Supplementary Materials

Short-Term Reliability of Treated Sewage Effluent from Riyadh Wastewater Treatment Plants for Irrigation Reuse: Performance and Pathways to Unrestricted Irrigation

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Table S1. Effluent quality, compliance and reliability of the two trains of WWTP 1, April 2026 (mean ± SD, range in parentheses; n = 27 days, BOD_5 n = 22).

Parameter	Train A	Train B
Effluent quality		
BOD_5 (mg/L)	14.0 ± 2.6 (10.0–18.6)	13.4 ± 3.0 (9.9–23.0)
TSS (mg/L)	8.9 ± 2.2 (5.0–12.0)	9.2 ± 2.5 (5.0–12.1)
Turbidity (NTU)	3.7 ± 1.3 (2.0–6.3)	3.9 ± 1.2 (2.4–6.3)
NH_4–N (mg/L)	6.9 ± 3.9 (0.4–15.3)	6.9 ± 3.9 (0.4–15.6)
TKN (mg/L)	7.9 ± 4.0 (1.9–16.4)	7.9 ± 4.0 (1.8–16.2)
COD (mg/L)	29.7 ± 5.0 (20.5–40.1)	29.3 ± 5.4 (20.4–42.7)
Residual chlorine (mg/L)	0.36 ± 0.02 (0.33–0.40)	0.36 ± 0.03 (0.31–0.39)
EC (µS/cm)	1724 ± 139 (1265–1876)	1726 ± 121 (1380–1871)
Days meeting limit (%)		
BOD_5 ≤ 10 mg/L (daily)	5	5
TSS ≤ 10 mg/L (daily)	67	52
Turbidity ≤ 5 NTU	81	81
NH_4–N ≤ 5 mg/L	41	33
Residual chlorine 0.2–0.5 mg/L	100	100
Reliability		
Turbidity: observed mean/m_x (95%)	1.2	1.2
NH_4–N: observed mean/m_x (95%)	2.9	2.9
BOD_5: P (30-day mean ≤ 10 mg/L) (%)	0	0
BOD_5: P (7-day mean ≤ 15 mg/L) (%)	86	93
TSS: P (30-day mean ≤ 10 mg/L) (%)	> 99	92

Probabilities from the circular block bootstrap (block length 3 days, 10,000 resamples); m_x from the coefficient of reliability (Equations (1) and (2) of the main text). Both trains fail the unrestricted BOD_5, NH_4–N and (at 95% reliability) turbidity requirements, as does the flow-weighted WWTP 1 effluent.

Table S2. Single-sample limits (turbidity 5 NTU; NH_4–N 5 mg/L), April 2026: empirical compliance with block-bootstrap 95% confidence interval, empirical 95th percentile, and mean required for compliance (m_x) and ratio of observed mean to m_x at 90%, 95% and 99% reliability.

Parameter	**Plant**	**Observed compliance, % (95% CI)**	**Empirical 95th percentile**	**90%: m_x / ratio**	**95%: m_x / ratio**	**99%: m_x / ratio**
Turbidity (NTU)	WWTP 1	85 (67–100)	5.7	3.5 / 1.1	3.2 / 1.2	2.6 / 1.5
	WWTP 2	44 (22–70)	9.4	3.5 / 1.8	3.1 / 2.0	2.5 / 2.5
	WWTP 3	70 (44–93)	91.4	2.2 / 7.8	1.3 / 13.0	0.5 / 33.9
	WWTP 3*	79 (54–96)	13.2	2.6 / 1.9	2.0 / 2.4	1.2 / 4.0
NH_4–N (mg/L)	WWTP 1	37 (19–59)	14.2	2.9 / 2.4	2.4 / 2.9	1.7 / 4.1
	WWTP 2	0 (0–0)	47.0	4.7 / 9.3	4.6 / 9.5	4.5 / 9.8
	WWTP 3	70 (44–93)	12.2	2.8 / 2.1	2.3 / 2.6	1.5 / 3.9
	WWTP 3*	71 (42–100)	12.1	2.9 / 2.0	2.4 / 2.4	1.6 / 3.5

WWTP 3* excludes the upset days of 10, 12 and 15 April (n = 24). Confidence intervals of the observed percentage from a circular block bootstrap of daily compliance (block length 3 days, 10,000 resamples). A ratio above 1 indicates that the limit would be exceeded more often than the reliability level allows. With 27 days, a 95% upper confidence bound at or above 95% (turbidity at WWTP 1; WWTP 3* for both parameters) means that 95% compliance cannot be excluded from these data.