

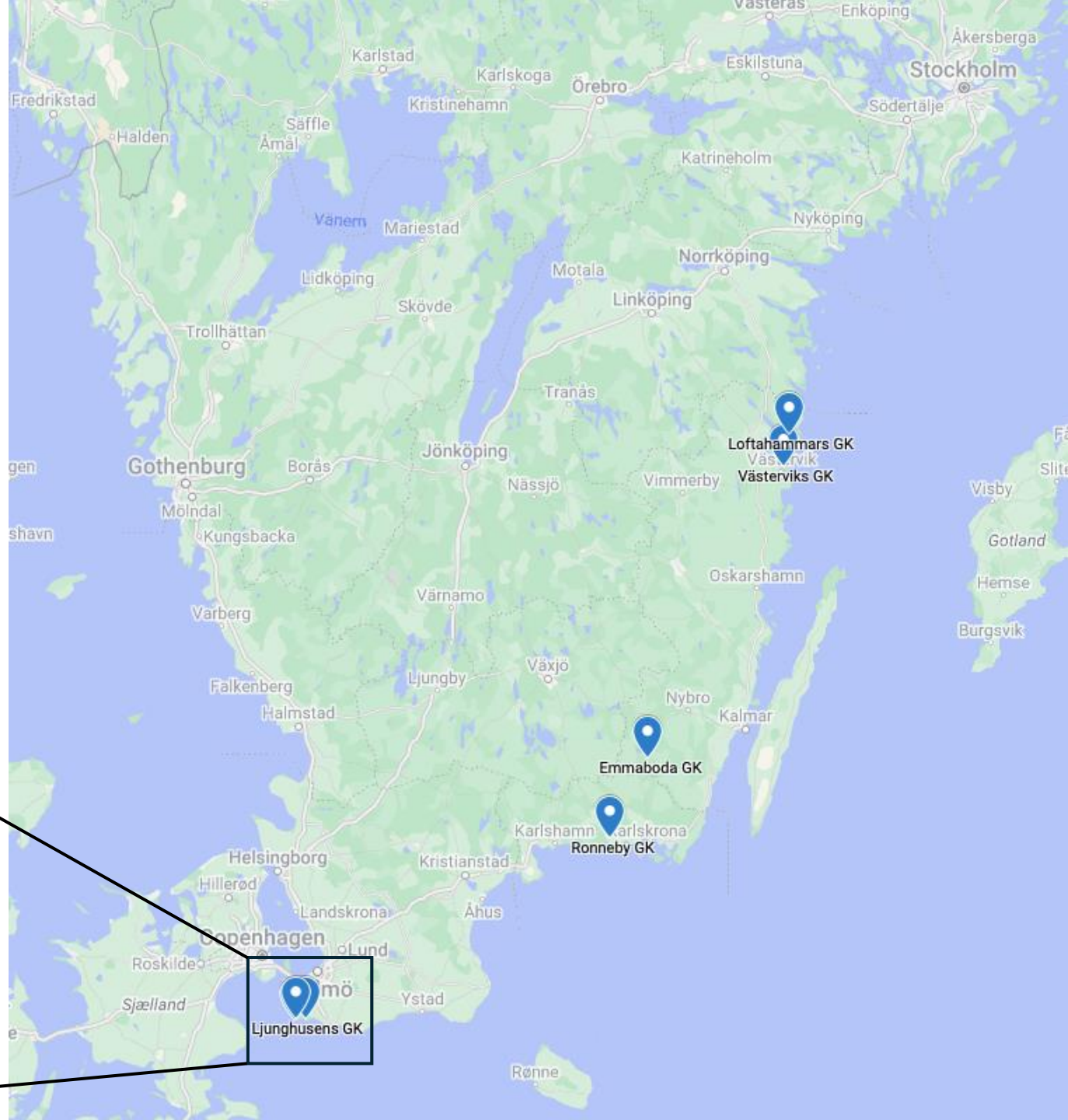
Recycled and brackish water for golf course irrigation in Sweden

Fairwater II



The golf courses that participated in the study are all on Sweden's Baltic Coast

1. Ljunghusen
2. Falsterbo
3. Flommen
4. Ronneby
5. Emmaboda
6. Vastervik
7. Loftahammar



Interpreting soil and water quality tests can be difficult – but in most cases interpretation can be greatly simplified

WATER ANALYSIS											
Submitted by Michael Bekken Langestrand 45 Grimstad, Norway 4879				Submitted for FAIRWATER- EMMABODA				AgSource LABORATORIES			
Date Received 2-Sep-2025				Date Reported 04-Sep-2025				Laboratory Sample # DF70054			
SAMPLE MARKED 28								Information Sheet # 81993			
				ANALYSIS OF CHEMICAL PROPERTIES		YOUR RESULTS			RATING OF YOUR RESULTS		
		UNIT OF MEASURE	RESULT	LBS/ ACRE FOOT	SATISFACTORY	POSSIBLE PROBLEM	PROBABLE PROBLEM				
WATER CHARACTERISTICS	pH	--	6.26	--							
	Hardness	ppm	51.55	--							
	Bicarbonate	ppm	25.38	--							
	Carbonate	ppm	69.03	--							
IMPACT ON GENERAL PLANT GROWTH		Electrical Conductivity (ECw) Total Soluble Salts	mmhos/cm ppm	0.30 192.64	-- 523.98						
IMPACT FROM ROOT CONTACT		Sodium Chloride Boron	meq/l ppm ppm	1.24 70.00 0.02	-- 190.40 0.05						
IMPACT FROM FOLIAGE CONTACT		Sodium Chloride	ppm ppm	28.50 70.00	77.52 190.40						
IMPACT ON SOIL STRUCTURE		Sodium Absorption Ratio Adj Electrical Conductivity (ECe) Total Soluble Salts	mmhos/cm ppm	0.99 0.30 192.64	-- -- 523.98						
To maintain good soil structure in arid regions, irrigation water should have the capacity to replace the soluble salts being dissolved. If the salts being dissolved are not replaced, a decrease in permeability may occur.					No anticipated difficulty with most crops.		Some difficulty for sensitive & moderately sensitive crops.				
							Significant difficulty for most crops.				
ANALYSIS OF NUTRIENTS											
PLANT NUTRIENTS AS NORMALLY REPORTED IN WATER ANALYSIS		RESULTS AS PPM	NUTRIENTS CONVERTED TO BASIC FERTILIZER MATERIAL FORMS			RESULTS LBS/ACRE FOOT	MEQ / LITER				
NITRATE (NO ₃ -N)		1.55	NITROGEN (N)			4.22	CATIONS	K ⁺	0.17		
PHOSPHATE (PO ₄)		0.01	PHOSPHATE (P ₂ O ₅)			0.02					
POTASSIUM (K)		6.57	POTASH (K ₂ O)			21.29					
MAGNESIUM (Mg)		3.53	MAGNESIUM OXIDE (MgO)			15.88					
CALCIUM (Ca)		14.83	CALCIUM (Ca)			40.34	ANIONS	Cl ⁻	0.29		
SULFATE (SO ₄)		12.02	SULFUR (S)			10.82					
MANGANESE (Mn)		0.01	MANGANESE (Mn)			0.03					
IRON (Fe)		0.64	IRON (Fe)			1.74					
BORON (B)		0.02	BORON (B)			0.05					
							pHc				
							Total Cations				
							Total Anions				
							SAR				

Soil Analysis

Submitted by

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Submitted for

FAIRWATER

AgSource

LABORATORIES

Laboratory Sample #

DF70016 - DF70024

Information Sheet #

81977

Date Received

2-Sep-2025

Date Reported

05-Sep-2025

Sample Identification	Phosphorus			Potassium	Calcium	Magnesium	Zinc	Manganese	Copper	Iron
	Bray I	Olsen	Mehlich							
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
10 GREEN RONN	17			87	161	71	2.6	7.6	1.0	170.7
11 GREEN RONN	26			79	148	74	1.6	7.7	0.7	175.2
12 GREEN RONN	24			76	128	66	1.1	8.9	0.6	206.8
13 GREEN EMM	60			42	51	18	0.3	2.2	1.4	342.8
14 GREEN EMM	31			52	121	20	1.0	2.5	1.0	277.8
15 GREEN EMM	29			65	93	22	1.3	3.4	1.1	304.8
16 GREEN VASTE	18			47	431	38	2.5	1.2	0.6	68.2
17 GREEN VASTE	15			51	411	40	2.5	1.2	0.6	62.6
18 GREEN VASTE	19			69	423	33	2.3	1.9	1.0	69.9
Optimum Levels Greens	25 - 45			100 - 130	429 - 496	95 - 120	1.0 - 3.0	5.0 - 15.0	0.5 - 1.5	4.0 - 20.0

Sample Identification	Soil pH	Sodium	Soluble Salts	Organic Matter	Cation Exchange	Percent Base Saturation				
		ppm	mmhos/cm	%	meq/100g	Hydrogen	Sodium	Potassium	Calcium	Magnesium
						%	%	%	%	%
10 GREEN RON	5.5	227.0	0.3	1.5	3.3	21.2	29.9	6.8	24.4	17.8
11 GREEN RON	5.3	226.0	0.3	1.5	3.5	28.3	27.7	5.7	20.8	17.4
12 GREEN RON	5.5	203.0	0.3	1.2	3.1	27.8	28.2	6.2	20.4	17.4
13 GREEN EMM	4.8	16.0	0.1	1.6	2.7	78.6	2.6	4.0	9.5	5.4
14 GREEN EMM	5.1	13.0	0.1	1.1	2.4	59.6	2.4	5.6	25.5	7.0
15 GREEN EMM	5.0	14.0	0.1	1.7	2.6	65.7	2.5	6.5	18.2	7.1
16 GREEN VAS	6.4	20.0	0.2	1.6	3.0	10.9	3.0	4.0	71.5	10.6
17 GREEN VAS	6.6	14.0	0.1	1.3	2.6		2.4	5.0	79.8	12.8
18 GREEN VAS	6.4	17.0	0.1	1.5	3.2	16.5	2.4	5.6	66.8	8.7
Optimum Levels Greens	5.9 - 6.5	10 - 80	0.1 - 1.0	1.0 - 3.0		1.0 - 10.0	< 5.0	2.0 - 7.0	65 - 75	15 - 25

Sample Identification	Boron	Sulfur	Nitrate	Ammonium	Chloride	Aluminum	Particle Size Analysis			
	ppm	ppm	ppm	ppm	ppm	ppm	Sand	Silt	Clay	Soil Texture
							%	%	%	
10 GREEN RON	0.2	26.9	1.9							
11 GREEN RON	0.3	19.0	2.7							
12 GREEN RON	0.2	20.6	1.0							
13 GREEN EMM	0.2	15.1	4.2							
14 GREEN EMM	0.2	10.4	7.4							
15 GREEN EMM	0.2	21.3	3.1							
16 GREEN VAS	0.1	8.1	13.4							
17 GREEN VAS	0.1	5.4	13.4							
18 GREEN VAS	0.2	10.0	8.7							
Optimum Levels Greens	0.5 - 1.0	8.0 - 20.0	5.0 - 25.0							

When working with or switching to lower quality irrigation water – two major salt related problems that are critical to understand

- **Salinity**

- Salt: substance that dissolves into water as ions ($\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$)
- Salinity: the amount of dissolved ions in water

- **As applied to turfgrass**

- Water
 - Electrical conductivity of irrigation water (EC_w)
- Soil
 - Electrical conductivity of soil water extract (EC_e)

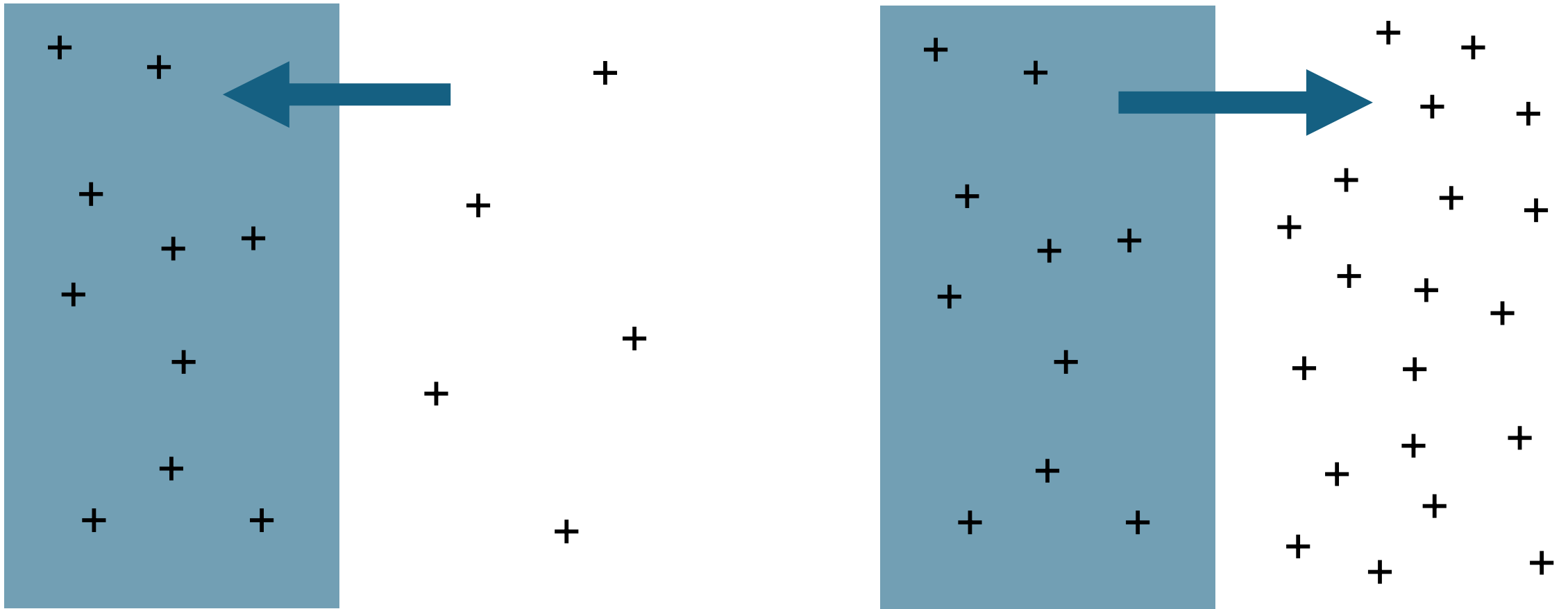
- **Sodicity**

- Sodicity: the quantity of sodium

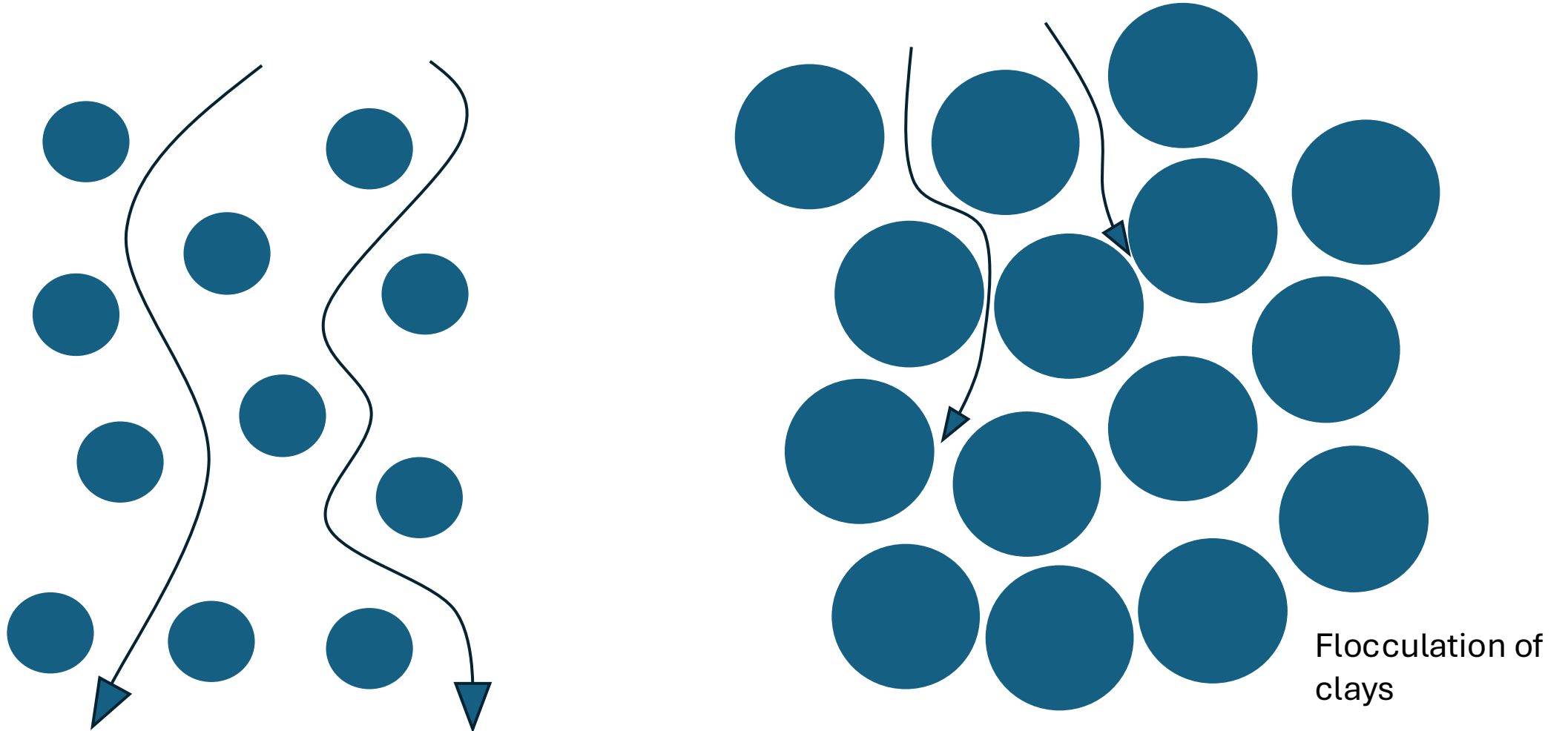
- **As applied to turfgrass**

- Water
 - Sodium adsorption ratio (SAR) – ratio of Na^+ to Ca^{2+} and Mg^{2+}
- Soil
 - Exchangeable sodium percentage (ESP) - Na^+ ions on soil exchange sites

What is the issue with high salinity?



What is the issue with high sodicity?

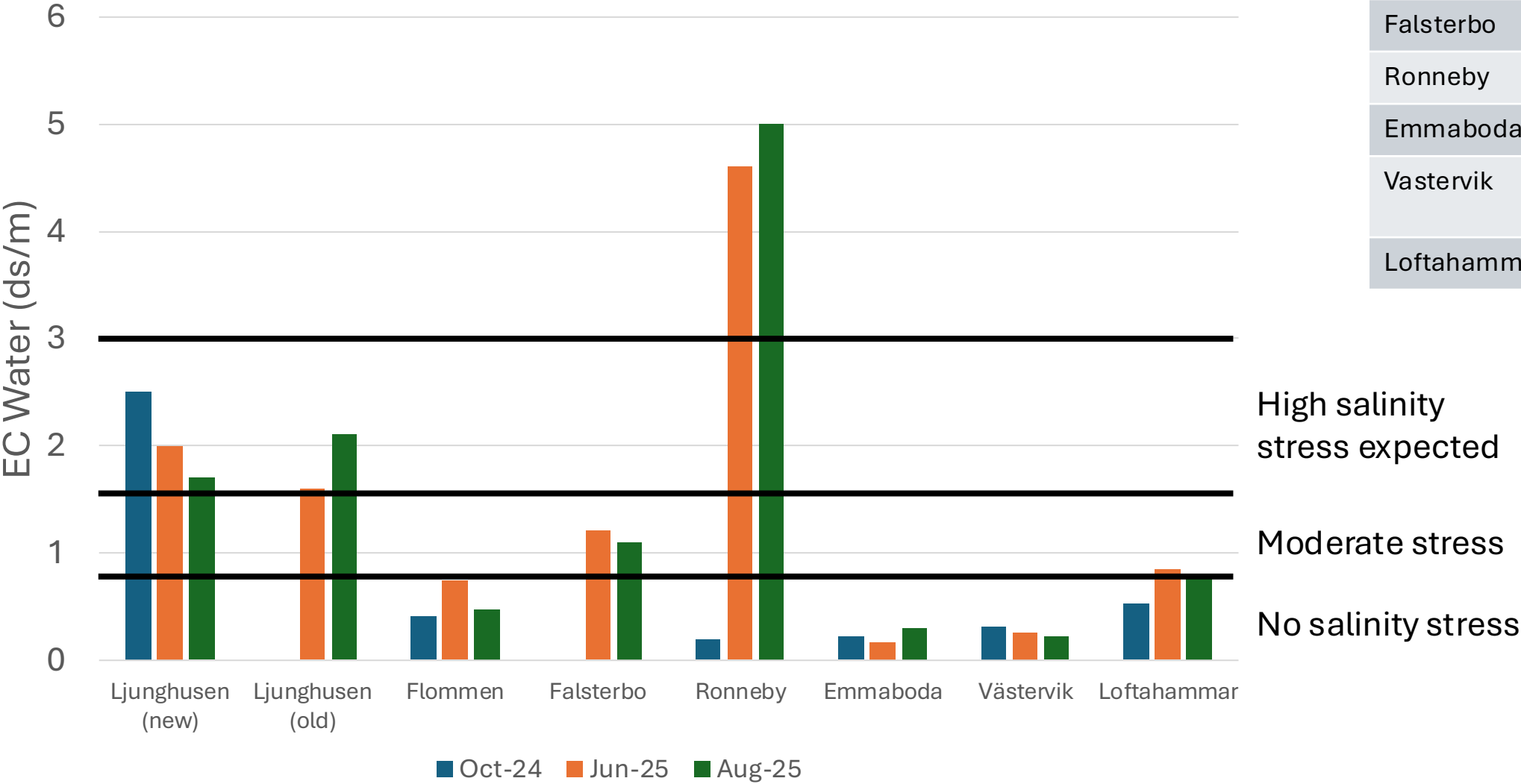




Sampling strategy (Oct-24, Jun-25, Aug-25)

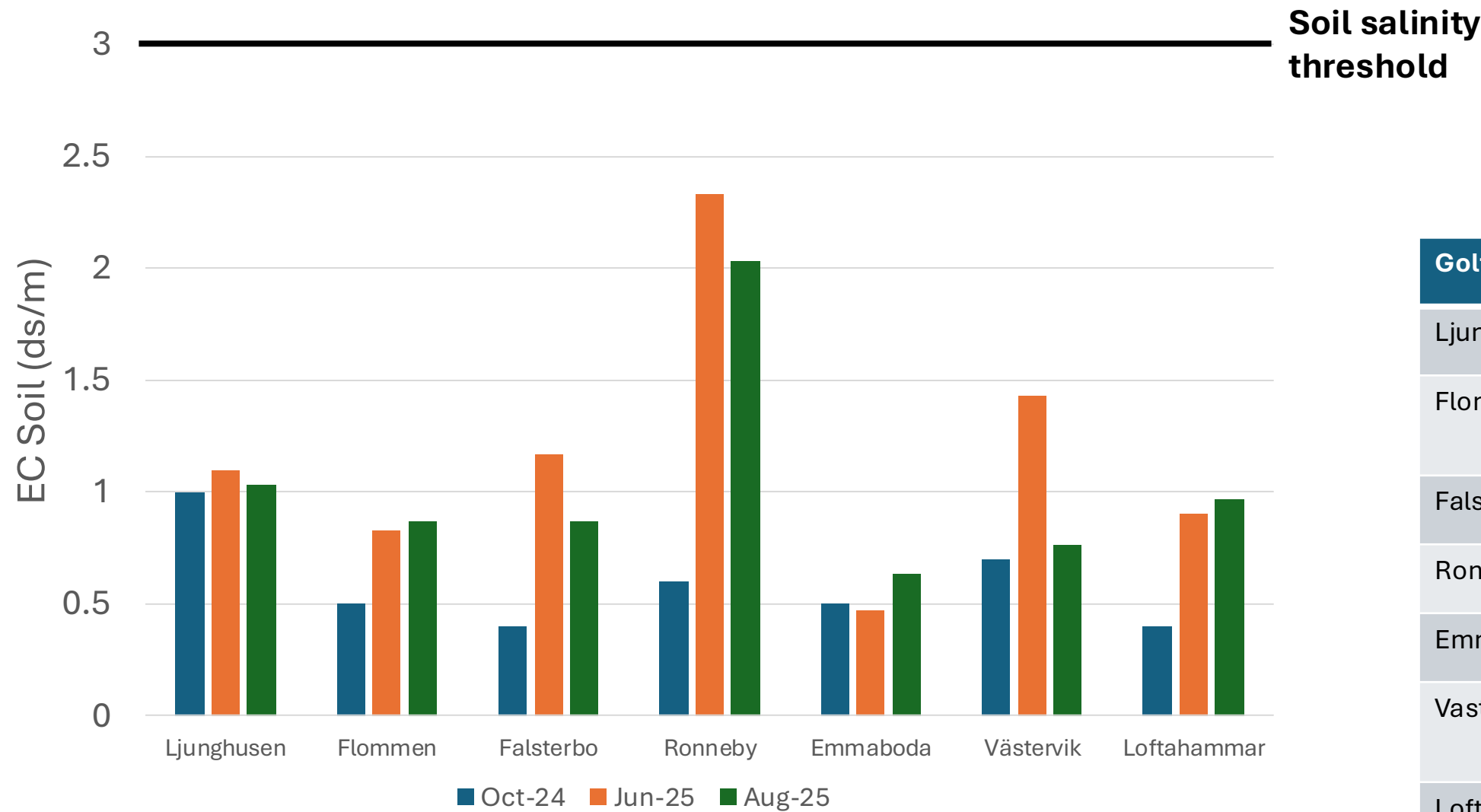
- Water
 - 1 water sample taken from irrigation system on each golf course
- Soil
 - 3 greens sampled per course from 0-10cm (average these in the results)

Salinity of Irrigation Water: Ronneby and Ljunghusen exceeded thresholds for cool season turfgrasses



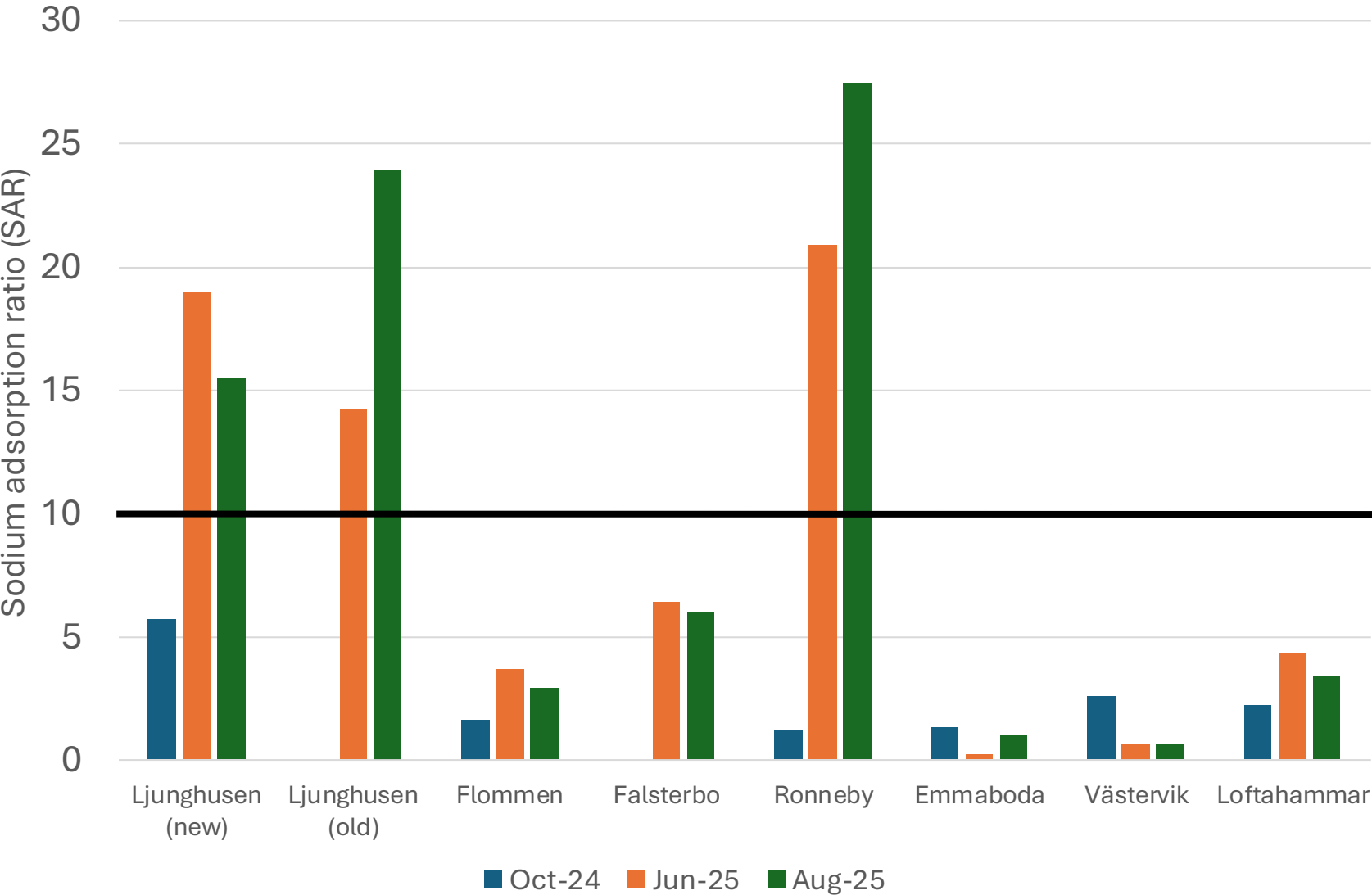
Golf course	Water source
Ljunghusen	Groundwater
Flommen	Groundwater, stormwater
Falsterbo	Groundwater
Ronneby	River
Emmaboda	Effluent
Västervik	Stormwater, baltic mix
Loftahammar	Effluent

Salinity of Putting Green Soil: All golf courses are below the critical threshold, but the lower the value the better



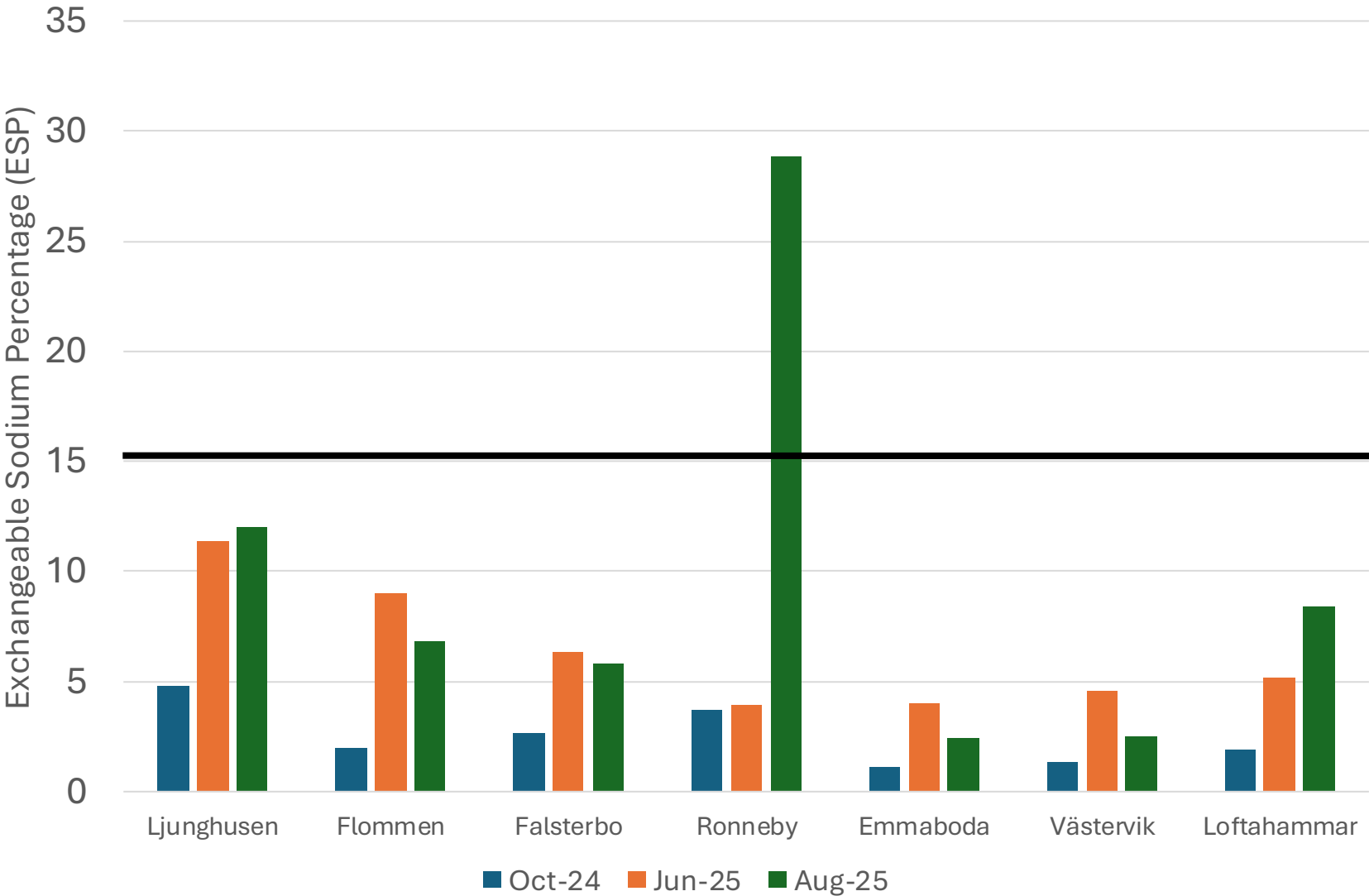
Golf course	Water source
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Sodicity of Irrigation Water: High sodicity of irrigation water observed at Ljunghusen and Ronneby



Golf course	Water source
Ljunghusen	Groundwater
Flommen	Groundwater, stormwater
Falsterbo	Groundwater
Ronneby	River
Emmaboda	Effluent
Västervik	Stormwater, baltic mix
Loftahammar	Effluent

Sodicity of Putting Green Soil: Sodic soil observed at Ronneby



Golf course	Water source
Ljunghusen	Groundwater
Flommen	Groundwater, stormwater
Falsterbo	Groundwater
Ronneby	River
Emmaboda	Effluent
Vastervik	Stormwater, baltic mix
Loftahammar	Effluent

Soil sodicity threshold

But remember that sodicity is not a problem on sandy soils!

What are potential solutions to high salinity or sodicity?

Salinity

Leaching fraction

$$LF = \frac{EC_W}{(5 * EC_T - EC_W)}$$

Water Requirement

$$WR = \frac{ET}{1 - LF}$$

Sodicity

Gypsum requirement

$$GR = \frac{CEC(ESP_i - ESP_t)}{100} * BD * D * 0.86$$

CEC – cation exchange capacity

ESP_i – initial ESP

ESP_t – target ESP

BD – bulk density

D – depth of soil to treat (root zone)

Conclusions

1. Some of the golf courses on the Baltic Coast of Sweden have high salinity and sodicity levels in their irrigation water
2. However...this is not always reflected in their soils (high precipitation)
3. Salinity and sodicity levels are important to monitor for golf courses using lower quality irrigation water
 - Leaching for high salinity
 - Gypsum for sodicity (rare)
4. Useful components
 - Salinity, sodicity, pH, nutrients, toxic elements
5. Useless components
 - Bicarbonate/carbonate, TDS

