SUPPORTING INFORMATION

Table S1 Data from various wastewater treatment plants during the first evaluation cycle

WWTP	Annual average influent concentration(mg/L)			Annual average effluent concentration(mg/L)			Energy (10^4kw.h)	Wet sludge production (10^4tons/year)	Operating cost (10^4yuan/year)	Treatment capacity (10^4m^3/d)	Water content of sludge (%)
	BOD_5	COD	NH_3-N	BOD_5	COD	NH_3-N					
WWTP1	84.9	242	27.5	2.96	24.7	0.612	1736.91	1.3509	3857	15	54
WWTP2	150	213	26.3	3.18	21.6	0.96	1941.49	1.4245	3563	11	53.8
WWTP3	105	291	30.4	4	19.2	0.69	584.45	0.8889	1442	4	78.3
WWTP4	102	341	24.7	2.9	34.5	1.01	511.76	2.096	1683	5	80
WWTP5	20.7	68.9	17.2	2.2	17.5	0.301	181.26	0.2759	541	2.5	78
WWTP6	18.2	59.2	13.5	1.8	15.7	0.574	122.33	0.1586	516	2	79
WWTP7	26.1	117	24.1	6.8	25.2	0.681	100.55	0.1143	429	2	79
WWTP8	91	182	29	6.5	20.3	0.44	1282.06	2.8565	4750	16.5	78.6
WWTP9	120	239	20.7	3	19	0.4	1000.01	2.3473	2084	15	78
WWTP10	79.3	183	34	2.73	23	2.62	218.45	0.6805	532	3	78
WWTP11	89.7	212	22.3	2	17.7	0.25	191.1	0.2738	641	1.5	79
WWTP12	51.8	223	20.4	2	31	0.55	1839.25	5.515	4342	20	77.3
WWTP13	104	247	27.9	2	11.9	0.17	1749.83	3.8653	3486	15	78.4
WWTP14	93.1	232	24.3	2	14.3	0.08	811.55	1.5291	1600	10	77.7
WWTP15	180	168	22.2	1.86	14.3	0.28	668.57	1.3297	1069	5	79.8
WWTP16	55.5	159	23.6	3.6	22.2	0.65	321.02	0.7856	729	3	79.1
WWTP17	127	399	14.6	5.8	36.3	1.44	545.55	2.1029	1215	4	79
WWTP18	222	576	14.6	2	51.9	0.362	385.86	1.1906	1246	4	78.8
WWTP19	100	217	25.9	2.4	20.1	0.69	287.51	0.5847	854	3.5	78.4
WWTP20	84	179	29.1	2.1	17.1	0.46	458.68	0.8358	1271	7	78.8
WWTP21	204	384	35.8	2.1	22.1	0.51	248.53	0.2923	470	2	77.9

Continued Table S1 Data from various wastewater treatment plants during the first evaluation cycle

WWTP	Annual average influent concentration(mg/L)			Annual average effluent concentration(mg/L)			Energy (10^4kw.h)	Wet sludge production (10^4tons/year)	Operating cost (10^4yuan/year)	Treatment capacity (10^4m^3/d)	Water content of sludge (%)
	BOD_5	COD	NH_3-N	BOD_5	COD	NH_3-N					
WWTP22	94	186	26.4	2.5	16.1	0.18	89.32	0.1486	268	1	78.4
WWTP23	146	308	30.3	2.5	16.8	0.64	281.96	0.3487	472	3	76.6
WWTP24	88	172	25.2	1.8	15.7	0.4	106.7	0.0595	364	1.1	76.8
WWTP25	106	226	17.9	2.6	23.6	0.38	148	0.1489	301	2	73.4
WWTP26	92	186	32.5	2.1	17	0.38	390.39	0.2373	867	2.5	75.6
WWTP27	124	228	47.5	2.9	21.3	0.8	60.95	0.0574	116	0.4	76.3
WWTP28	121	359	20.8	2.8	28.6	0.9	1003.29	2.4548	3226	9	79.2
WWTP29	82.1	249	21.8	2.8	31	0.34	214.31	0.5369	813	3	79.4
WWTP30	102	305	22	2.8	26.5	0.21	368.63	1.1059	1491	3	79.8
WWTP31	187	428	25.9	32	21.8	0.7	752.65	1.9951	1374	8	81.5
WWTP32	198	420	28.8	3.2	22.6	0.7	724.13	1.6313	1087	8	81.8
WWTP33	160	390	33.8	3.1	21.5	0.7	329.12	0.848	799	4	82.3
WWTP34	134	306	28.4	3.8	29.5	0.8	176.97	0.5773	634	4	81.9
WWTP35	137	316	24.8	2.7	19.4	0.3	178.83	0.5451	535	4	81.8
WWTP36	129	395	31.7	2.68	24	1.72	1662.1	4.4509	2224	18	78.8
WWTP37	130	286	22	2.44	21.8	1.59	1422.84	2.9305	2093	14	80.3
WWTP38	148	335	18.8	2.68	23.9	0.7	470.77	0.8448	926	4	81.7
WWTP39	131	284	16.4	2.7	29.8	0.722	458.98	4.5019	903	6	78.6
WWTP40	134	291	31.2	2.74	22.1	1.22	2462	5.1218	342	25	79.4
WWTP41	156	315	27.6	6.98	32.4	1.13	328.2	0.6086	836	4	75.6
WWTP42	165	327	36.1	6.28	28.4	0.82	395.63	0.305	1692	4	80

Continued Table S1 Data from various wastewater treatment plants during the first evaluation cycle

WWTP	Annual average influent concentration(mg/L)			Annual average effluent concentration(mg/L)			Energy (10^4kw.h)	Wet sludge production (10^4tons/year)	Operating cost (10^4yuan/year)	Treatment capacity (10^4m^3/d)	Water content of sludge (%)
	BOD_5	COD	NH_3-N	BOD_5	COD	NH_3-N					
WWTP43	129	550	24.6	6.2	52	1.1	205.57	2.206	464	2.5	80
WWTP44	200	388	25.9	4.6	46	4	1068.59	3.3091	5600	9.8	55
WWTP45	45.9	125	15.9	2.3	26..3	0.37	218.31	0.2628	472	2	81.2
WWTP46	140	285	25.2	11.5	38	2.13	1334.36	3.2165	3037	18	78.61
WWTP47	124	289	24.3	6.6	39	2.01	1734.46	3.214	4671	15	78.04
WWTP48	93	224	22.4	4	25.7	0.53	441.04	0.9743	850	5	78.99
WWTP49	90.5	240	28.7	8.3	31.5	3.74	185	9.8574	4402	14.5	78.4
WWTP50	90.2	227	28.1	5.5	23.1	1.16	485.88	3.8024	1417	4	793
WWTP51	94.3	225	26.7	7	24.2	1.97	132.25	0.7144	603	1	79.1
WWTP52	86.2	306	20.4	5	50.8	2.68	196.93	0.5918	1410	2	60.8
WWTP53	128	252	27.8	7.4	25.1	1.56	145.53	1.1216	884	2	78.7
WWTP54	74	173	20	7	26.2	3.51	37.64	0.0878	206	0.5	78.7

Table S2 Data from various wastewater treatment plants during the second evaluation cycle

WWTP	Annual average influent concentration(mg/L)			Annual average effluent concentration(mg/L)			Energy (10^4kw.h)	Wet sludge production (10^4tons/year)	Operating cost (10^4yuan/year)	Treatment capacity (10^4m^3/d)	Water content of sludge (%)
	BOD_5	COD	NH_3-N	BOD_5	COD	NH_3-N					
WWTP1	81	234	24.4	4.2	19.8	0.91	1773.36	1.3834	3670	15	51.8
WWTP2	76	215	26.6	4.2	18.9	1.03	2020.89	1.506	3590	13.5	53.6
WWTP3	81	235	25.1	4.1	16.7	0.43	606.3	0.7514	1329	6.5	78.9
WWTP4	108	303	20.6	2.8	25.6	0.25	511.76	1.3585	2902	7.5	60
WWTP5	21	72	20.1	2.1	22.3	0.52	211.59	0.3337	541	2.5	79.3
WWTP6	32	100	15.5	2.4	19.7	0.63	154.99	0.3306	654	2	80
WWTP7	21	92	24.6	6.02	27.6	0.26	68.46	0.1886	293	2	80
WWTP8	78	153	25.6	6.73	22.8	0.6	1269.23	2.2698	4120	16.5	77.9
WWTP9	99	187	20.3	3	18	0.4	959.55	2.1884	2076	15	78
WWTP10	59	139	28.1	2.58	22	2.15	206.58	0.4955	613	3	78
WWTP11	64	159	20.7	2	16.4	0.31	186.32	0.2868	595	1.5	79
WWTP12	49	209	19.5	2	30.4	0.6	1917.42	5.757	2822	20	77.4
WWTP13	104	234	26.2	2	11.6	0.16	1756.66	3.7211	3111	15	78.7
WWTP14	98	262	19.5	2	14.5	0.6	925.61	1.5288	2222	10	78.2
WWTP15	59	234	18.8	1.96	11.6	0.23	753.06	1.1533	1308	9.5	78.5
WWTP16	52	152	20.6	3.4	22.2	0.3	318.65	0.6327	551	3	79.1
WWTP17	125	326	11.7	4.9	32.1	0.62	624.63	2.2211	826	6	78.9
WWTP18	276	651	13.4	2	51.7	0.56	501.46	1.4074	1646	4	78.6
WWTP19	122	299	27	2.1	15.9	0.48	295.1	0.611	857	3.5	78.3
WWTP20	83	175	26.2	2.1	15.4	0.24	496.57	0.81	1384	7	78.8
WWTP21	210	421	37.5	2.2	18.6	0.41	280.26	0.4089	541	2	77.4

Continued Table S2 Data from various wastewater treatment plants during the second evaluation cycle

WWTP	Annual average influent concentration(mg/L)			Annual average effluent concentration(mg/L)			Energy (10^4kw.h)	Wet sludge production (10^4tons/year)	Operating cost (10^4yuan/year)	Treatment capacity (10^4m^3/d)	Water content of sludge (%)
	BOD_5	COD	NH_3-N	BOD_5	COD	NH_3-N					
WWTP22	105	219	26.8	2.4	15.5	0.24	125.06	0.1882	335	1	77.5
WWTP23	195	412	31.2	2.3	22.5	0.77	372.11	0.495	583	3	76.9
WWTP24	82	171	25.9	2	16.1	0.53	109.42	0.057	540	1.1	79
WWTP25	89	182	15.1	2.3	19.4	0.25	134.95	0.1467	403	2	73.9
WWTP26	96	199	33.8	2.2	18.4	0.31	416.62	0.2958	878	2.5	76
WWTP27	116	225	35.3	2.4	20.4	0.65	65.54	0.0548	116	0.4	73.8
WWTP28	138	424	19	2.7	24.6	0.72	1016.6	2.4625	2115	9	79.2
WWTP29	83	249	18.8	2.6	31.6	0.33	251.02	0.639	550	3	79.5
WWTP30	119	356	22.2	2.6	26	0.23	439.8	1.152	815	3	79.8
WWTP31	152	371	34	3.4	22.4	0.6	779.24	2.2833	1381	8	62.9
WWTP32	140	341	32	3.1	22.1	0.6	737.39	1.634	1227	8	83.6
WWTP33	124	308	32	3.2	24.3	1.2	301.62	0.7993	869	4	84.8
WWTP34	117	273	31	3.7	29.5	0.8	179.53	0.6083	619	4	85
WWTP35	131	313	22	3.4	20.3	0.3	254.51	0.8276	655	4	85.2
WWTP36	129	356	28.9	1.87	23	1.05	1819	6.7	3259	18	78.4
WWTP37	131	299	19.8	2.42	22.8	1.11	1598.52	8.81874	2823	14	77.9
WWTP38	136	311	17.5	2.6	25	0.56	444.11	1.8975	1331	4	78.3
WWTP39	109	227	17.3	2.68	30.2	0.35	449.87	1.1185	1042	6	79.6
WWTP40	115	275	30	2.8	17.1	0.7	2462.42	6.5517	4284	25	79.4
WWTP41	144	290	25.5	2.77	19.4	0.21	432.04	0.716	1011	4.8	51.9
WWTP42	142	339	35.7	7.28	27.3	0.72	413.83	0.335	1720	7	80

Continued Table S2 Data from various wastewater treatment plants during the second evaluation cycle

WWTP	Annual average influent concentration(mg/L)			Annual average effluent concentration(mg/L)			Energy (10^4kw.h)	Wet sludge production (10^4tons/year)	Operating cost (10^4yuan/year)	Treatment capacity (10^4m^3/d)	Water content of sludge (%)
	BOD_5	COD	NH_3-N	BOD_5	COD	NH_3-N					
WWTP43	208	670	26.1	3.49	52.5	2.1	230.58	2.2231	1029	2.5	80
WWTP44	106	295	19.1	3.7	40	1.83	1157	2.9865	5841	9.8	56.2
WWTP45	30	100	16.7	0.8	19.5	0.23	217.78	3.1021	460	2	80.7
WWTP46	130	268	25	8.7	37.5	1.49	1294.49	4.0726	2762	18	78.6
WWTP47	111	273	26.2	6.2	38.4	1.45	1621.57	4.3214	3770	15	78.1
WWTP48	93	224	22.4	4	25.7	0.53	441.04	0.9742	850	5	79
WWTP49	90	240	29.4	8.3	30	3.41	789.71	10.8544	2352	20	78.3
WWTP50	100	228	28.1	5.6	24	1.41	490.24	5.4495	924	4	79
WWTP51	93	225	25.5	6.8	22	1.22	129.67	4.4136	450	1	79.2
WWTP52	82	295	20.7	5	48	1.47	200.11	0.452	1591	2	60.2
WWTP53	125	249	27.4	7.5	25	1.56	190.95	7.5219	509	2	78.8
WWTP54	67	171	17.8	6.9	25	3.14	38.5	0.0958	165	0.5	78.5

Table S3 Descriptive statistics of the input–output indicators for 2016–2017

Indicator type	Year	Max	Min	Mean
Input				
Consumption of energy (10^4kW·h)	2017	2462.420	38.500	656.357
	2016	2462.000	37.640	618.484
Desire outputs				
COD reduction (mg/L)	2017	617.500	49.700	239.087
	2016	524.100	43.500	243.459
BOD_5 reduction (mg/L)	2017	274.000	14.980	102.472
	2016	220.000	16.400	109.890
NH_3-N reduction (mg/L)	2017	37.090	11.080	23.453
	2016	46.700	12.930	24.337
Undesire output				
Wet sludge production (10^4tons/year)	2017	10.854	0.055	2.104
	2016	9.860	0.057	1.654

Table S4 Pearson autocorrelation test

Effluent discharge standards	Indicator type	TE	Age of WWTPs	Annual flow rate	Pollutant removal rate
National Standard I-A	TE	1.000			
	Age of WWTPs	–0.402*	1.000		
	Actual treatment volume	–0.436*	0.201	1.000	
	Pollutant removal rate	–0.1470*	-0.311	0.163	1.000
National Standard I-B	TE	1.000			
	Age of WWTPs	–0.765*	1.000		
	Actual treatment volume	–0.521*	0.520*	1.000	
	Pollutant removal rate	0.396	-0.219	0.371	1.000

Table S5 Variance inflation factor (VIF) test results

Effluent discharge standards	Variable	VIF	1/VIF
National Standard I-A	Age of WWTPs	1.19	0.839
	Actual treatment volume	1.11	0.904
	Pollutant removal rate	1.18	0.851
	Mean VIF	1.16	
National Standard I-B	Age of WWTPs	2.73	0.367
	Actual treatment volume	3.08	0.324
	Pollutant removal rate	1.41	0.710
	Mean VIF	2.41	

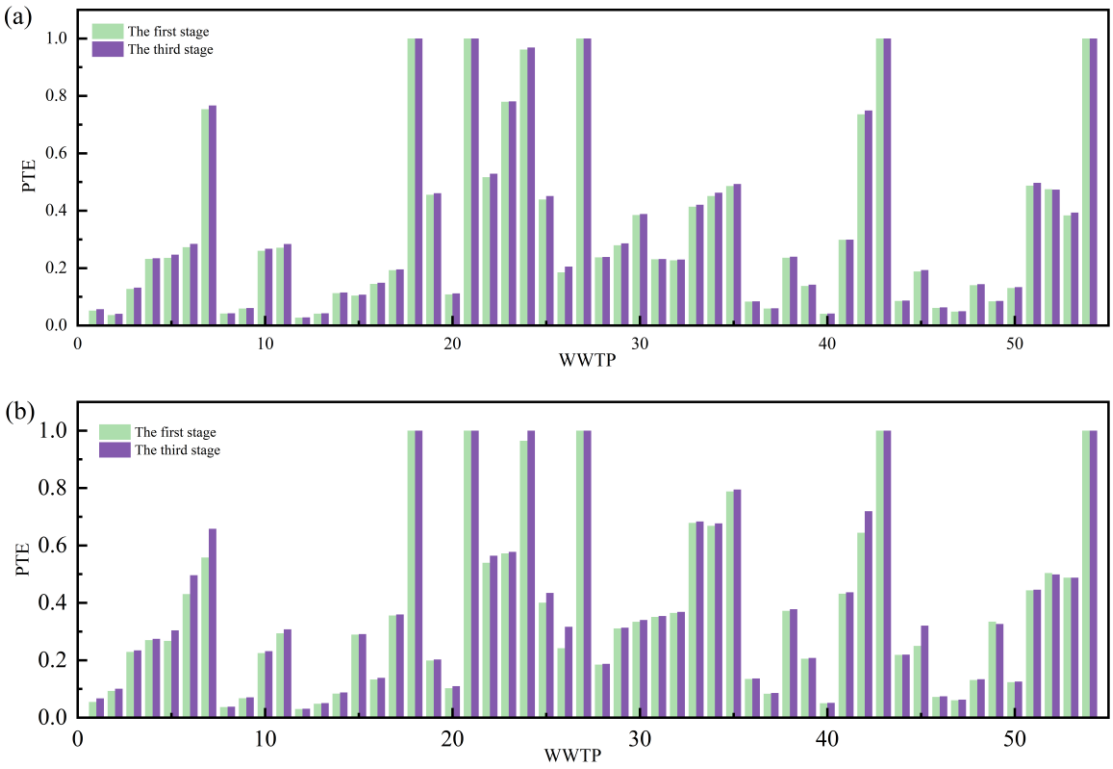

Fig. S1 Comparison of the PTE values of the first and third stages of wastewater treatment plants. (a) The first and (b) second cycles, respectively.

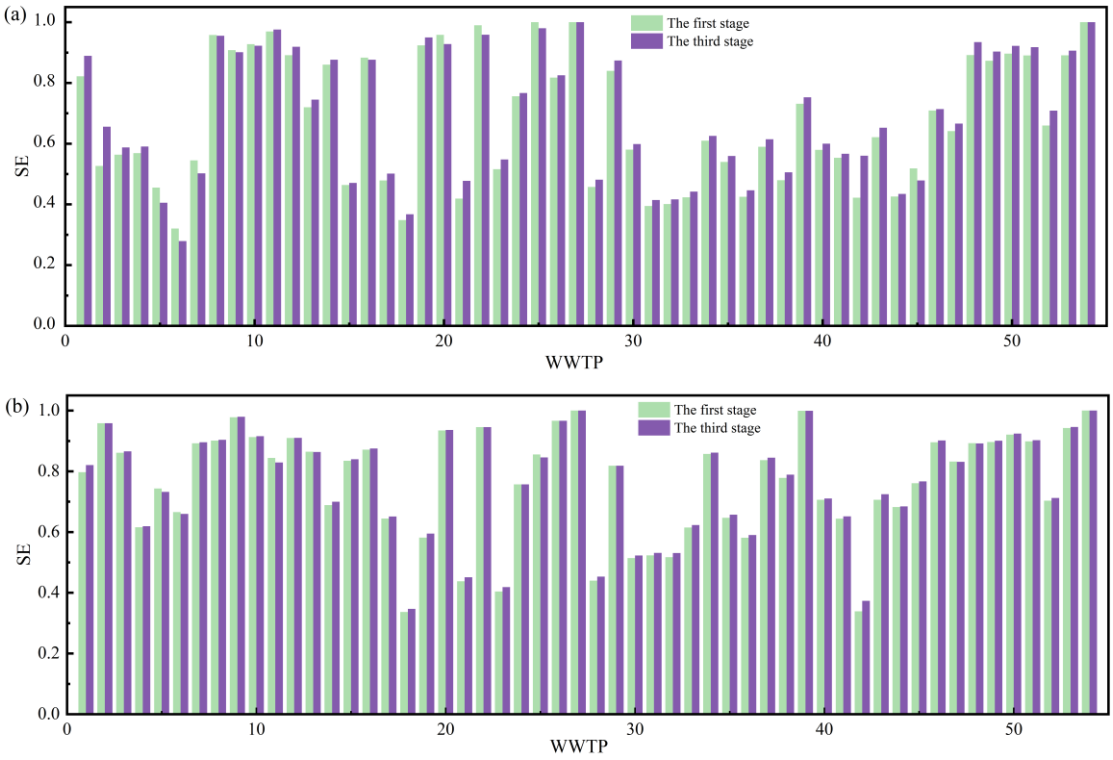

Fig. S2 Comparison of the SE values of the first and third stages of wastewater treatment plants. (a) The first and (b) second cycles, respectively.

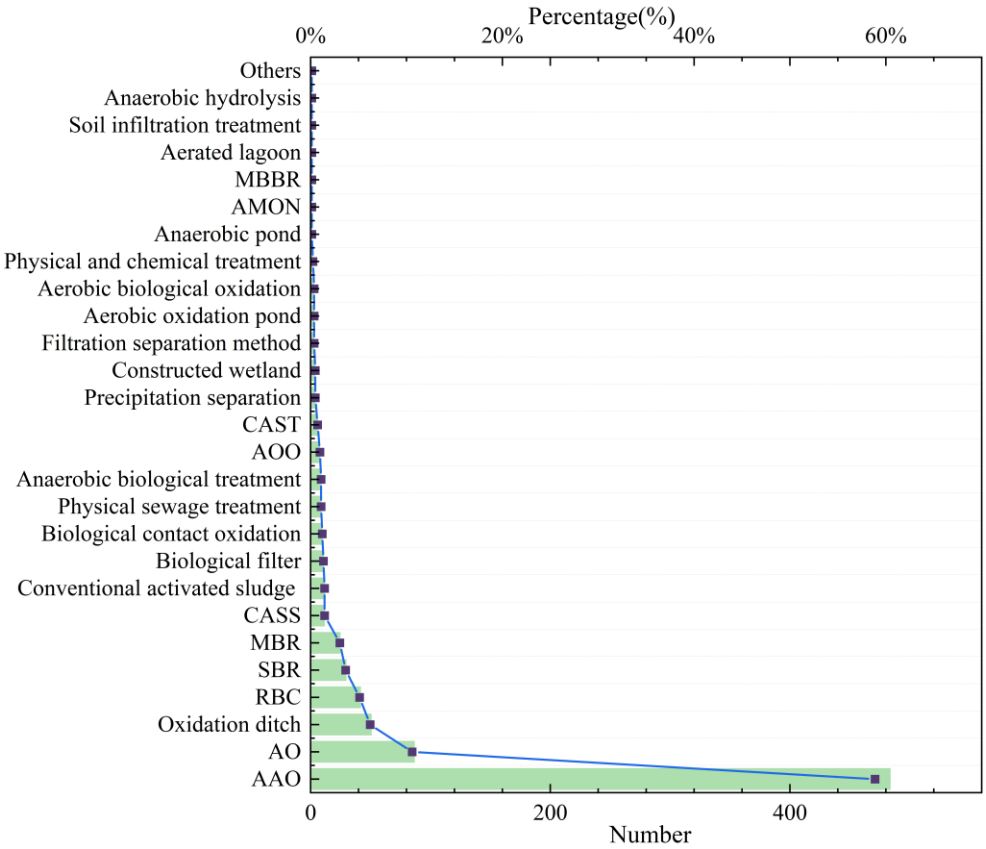

Fig. S3 Number and percentage of various technologies in WWTPs in Jiangsu Province