Analysis of results of pilot testing of EcoSystem Plus® (ESP) in China

March 2017

1. A pilot test was conducted at a municipal wastewater treatment plant (WWTP) with a flow rate of 4,100 tons/day (4,100 m^3/day). A biological wastewater treatment at this WWTP is carried out using a sequencing batch reactor activated sludge process (SBR). Descriptions of the WWTP and a pilot treatment system are provided in a Trial Application Plan attached to this document.
2. Analysis of the results of the WWTP influent wastewater quality show signification fluctuations of contaminant values in the wastewater, for example, 180 ÷ 1200 mg/l for COD and 70 ÷ 500 mg/l for BOD. It is not easy for an activated sludge process to react to such huge range of the wastewater influent quality parameters and provide appropriate consistent biological treatment results.
3. Based on a range of BOD in the influent (70 to 500 mg/l) a value of 200 mg/l was selected as the medium value of the influent BOD. Based on a guidance of ESP manufacturer, Bio-Organic Catalyst, Inc, a dose of ESP is recommended as 1 mg/l per 100 mg/l of BOD. It means that for this particular wastewater treatment plant, a dose of ESP should fluctuate from 0.7 mg/l to 5 mg/l. In some cases, it is recommended to use even higher doses of ESP to address other types of contamination in the wastewater.
4. If we assume that a dose of ESP is 2.0 mg/l (2 ppm) based on the medium BOD of 200 mg/l, we can calculate an amount of ESP that needs to be added into wastewater. If 40 liters of wastewater need to be treated, we can use the following ratio for calculations of the amount of ESP required for each test.
   - 2.0 liters of ESP per 1,000 m^3 of wastewater
   - Converting liters of ESP to milliliters and cubic meters of wastewater to liters
   - 2,00 ml of ESP per 1000,000 liters of wastewater
   - "X" ml of ESP per 40 liters of wastewater
   - X = (2,00 ml x 40 liters)/ 1000,000 liters = 0.08 ml of ESP per 40 liters of wastewater
5. The calculated value was rounded up and 0.1 ml of ESP added during each test.
6. A commercial ESP concentrate was diluted in 50 times before the product was added into influent wastewater.
7. Attached is Table 1 showing the test results for the following doses of ESP: 5 ppm, 10 ppm, 15 ppm, and 20 ppm.

Table 1

日期/ Date	ESP Dosage 加药量	COD (Req. <50)			NH3-N (Req. <8) 氨氮			TKN (Req. <15) 总氮			P (Req. <0.5) 总磷		
Sample 水样		Inf进水	Eff出水	Trial试验	Inf进水	Eff出水	Trial试验	Inf进水	Eff出水	Trial试验	Inf进水	Eff出水	Trial试验
2017.3.7	5ppm	1226	207	89	73	25	16	82	40	42	6.98	0.34	3.19
2017.3.8-01	5ppm	270	26	42.88	52	25	14.91	73	41	26.56	4.86	0.38	2.67
2017.3.8-02	5ppm			45.2			22.74			58.35			1
2017.3.9-01	5ppm	182	30.08	56	56.06	26.68	14.91	66.82	46.78	53.52	4.41	0.15	0.86
2017.3.9-02	5ppm			44.35			27.13			50.2			0.51
2017.3.10-01	5ppm	361.6	28.16	46.37	67.91	26.65	27.75	73.01	43.08	50.47	6.2	0.63	0.53
2017.3.10-02	5ppm			44.35			27.13			50.09			0.39
2017.3.13	10ppm	547.55	25.16	41.53	85.06	26.47	12.05	88.55	43.14	35.31	7.44	0.95	0.472
2017.3.14	10ppm	483.44	25.8	53.64	73.56	26.67	10.62	82.25	51.72	32.97	8.61	0.68	3.74
2017.3.15	10ppm	329.59	20.48	48.17	66.49	26.54	30.48	70.73	42.27	46.89	6.34	1.16	1.34
2017.3.16	15ppm	401.56	17.81	49.79	74.2	23.65	7.73	75.18	37.92	34.6	7.09	1.47	1.47
2017.3.17	20ppm												

8. Attached is also Table 2 showing dissolved oxygen (DO) measurements in a blank test and in the tests with different ESP doses. The table demonstrates that, by using ESP, a level of DO increased from 0.94 mg/l (blank probe) immediately to 4.3 - 8.4 mg/l. The DO in 30 min increased from 0.95 mg/l (blank probe) to 9.56 - 11.58 mg/l for different ESP doses. It means that ESP increased DO level in the wastewater in 10 times! Please verify. If ESP can increase DO in wastewater, it will allow us to reduce energy consumption for aeration at the wastewater treatment plant.

Table 2

Tank Volume: 20L	**DO value test**				
Date	2017/3/15			2017/3/16	2017/3/17
ESP Dosage	Blank	10ppm	5ppm	15ppm	20ppm
0min	0.94	4.3	6.53	15.47	8.48
5min			10.17		10.12
10min			9.74	19.21	11.56
20min		12	9.5		11.15
25min				19.88	
30min	0.95		9.56		11.58
35min				19.65	
40min		18.35			12.1
50min				20.45	
60min		18.17			11.76
70min				18.91	
90min		14.59			
120min		15.53			11.73

9. As it was noted above, it is not easy to treat wastewater with such huge range of fluctuation of the major water quality parameters. For example, COD of influent water was 1,226 mg/l on March 3 and 182 mg/l on March 9. An influent and an effluent value of BOD were not measured during the tests.
10. Based on the results achieved during the study, it was possible to obtain the required residual level of COD in the treated water less than 50 mg/l for ESP during all days. The first day, the result was 89 mg/l due to a very high COD level in the influent water, 1226 mg/l. For comparison, COD in the effluent without ESP for the same day was 207 mg/l.

11. For NH3-N, good results were achieved on Mach 14 with an ESP dose of 10 ppm and on March 16 with a dose of 15 ppm. The result on March 16 was 7.73 mg/l, below the required level of 8 mg/l. By comparison of the results, we can note that such good results were impossible to achieve without ESP.
12. For Total Kjeldahl Nitrogen (TKN), relatively good results were obtained on March 8 and March 13 and 14. For complete nitrification - denitrification process NH3 - NO2 - NO3 - N2, a regular aerobic activate sludge treatment had some limits. In particular, more time is required for aerobic process (minimum 5 hours are require for BOD removal first, then nitrogen removal), a stage of anoxic /anaerobic treatment may help, no toxics must be present in influent, etc.
13. Phosphorus (P) removal. The results show that removals of P up to required level below 0.5 mg/l were achieved on March 9 and 10 with an ESP dose of 5 ppm. We should note that biological phosphorous removal depends on removal of nitrate.
14. In general, we can say that the results of the tests conducted by our team in China are acceptable and sufficient for conducting a full-scale study. Our practice shows that the results of a full-scale study are always better than the results of pilot testing.

Trial Application Plan

1. Background - To verify the effectiveness of ESP application in China market according to most potential customer's concern, a small municipal waste water treatment plant was selected to carry out the trial application.
2. Waste Water status and parameter.

Item No.	Item	Unit	Value
1	Influent		4100
2	Effluent		3500
3	COD	mg/L	180-1200
4	BOD	mg/L	70-500
5	NH_3-N	mg/L	65-85
6	Total N	mg/L	85-100
7	Total P	mg/L	15-22
8	Inf pH	\	4.6-7
9	Effluent COD Requirement	mg/L	<50
10	Effluent BOD Requirement	mg/L	<10
11	Effluent NH_3-N Req.	mg/L	5-8
12	Effluent Total N Req.	mg/L	<15
13	Effluent Total P Req.	mg/L	<0.5
14	Eff pH Req.	\	6.9
15	Effluent SS Req.	mg/L	10

3. Current process and setting.
   - SBR Process (Sequencing Batch Reactor Activated Sludge Process), comprise of, adjusting tank, 1000m^3X1, supply waste water to aeration tank
   - Reactor tank 1000m^3X4, alternative operating
   - Aeration Volume: 900m^3/minute
   - Sedimentation span: 40 minutes
   - Draining: 72 minutes
4. Experimental SBR device configuration:
   1. Cylinder aeration reactor, Dia.150mm, H800mm, effective reaction volume 12L
   2. Water pump 1
   3. Water flow meter 1, max reading 200L/Hr
   4. Aeration pump 1
   5. Air flow meter 1, max reading 2.5m^3/Hr
   6. Water reservation tank 1, volume 40L

5. Experimental plan: The actual process was miniaturized proportionally to try to imitate the actual process as possible, the configuration was set as follows,
    1. Aeration tank volume: 12L
    2. Aeration volume: 0.6m^3/Hr
    3. ESP dosage: 1ppm per 100 BOD, medium value of BOD 200 is selected to calculate the ESP dosage, water tank 40L, ESP dosage 0.08ml, considering the fluctuating of influent COD, 0.1ml was added to 20L influent water.
    4. 40L of experimental water is taken from the planet aeration tank once the aeration start each time, then add to the experimental device water tank.
    5. Lab test specimen is taken from the upper layer clear water after 130 minutes aeration and 40 minutes sedimentation.
    6. Lab test date: COD, NH3-N, TN, Tp
    7. 2 cycles of trial operation conducted each day,
    8. After experiment every day, clear water and 1/5 of the sludge was drained, new water was taken from the active aeration tank and add to the water tank to circulate.