

Supplementary information (SI)

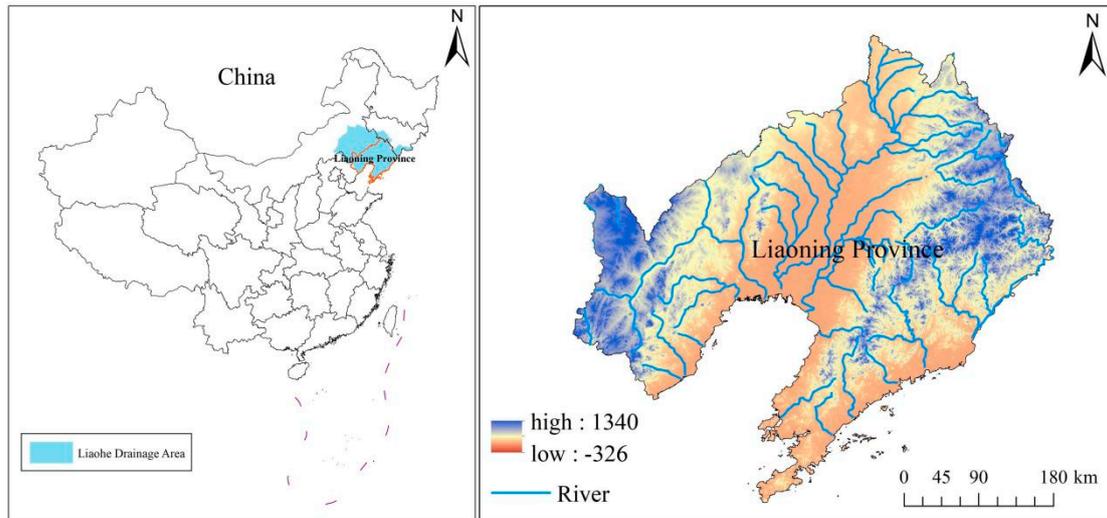


Figure S1 Location of study area

Table S1. Number of cases and brief description of potential urban sewage treatment technologies

Number	Potential technologies	Number of cases	Description
1	A/O	12	An improved activated sludge method that adds anoxic biological treatment process before the traditional activated sludge treatment system. The anaerobic section is used to remove nitrogen and phosphorus, and the aerobic section is used to remove organic pollutants in sewage.
2	A ² /O	33	A sewage treatment technology that completes biological reaction processes such as phosphorus removal, nitrogen removal, and organic matter degradation through alternate changes in anaerobic, anoxic, and aerobic environments
3	SBR	10	An activated sludge wastewater treatment technology operated by intermittent aeration mode. Core of the technology is the SBR reaction tank, which integrates the functions of homogenization, primary sedimentation, biodegradation, and secondary sedimentation into one tank, without a sludge reflux system.
4	TAS	8	A biological sewage treatment technology with activated sludge as the main body. Under the condition of artificial oxygenation, this technology uses the biological aggregation, adsorption and oxidation of activated sludge to decompose and remove organic pollutants in sewage.

5	CWS	7	A technology for treating pollutants in sewage by means of adsorption, retention, degradation, filtration, precipitation, microbial metabolic decomposition, etc.
6	BT	7	Microorganisms and micro-animals are attached to the filter material or some carriers to grow and breed, forming a membrane-like biological sludge, that is, a biofilm. The sewage is in contact with the biofilm, and the organic pollutants in the sewage are taken as nutrients by the microorganisms on the biofilm. The sewage is purified while the microorganisms reproduce themselves.

Table S2. Indicator system of urban sewage treatment technology assessment and the calculation formula of each indicator in the indicator layer

Target layer	Criterion layer	Element layer	Indicator layer	Indicator description	Calculation formula
Comprehensive assessment of urban sewage treatment technology	Environment	Environmental benefit	COD removal rate (H1)	Removal effect of COD after stable operation of sewage treatment technology	$(\text{COD influent concentration} - \text{COD effluent concentration}) (\text{mg/L}) / \text{COD influent concentration} (\text{mg/L}) \times 100\%$
			BOD removal rate (H2)	Removal effect of BOD after stable operation of sewage treatment technology	$(\text{BOD influent concentration} - \text{BOD effluent concentration}) (\text{mg/L}) / \text{BOD influent concentration} (\text{mg/L}) \times 100\%$
			SS removal rate (H3)	Removal effect of SS after stable operation of sewage treatment technology	$(\text{SS influent concentration} - \text{SS effluent concentration}) (\text{mg/L}) / \text{SS influent concentration} (\text{mg/L}) \times 100\%$
			Ammonia nitrogen removal rate (H4)	Removal effect of ammonia nitrogen after stable operation of sewage treatment technology	$(\text{Ammonia nitrogen influent concentration} - \text{Ammonia nitrogen effluent concentration}) (\text{mg/L}) / \text{Ammonia nitrogen influent concentration} (\text{mg/L}) \times 100\%$
			TN removal rate (H5)	Removal effect of TN after stable operation of sewage	$(\text{TN influent concentration} - \text{TN effluent concentration}) (\text{mg/L}) / \text{TN influent concentration}$

Target layer	Criterion layer	Element layer	Indicator layer	Indicator description	Calculation formula	
				treatment technology	$(\text{mg/L}) \times 100\%$	
			TP removal rate (H6)	Removal effect of TP after stable operation of sewage treatment technology	$(\text{TP influent concentration} - \text{TP effluent concentration}) (\text{mg/L}) / \text{TP influent concentration} (\text{mg/L}) \times 100\%$	
		Secondary pollution	Sludge production (H7)	Average amount of sludge produced by 1 ton of sewage.	Daily sludge production (ton)/daily treated water (ton)	
	Economic	Technical cost		Investment cost (E1)	Ratio of the one-time construction investment cost of the sewage plant to the daily tons of water treated.	$(\text{land cost} + \text{civil construction cost} + \text{equipment purchase cost}) (\text{ten thousand yuan}) / \text{daily treated water volume (ton)}$
				Operating cost (E2)	Cost of treating 1 ton of wastewater in the sewage plant.	$(\text{electricity cost} + \text{pharmaceutical cost} + \text{labor cost} + \text{equipment depreciation cost} + \text{other costs}) (\text{ten thousand yuan}) / \text{daily water volume (ton)}$
	technical performance	Technical applicability	Resistance to hydraulic shock load (J1)	Adaptation ability of the evaluated technology to the incoming water quantity and the change of water quality, characterized by the change coefficient of water consumption	$\text{Annual maximum daily water treatment (ton)} / \text{Annual average daily water treatment (ton)}$	
		Technical reliability	Operational stability (J2)	Characterized by the annual effluent standard rate	$\text{Annual effluent standard days (days)} / \text{annual total operating days (days)} \times 100\%$	

Target layer	Criterion layer	Element layer	Indicator layer	Indicator description	Calculation formula
			Ease of operation management (J3)	Closely related to the widespread availability of sewage treatment technologies, directly affecting the stable standard of effluent.	The expert judgment method is used to assign the score, which ranges from 0 to 100. The easier the operation management is, the higher the score is, and the lower the score is otherwise.

Table S3. Descriptive statistics of environmental, economic and technical indicator data for the assessment of six alternative wastewater treatment technologies

Indicators	Types	Statistical values	A/O	A2/O	SBR	TAS	CWS	BT
H1(%)	quantitative	Minimum value	34.74	13.5	70.66	66.38	80.23	61.2
		Average value	82.35	87.97	86.8	85.24	86.57	84.54
		Median	86.42	89.49	87.89	85.86	87.58	87.94
		Maximum value	96.6	99.63	96.28	94.58	90.87	94.9
		Standard deviation	10.38	7.92	4.98	5.13	2.82	7.55
H2(%)	quantitative	Minimum value	35.51	28.95	79.22	81.93	40	74.36
		Average value	86.14	92.88	93.02	91.62	79.94	90.97
		Median	91.77	94.02	93.86	91.46	87.31	93.05
		Maximum value	98.2	99.95	98.83	99.4	95.13	97.66
		Standard deviation	12.98	5.61	4.04	3.64	14.98	5.86
H3(%)	quantitative	Minimum value	57.32	50.11	61.27	83.68	10.13	78.95
		Average value	89.75	93.9	93.15	94.28	82.09	90.83
		Median	91.25	95.38	94.92	95.39	90.45	90.95
		Maximum value	98.99	100	99.81	99.04	98.56	99.16
		Standard deviation	7.85	5.56	6.47	2.68	18.22	4.83
H4(%)	quantitative	Minimum value	12.04	2.49	50.69	55.71	44.83	23.64
		Average value	87.26	89.87	92.66	87.39	73.29	79.7
		Median	92.33	95.54	94.12	91.25	68.09	86.4
		Maximum value	99.7	99.73	98.46	99.72	97.65	98.75
		Standard deviation	13.28	15.87	6.58	11.78	13.99	17.7
H5(%)	quantitative	Minimum value	11.9	0.58	5.68	30.71	32.14	16.63
		Average value	61	64.94	60.87	66.39	54.95	48.98
		Median	61.71	65.77	61.53	65.35	56.55	54.95
		Maximum value	94.59	99.6	81.51	90.41	84	89.86

Indicators	Types	Statistical values	A/O	A2/O	SBR	TAS	CWS	BT
		Standare deviation	16.35	15.47	12.02	11.32	9.82	14.53
H6(%)	quantitative	Minimum value	27.73	7.23	6.24	27.86	40	13.41
		Average value	75.32	84.46	83.29	77.96	72.02	74.94
		Median	75	87.52	84.75	80.34	73.7	84.69
		Maximum value	97.84	99.92	95.55	98.13	94.63	95.12
		Standare deviation	12.52	11.75	9.23	13.17	10.47	21.32
H7(kg/d)	quantitative	Minimum value	0.011	0.003	0.09	0.026	0.087	0.035
		Average value	0.216	0.348	0.334	0.156	0.188	0.286
		Median	0.111	0.194	0.277	0.091	0.123	0.342
		Maximum value	0.667	2.129	0.81	0.575	0.419	0.52
		Standare deviation	0.208	0.409	0.22	0.157	0.136	0.168
E1(ten thousand yuan / ton water)	quantitative	Minimum value	0.012	0.005	0.135	0.1	0.064	0.097
		Average value	0.352	0.516	1.151	0.364	0.414	0.302
		Median	0.362	0.395	0.22	0.344	0.378	0.194
		Maximum value	0.837	3.626	15.309	1.977	0.834	3.292
		Standare deviation	0.168	0.516	3.551	0.283	0.356	0.451
E2(ten thousand yuan / ton water)	quantitative	Minimum value	0.013	0.007	0.022	0.011	0.021	0.007
		Average value	0.029	0.048	0.055	0.034	0.029	0.032
		Median	0.028	0.039	0.029	0.026	0.028	0.025
		Maximum value	0.054	0.188	0.416	0.105	0.041	0.11
		Standare deviation	0.014	0.036	0.091	0.024	0.008	0.026
J1	quantitative	Minimum value	0.46	0.2	0.71	0.62	0.92	0.65
		Average value	1.63	1.63	1.19	1.88	1.15	1.14
		Median	1.15	1.16	1.16	1.17	1.07	1.06
		Maximum value	3.86	2.27	0.22	2.18	0.18	0.5
		Standare deviation	41.81	20.1	2.75	11.6	1.66	4.42
J2(%)	quantitative	Minimum value	96.67	3.23	3.45	50	100	100
		Average value	99.99	98.88	99.46	99.73	100	100
		Median	100	100	100	100	100	100
		Maximum value	100	100	100	100	100	100
		Standare deviation	0.2	8.37	7	3.68	0	0
J3	qualitative to quantitative	Average value	82.5	77.5	95	87.5	82.5	87.5