AK 026

Statement of Verification

EU Environmental Technology Verification Pilot Programme

Technology Type: **Domestic/urban wastewater treatment**

Technology Name: **RichWater series 2018**

Statement Registration Number: **VN20200042**

Date of Issue: **05 October 2020**

THE VERIFICATION PROCESS, WHOSE RESULTS ARE SUMMARISED IN THIS STATEMENT, COMPLIES WITH THE EU-ETV GENERAL VERIFICATION PROTOCOL AND WITH THE EN ISO 14034:2018 ENVIRONMENTAL MANAGEMENT - ENVIRONMENTAL TECHNOLOGY VERIFICATION (ETV) (ISO 14034:2016)

VERIFICATION BODY AND PROPOSER DETAILS

Verification Body	Proposer
Environmental Technology Verification Body Institute for Ecology of Industrial Areas Katowice, Poland	BIOAZUL S.L.
Contact person	**Contact person**
Izabela Ratman-Kłosińska	Rafael Casielles Restoy
Address	**Address**
ul. Kossutha 6 40-844 Katowice, Poland tel.: (0-32) 254-60-31 ext. 243 fax: (0-32) 254-17-17 e-mail: etv@ietu.katowice.pl	Av. Manuel Agustin Heredia 18, 1º4. 29001. Malaga, Spain
Website	**Website**
www.etv.ietu.pl	www.bioazul.com

Verification Body

dr inż. Andrzej Węgrzyn
Director of the Institute for Ecology of Industrial Areas

Proposer

BIOAZUL
ENERGÍA • MEDIO AMBIENTE
B-92464619
Tel. 951 047 290
Avda Manuel Agustin Heredia,18, 1º4
29001 Malaga (SPAIN)

Antonio Lorenzo Lopez
CEO

Internet address where the Statement of Verification is available:
https://ec.europa.eu/environment/ecoap/etvv/

1 Technology description

RichWater series 2018 is a part of RichWater Technology treatment system intended to treat and reclaim water from domestic/urban wastewater for combined irrigation and fertilization purpose.

RichWater series 2018 involves the following treatment steps:

- rotary screen for separation of fine solids larger than 2 mm in diameter,
- biological reactor for degradation of the organic contamination and ammonium nitrogen,
- Membrane Tank with ultrafiltration modules for production of treated wastewater free of pathogens and suspended solids
- UV disinfection system with a low-pressure UV lamp for microbiological contamination removal.

RichWater series 2018 does not involve the denitrification step. The absence of denitrification enables obtaining higher levels of nitrates in the effluent compared to conventional activated sludge process and therefore provides an optimal water (effluent) for irrigation while meeting quality levels required by the EU Directive 91 /271 /EEC and the Spanish Royal Decree from RD1620/2007.

2 Application

2.1 Matrix

The technology is intended to treat domestic/urban wastewater after sand and grease removal.

2.2 Purpose

The purpose of the RichWater series 2018 is to treat domestic/urban wastewater that enters the wastewater treatment plant at a minimum to the quality levels required by the EU Directive 91 /271 /EEC and the Spanish Royal Decree from RD1620/2007 while preserving the content of nutrients: nitrates, phosphorus and potassium.

2.3 Conditions of operation and use

RichWater series 2018 can serve either as a complete treatment system to replace a conventional municipal wastewater treatment or to treat a part of the influent. The application of the reclaimed water produced by RichWater series 2018 for irrigation of crops under typical conditions of use and operation requires assembling to a mixing unit, an irrigation system and a monitoring and control module that are parts of the RichWater technology treatment system. These modules of the Richwater technology have not been subject to performance verification. The mixing unit serves either to supplement the effluent produced by RichWater series 2018 with clear water according to the crop demands and to avoid overdosing of fertilizers when any substance in the reclaimed water has a concentration value too high to be supplied directly to the target crops, or to add fertilizers in order to complement the nutrients contained in the reclaimed water if necessary. The mixing unit is assembled to an irrigation system (i.e. fertigation module) which distributes the nutrient rich mixture of reclaimed water and clear water to the crops. The monitoring and control module serves to measure parameters relevant for proper irrigation and dosage of fertilizer such as soil humidity, pH, nutrient demand, etc. and control the operation of the mixing and irrigation modules. The content of nutrients in the treated effluent depends on their concentration in raw wastewater.

The membrane reactor is equipped with membrane modules provided by the company MicroClear® (Filter Housing MB2-4 MicroClear® MCXL2).To ensure proper operation of the bioreactor, a

systematic membrane cleaning (once a day) using sodium hypochlorite and nitric acid solution is required.

In the disinfection system a low-pressure UV lamp provided by Xylem has been used (model MINI 65W/4P).

2.4 Verification parameters definitions summary

The performance parameters for the verification comprise parameters that describe the effluent quality before and after treatment, regulatory requirements, and parameters that assess equipment performance. The table below presents a summary of the performance parameters and the test methods.

Performance parameters				
Parameter	**Value (unit)**	**Existing legal requirements and/or BAT values**	**Test or measurement method(s)**	**Frequency of measurement**
Daily average concentration of Biochemical Oxygen Demand (BOD_5)	g O_2/m^3	Effluent[1] : ≤ 25 g O_2/m^3	Composite samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to manometry method . Test method based on: SM 5210 D of 2017	Twice a week
Daily average concentration of Chemical Oxygen Demand (COD)	g O_2/m^3	Effluent[1] : ≤ 125 gO_2/m^3	Composite samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to photometric titration method. Test method based on: ISO 6060 of 1989	Twice a week
Daily average concentration of total suspended solids	g/m^3	Effluent[1] : ≤ 35 g/m^3	Composite samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to gravimetry method. Test method based on: UNE-EN 872 of 2006	Twice a week
Daily average concentration of total nitrogen	g N/m^3	Effluent[2] : none	Composite samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to UV-Visible spectrophotometry method. Test method based on: UNE EN ISO 11905 of 1998	Twice a week
Daily average concentration of nitrates	mg $N\text{-}NO_3/L$	Effluent[2] : none	Composite samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to UV-Visible spectrophotometry method. Test method based on: DIN 38405 D9-2 of 2011	Twice a week
Daily average concentration of total phosphorus	g P/m^3	Effluent[2] : none	Composite samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to UV-Visible spectrophotometry method. Test method based on: UNE EN ISO 6878 of 2005	Twice a week
Daily average concentration of potassium	g/m^3	Effluent[2] : none	Composite samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to ICP method. .Test method based on: EPA200.7 revision 4.4, 1994	Twice a week
Daily average concentration of turbidity	NTU	Effluent[2] : ≤ 10 NTU	Composite samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to nefelometry method. Test method based on: Standard Methods, 19th Edition.	Twice a week
pH	-	Effluent[2] : none	Composite samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to Electrometry method.. Test method based on: SM 4500-H+ of 2017.	Twice a week
Escherichia Coli	CFU/100 ml	Effluent[2] : max 100 CFU/100 ml	Grab samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to method UNE-EN ISO 9308-1:2014	Twice a week

Legionella spp.	*CFU/L*	Effluent[2]: *max 1000 CFU/L*	Grab samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to method UNE: ISO 11731:2007-08	Twice a week
Nematodes	*egg/10 L*	Effluent[2]: *max 1 egg/10 L*	Grab samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to Bailenger Method modified from WHO (Microscopy), 1996	Twice a week
Salmonella spp.	*CFU/L*	Effluent[2]: none	Grab samples collected at the influent and effluent of the RichWater series 2018 and analyzed according to method: UNE EN-ISO 19250:2013.	Twice a week
Operational parameters				
Parameter	**Value (unit)**	**Existing legal requirements and/or BAT values**	**Test or measurement method(s)**	**Frequency of measuremen**
Wastewater flow rate	m^3/h	none	Measurement on-line with calibrated flowmeter	Continuous
Hydraulic retention time in biological reactor	*H*	none	Calculated	Twice a week
Hydraulic retention time in RichWater series 2018 membrane tank	H	None	Calculated	Twice a week
Temperature of wastewater	°C	none	Measurement on-line with calibrated temperature sensor	Continuous
Concentration of dissolved oxygen in biological reactor	gO_2/m^3	none	Measurement with calibrated oxygen sensor	Continuous
Concentration of dissolved oxygen in RichWater series 2018 membrane tank	gO_2/m^3	None	Measurement on site with portable oxygen meter	Twice a week
*Mixed liquor suspended solids concentration (MLSS)*in biological reactor	kg/m^3	None	Grab samples taken from a RichWater series 2018 biological reactor and analyzed according to gravimetry method (drying at 105º and 550º respectively for MLSS and MLVSS)	Twice a week
Mixed liquor suspended solids concentration (MLSS) in RichWater series 2018 membrane tank	kg/m^3	None	Grab samples taken from a RichWater series 2018 membrane tank and analyzed according to gravimetry method (drying at 105º and 550º respectively for MLSS and MLVSS)	Twice a week
Sludge age in biological reactor	*D*	None	Calculated	Twice a week
Sludge age in RichWater series 2018 membrane tank	D	None	Calculated	Twice a week
Sludge organic load (F/M)	kg BOD_5/kg·d	None	Calculated	Twice a week
Organic loading rate (OLR)	kg $COD/m^3 \cdot d$	None	Calculated	Twice a week
Transmembrane pressure	*Bar*	None	On-line measurement with calibrated pressure meter	Continuous
Environmental parameters				
Environmental parameters to be verified are the same as performance parameters				

[1] According to Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment

[2] According to maximum admitted values of parameters defined for TWW use on crops with direct contact to the water specified in the Spanish Royal Decree1620/2007).

3 Test and analysis design

3.1 Existing and new data

No existing data was used in verification.

3.2 Laboratory or field conditions

Testing for the verification of RichWater series 2018 was carried out in the period of 24 Sept. 2018 to 11 Dec. 2018 on a demonstration installation at an existing municipal wastewater treatment plant located in the municipality of Algarrobo in Malaga, Spain (Estación Depuradora de Algarrobo, Calle de la Realenga, 29751 Algarrobo, Málaga, Spain) to treat a part of its with influent flow below 5 m^3/h.

The municipal wastewater treatment plant treats wastewater originating from the 6,284 inhabitants of Algarrobo town. The flow at the plant is characterized by high seasonal fluctuation due to presence of tourists during summer. Wastewater inflow during summer is in the range of 4,000 – 6,000 m^3/day, while during the rest of the year is approximately 2,000 – 4,000 m^3/day.

3.3 Matrix compositions

The matrix during the testing was wastewater that was flowing in the municipal wastewater plant of Algarrobo and was free of sand and grass.

3.4 Test and analysis parameters

The key parameters tested and referred to the influent and effluent quality and monitoring of operational parameters. A total 16 of samples of the effluent and 16 samples of the influent were taken during the testing period. The total duration of each composite sampling was 24h. Grab samples of influent and effluent for microbiological analyses were collected within 2 hours after the autosampler stops the 24 hours sampling. Grab samples of the mixed liquor for MLSS, MLVS analysis were taken from the aeration and membrane tanks on the same days as the samples for microbiological analyses within 2 hours after the autosampler completed the 24 hours sampling. The methods used in laboratory tests are described in section 2.4.

3.5 Parameters measured

See the table of results.

4 Verification results (performance, operational and environmental parameters)

Performance parameters of the influent and effluent

Parameter	Influent/ effluent	Main value Min/max with U_{total}	Number of measurements
wastewater flow	influent	**3,15 m^3/h** Min 0,41 m^3/h, Max 4,82 m^3/h	Measurement on line during 49 days
temperature	influent	**22,61°C** Min (17,10±0,50) °C, Max (27,30±0,50) °C	Measurement on line during 49 days
BOD_5	influent	**163,25 gO_2/m^3** Min(93,00±30)gO_2/m^3, Max(232,00±74) gO_2/m^3	16
	effluent	**<15 gO_2/m^3**	16
COD	influent	**408 gO_2/m^3** Min(239,00±72)gO_2/m^3, Max(646,00±103) gO_2/m^3	16
	effluent	**23,67 gO_2/m^3**	16

Performance parameters of the influent and effluent			
Parameter	**Influent/ effluent**	**Main value Min/max with U_{total}**	**Number of measurements**
		Min(15,00±5)gO_2/m^3, Max(32,00±10) gO_2/m^3	
TSS	Influent	**210,06 g/m^3** Min(106,00±28)g/m^3, Max(397,00±103) g/m^3	16
	Effluent	**<8 g/m^3**	16
Total nitrogen	Influent	**38,81 g N/m^3** Min(25,00±5)g N/m^3, Max(67,00±14) g N/m^3	16
	Effluent	**26 g N/m^3** Min(16,00±5)g N/m^3, Max(45,00±10) g N/m^3	16
Nitrates	Influent	**<22 g N/m^3**	16
	effluent	**92,31 g N/m^3** Min(23,0±)g N/m^3, Max(180,68±) g N/m^3	16
Total phosphorus	Influent	**5,97 g/m^3** Min(3,30±0,6)g/m^3, Max(12,00±2) g/m^3	16
	effluent	**4,34 g/m^3** Min(0,16±0,03)g/m^3, Max(12,00±2) g/m^3	16
Potassium	Influent	**14,82 g/m^3** Min(8,80±1,1)g/m^3, Max(25,00±3) g/m^3	16
	effluent	**4,43 g/m^3** Min(8,10±1,0)g/m^3, Max(24,00±3) g/m^3	16
pH	Influent	**7,73** Min(7,10±0,1), Max(8,00±0,1)	16
	effluent	**7,91** Min(7,50±0,1), Max(8,30±0,1)	16
Turbidity	Influent	**120,00 NTU** Min (3,00 ±0,3) NTU, Max (349,00±42) NTU	16
	effluent	**0,69 NTU** Min (0,16 ±0,02) NTU, Max (2,30±0,3) NTU	16
Escherichia Coli	effluent	In **94%** of the effluent samples, the concentration was **below 50** CFU/100 mL. Only in one sample *Escherichia Coli* content was 90 CFU/100 mL but it was below the maximum admitted values of this parameter defined for TWW use on tree crops at RD1620/2007 (100 CFU/100 mL).	16
Legionella spp	effluent	**94%** of effluent samples did not contain Only in one sample *Legionella* content was 1200 CFU/L. The maximum admitted value of this parameter is 1000 CFU/L for at least 90% samples (RD1620/2007). The sample that exceed the maximum admitted value did not exceed the maximum deviation limit of 1 logarithmic unit.	16
Salmonella	effluent	**100%** of samples did not contain *Salmonella*	16
Nematodes	effluent	**100%** of effluent samples did not contain Nematodes.	16
Operational parameters at the biological reactor			
HRT		**22,96 h** Min (9,86±0,21)h, Max (115,90±28,27)h	16 (calculated)

Performance parameters of the influent and effluent			
Parameter	**Influent/ effluent**	**Main value Min/max with U_{total}**	**Number of measurements**
temperature	**22,61 °C** Min (17,30±0,50) °C, Max (27,30±0,50) °C		Measurement on line during 49 days
Dissolved oxygen	**1,64 mg/L** Min (0,50±0,50) mg/L, Max (2,40±0,50) mg/L		16
MLSS	**3475,50 mg/L** Min (1797,00±161,73)mg/L, Max (4910,00±441,90) mg/L		16
Sludge age	**58,83 d** Min (6,35±2,87) d, Max (365,66±175,11) d		16 (calculated)
F/M	**0,08 kg BDO_5/kg·d** Min(0,01±0,00) kg BDO_5/kg·d Max (0,23±0,08) kg BDO_5/kg·d		16 (calculated)
OLR	**0,59 kg COD/m^3·d** Min (0,11±0,03) kg COD/m^3·d, Max (1,13±0,18) kg COD/m^3·d		16 (calculated)
Operational parameters at the membrane reactor			
HRT	**4,52 h** Min (1,94±0,04)h, Max (22,83±5,57)h		16 (calculated)
Dissolved oxygen	**5,67 mg/L** Min (3,00±0,50) mg/L, Max (6,90±0,50) mg/L		16
MLSS	**4104,81 mg/L** Min (2297,00±206,73)mg/L, Max (5870,00,00±528,30) mg/L		16
Sludge age	**8,26 d** Min (1,17±0,55) d, Max (49,01±25,49) d		16 (calculated)
F/M	**0,34 kg BDO_5/kg·d** Min(0,51±0,02) kg BDO_5/kg·d Max (0,78±0,26) kg BDO_5/kg·d		16 (calculated)
OLR	**3,01 kg COD/m^3·d** Min (0,58±0,17) kg COD/m^3·d, Max (5,73±0,93) kg COD/m^3·d		16 (calculated)

The following figures, extracted from the test report, summarise the influent and effluent characteristics and operational parameters at the biological and membrane reactors.

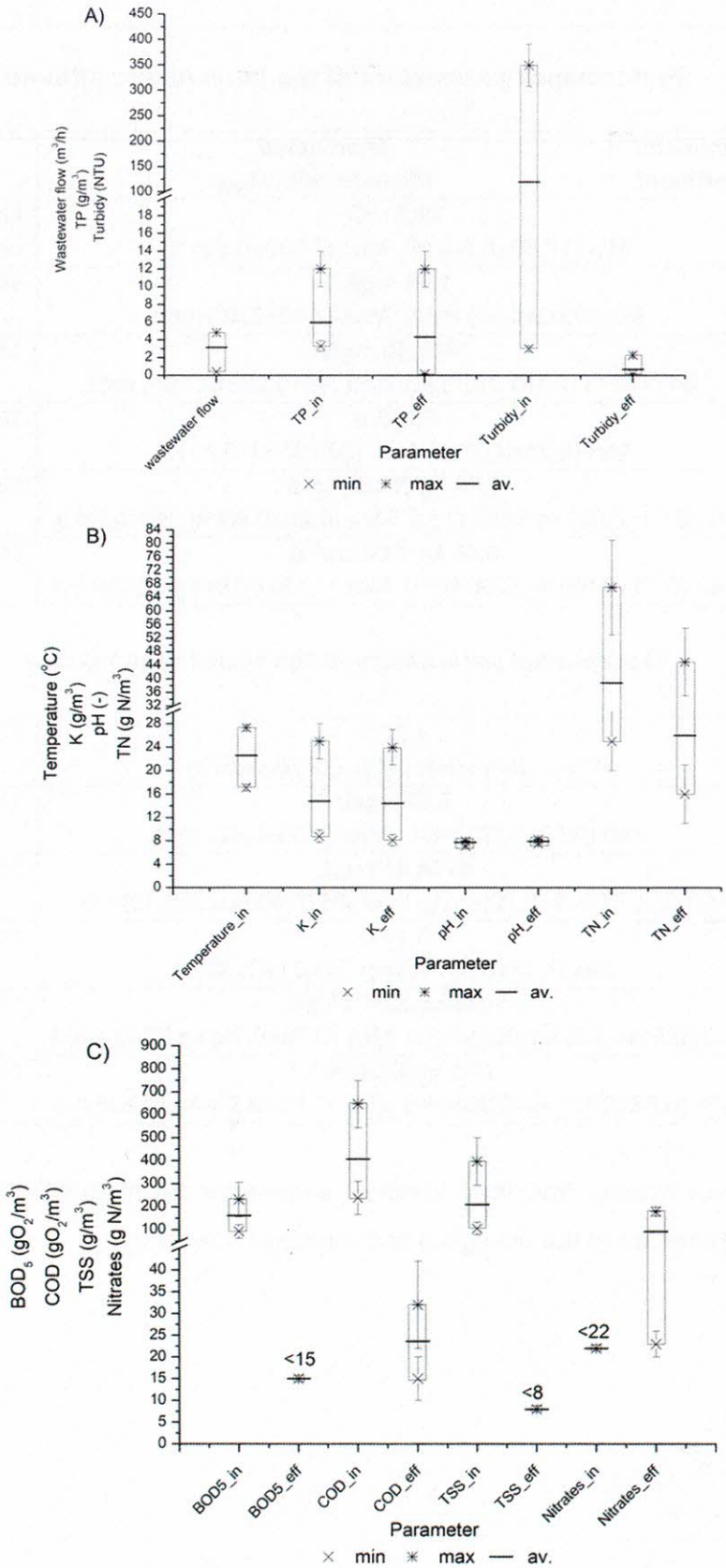

Figure 1: Physical and chemical parameters of the influent and effluent: A) Wastewater flow, TP, Turbidity; B) Temperature, K, pH, TN; C) BOD_5, COD, TSS, Nitrates

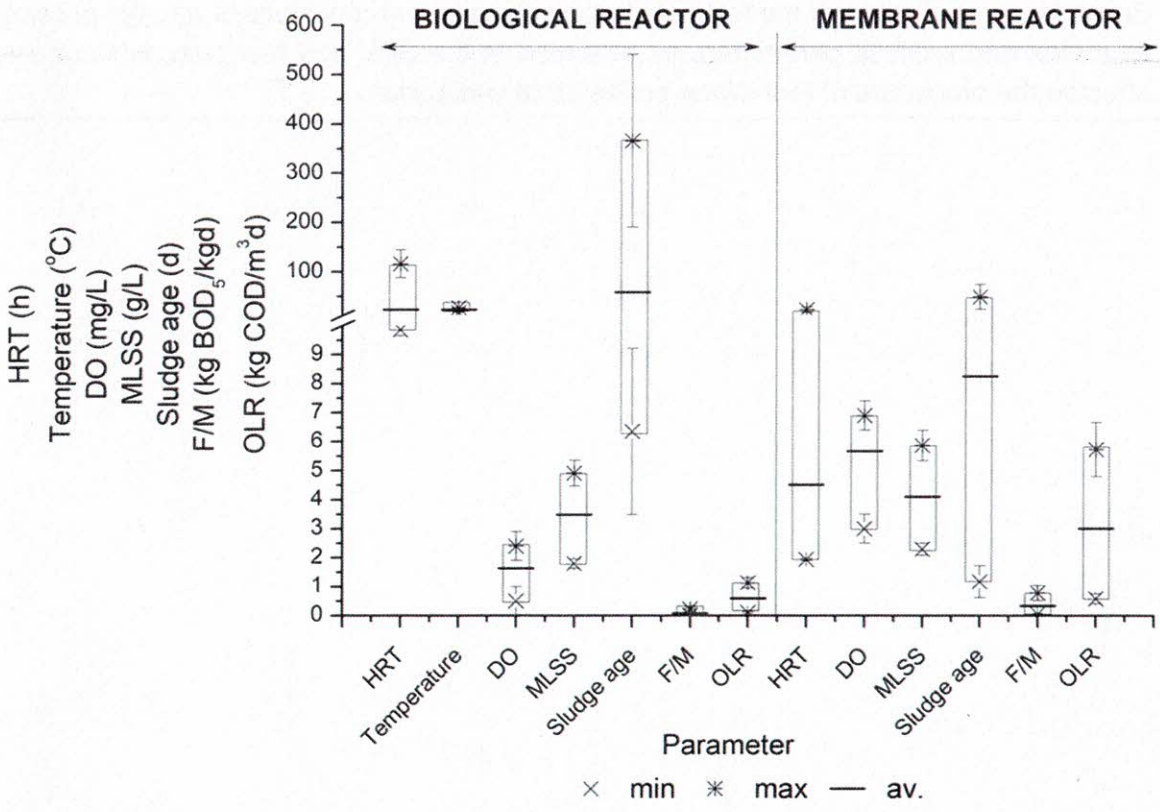

Figure 2: Operational parameters at the biological and membrane reactors

5 Additional information, including additional parameters[1]

The following parameters were declared by the Proposer but were not part of this verification:

- Energy consumption of Richwater series 2018: 2,49 kWh/m^3.
- Chemicals consumption for membrane cleaning: 24.5 liters of Sodium hypochlorite + 7 m^3 of Nitric acid solution at pH 2 of 100 ppm to 500 ppm once a day.

6 Quality assurance and deviations

The verification was carried out according to the Quality Assurance Plan described in the verification protocol. During testing, internal and external audits were carried out by TB IRTENE and Environmental Technologies Verification Body IETU, respectively. There were several deviations to the specific verification protocol and test plan (for details consult the Verification Report). Most deviations were of practical nature, such as a damage of input flow meter, problems with aeration in bioreactors, and weather conditions (heavy rains). None of the deviations were considered to have significant impact on the verification.

[1] with comments or caveats where appropriate

Because the verification of the technology took place in real conditions, it was not possible to maintain all matrix and process parameters as assumed in the SPV and test plan, which however has not affected the procedure of RichWater series 2018 verification.