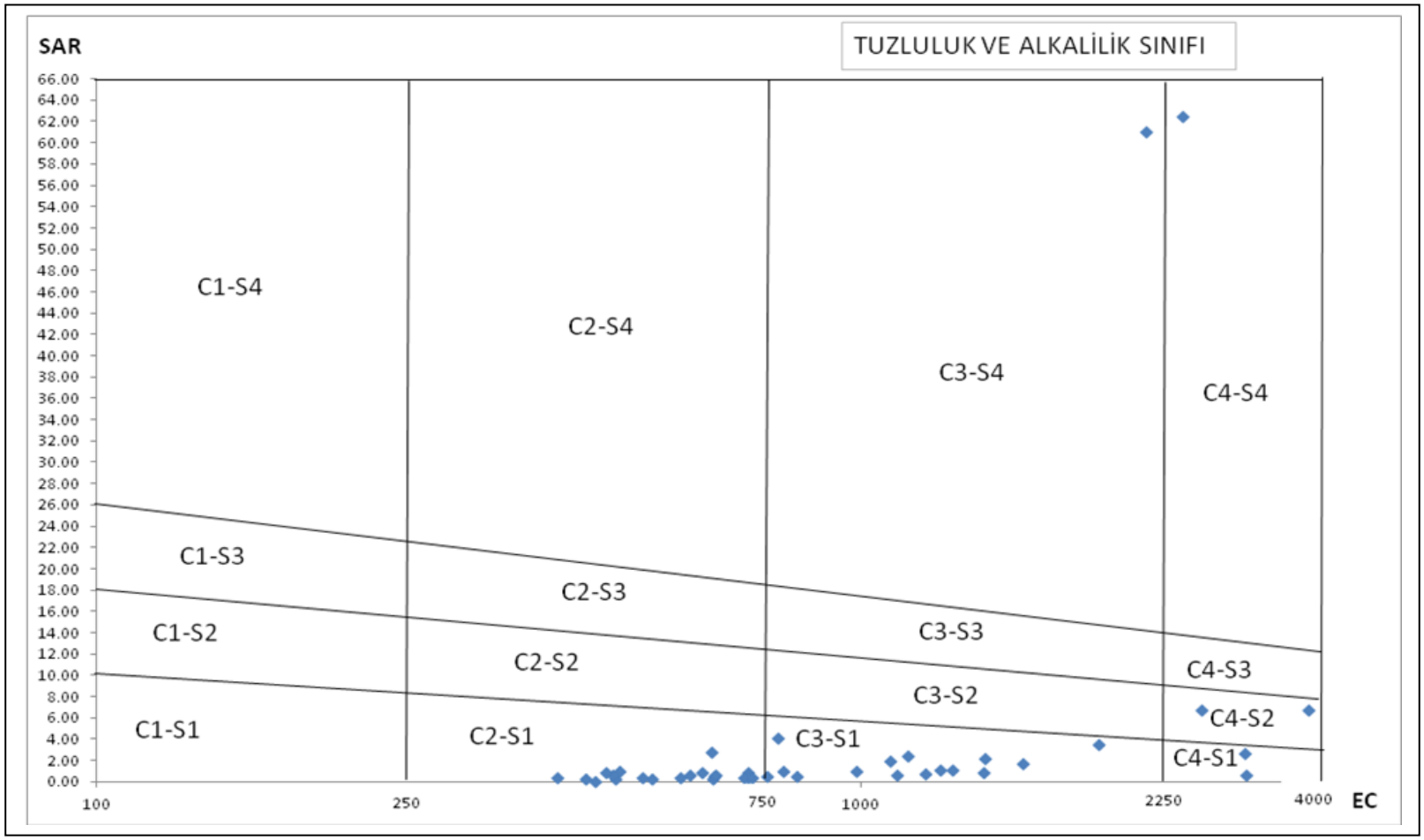

Figure 2. *Salinity and alkalinity classes of water samples*

Table 5. *Evaluation of water quality for agricultural use*

Village	Sample	Source	USA Salinity Lab Class (irrigation)	Boron concentration (mg/l)	Boron class for sensitive plants	Boron class for moderately sensitive plants	Boron class for resistant plants	Purpose of use		Conformity	
								(I)	(L)	(I)	(L)*
Ballikpinar	BP-1	Fountain	C2-S1	0.9	3	2	1		●	✓	✓
	BP-2	Dug well	C4-S2	1.9	5	3	2		●	x	✓
	BP-3	Drilling well	C2-S1	0.0	1	1	1	●		✓	✓
Gaziosman-	GP-1	Dug well	C3-S1	0.7	3	2	1			x	✓
Gokcehoyuk	GH-1	Fountain 1	C3-S1	0.4	2	1	1		●	✓	✓
	GH-2	Fountain 2	C2-S1	0.3	1	1	1		●	✓	✓
Hacilar	HA-1	Drilling well	C4-S4	6.8	5	5	5	●		x	x
Hacihasan	HH-1	Dug well	C3-S1	0.3	1	1	1		●	✓	✓
	HH-2	Drilling well	C3-S1	0.6	2	1	1		●	x	✓
Karaoglan	KO-1	Drilling well	C3-S1	2.0	5	4	3	●		x	✓
	KO-2	Fountain	C2-S1	0.4	2	1	1		●	✓	✓
	KO-3	Drilling well	C2-S1	0.2	1	1	1		●	✓	✓
	KO-4	Drilling well	C2-S1	0.1	1	1	1		●	✓	✓
	KO-5	Fountain	C2-S1	0.1	1	1	1		●	✓	✓
	KO-6	Drilling well	C2-S1	0.2	1	1	1		●	✓	✓
	KO-7	Drilling well	C2-S1	0.9	3	2	1	●	●	✓	✓
	KO-8	Drilling well	C2-S1	0.2	1	1	1	●	●	✓	✓
	KO-9	Lagoon 2	C2-S1	0.0	1	1	1	●	●	✓	✓
Ogulbey	OB-1	Drilling well	C3-S1	0.8	2	2	1		●	x	✓
	OB-2	Drilling well	C4-S1	0.0	1	1	1	●		x	✓
	OB-3	Drilling well	C2-S1	0.0	1	1	1	●		✓	✓
	OB-4	Old network	C2-S1	0.0	1	1	1		●	✓	✓
	OB-5	Drilling well	C3-S1	0.1	1	1	1	●		x	✓
	OB-6	Drilling well	C4-S1	0.1	1	1	1	●		x	✓
	OB-7	Fountain	C3-S1	0.0	1	1	1		●	x	✓
	OB-8	Drilling well	C3-S1	0.0	1	1	1		●	x	✓
Orencik	ÖR-1	Old network	C2-S1	0.0	1	1	1			✓	✓
	ÖR-2	Old network	C2-S1	0.4	2	1	1			✓	✓
	ÖR-3	Dug well	C3-S1	0.2	1	1	1	●		x	✓
Yaglipinar	YP-1	Drilling well	C3-S1	0.3	1	1	1		●	✓	✓
	YP-2	Old network	C3-S1	0.5	1	1	1		●	x	✓
	YP-3	Creek	C4-S2	0.4	1	1	1		●	x	✓
	YP-4	Fountain 1	C2-S1	0.1	1	1	1		●	✓	✓
	YP-5	Fountain 2	C3-S1	0.4	1	1	1		●	x	✓
Yavrucak	YC-1	Dug well	C3-S1	1.1	4	2	2	●		x	✓
	YC-2	Old network	C2-S1	0.3	2	1	1	●		✓	✓
	YC-3	Drilling well	C4-S4	9.7	5	5	5			x	x
Yurtbeyi	YB-1	Drilling well	C2-S1	0.4	2	1	1		●	✓	✓
	YB-2	Fountain 1	C2-S1	0.4	2	1	1		●	✓	✓
	YB-3	Old network	C2-S1	0.4	2	1	1		●	✓	✓
	YB-4	Fountain 2	C2-S1	0.0	1	1	1		●	✓	✓

(I): Irrigation, (L): Livestock

(L)*: Quality is assessed considering boron only.

● currently used for the specified purpose

✓ suitable for the specified purpose

x not suitable for the specified purpose

Boron classes were also evaluated. As seen from Table 7, 59% of samples are Class 1, 22% of samples are Class 2, 7% are Class 3, 2% are Class 4 and 10% are Class 5 regarding the irrigation of sensitive plants. Similarly, 78% of samples are Class 1, 12% are Class 2, 2% are Class 3, 3% are Class 4 and 5% are Class 5 regarding the irrigation of moderately sensitive plants. On the other hand, 88% of samples are Class 1, 5% are Class 2, 2% are Class 3 and 5% are Class 5 for the irrigation of resistant plants. The boron concentration in the groundwaters of the region is of natural origin; Turkey lands are very rich in boron, which results in high boron concentrations in the water resources of some regions. Therefore, this situation cannot be regarded as environmental pollution, however the worse quality of water in addition to water scarcity adversely affects the agricultural activities in Golbasi SEPA.

In terms of livestock drinking, only two samples exceeded the recommended limit of 5 mg/l; these are HA-1 (Hacilar) and YC-3 (Yavrucak), respectively. Fortunately, both water resources are not used for livestock drinking at the moment. Therefore, it can be stated that boron is not a problem for animals fed in the region. However, long term exposure to these concentrations should be investigated.

Table 7. *Ratio of samples with different boron classes*

Boron Class	Sensitive Plants		Moderately sensitive plants		Resistant Plants	
	Number of samples	%	Number of samples	%	Number of samples	%
1	24	59	32	78	36	88
2	9	22	5	12	2	5
3	3	7	1	2	1	2
4	1	2	1	3	0	0
5	4	10	2	5	2	5
Total	41	100	41	100	41	100

4. CONCLUSIONS

Golbasi SEPA is suffering from water scarcity and water quality problems. In recent years, there has been an increasing demand for groundwater resources for irrigation and livestock drinking purposes. Indeed, it has been forbidden to drill new wells in an attempt to protect the groundwater resources in the region. Salinity and boron contamination problem, although a natural phenomena, adversely affects the agricultural activities.

This study figures out the existing situation in terms of water quality used for agriculture in Golbasi SEPA, and focuses on salinity and boron contamination problem. The analysis of samples taken from 41 points revealed that 41% of all samples are not suitable for irrigation and 41% of samples used for irrigation are of worse quality. On the other hand, boron concentrations are at acceptable levels for livestock drinking.

5. REFERENCES

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