APRIL 2020

CASE STUDY

The application of ASIA to a wastewater treatment plant (type BNR CLASSIC) serving 13.000 Equivalent Inhabitants

Client: CAFC Spa – Udine – Italy

Location: Latisana Capoluogo (UD)

[NOTE: This document is our english translation of the technical report made by Cafc and written in italian. The original italian report (see next page) is available on request writing to our e-mail asia@igpeng.it

RELAZIONE TECNICA

Applicazione del Sistema "ASIA" ad un depuratore "BNR" classico, con potenzialità di 13.000 abitanti equivalenti

Risultati dei Test

Il Direttore
Divisione Operativa Depurazione
ing. Michele Mion

(Aprile 2020)

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SUMMARY

CAFC Spa has always pursued the objective of continuously improving the energy efficiency of its plants and to contain their polluting emissions as much as possible, so as to reduce their so named "ecological footprint".

The area with the highest potential improvement is the oxidation section of biological wastewater treatment plants, which is by far the most energy-consuming. In fact, the electricity consumed for oxidation is an average 45-65 % of the total energy spent on the entire water treatment plant (including the initial lifting, but excluding sludge treatment).

In an effort to reduce energy consumption and optimize the process CAFC has decided to test the "ASIA" System (Advanced System Intermittent Aeration), produced by IGP Engineering srl, because this tool has been designed specifically to achieve the above targets in purification plants with biological oxidation.

In order to check and quantify the advantages obtainable by using "ASIA", CAFC Spa has decided to install it on the wastewater treatment plant of Latisana Capoluogo (Udine) and, by comparing operating data prior to and after its installation, this report illustrates the results achieved.

The performance of ASIA appears to have fully met expectations: its installation has proved in fact to be simple and fast and the ASIA software (which continuously controls the oxidative phase of the purification process) has made it possible to constantly obtain both significant energy savings, and a clear-cut improvement in the abatement of nitrogen in the nitrification section.

PRELIMINARY REMARKS

CAFC Spa is constantly pursuing energy efficiency and process improvement in wastewater treatment plants, with the aim of reducing their “carbon footprint” (corresponding to the amount of greenhouse gas emissions generated by production processes).

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With this in mind, an innovative process control system called "ASIA" (Advanced System Intermittent Aeration), made by IGP Engineering srl (Trieste, Italy) has been tested on the medium capacity civil water treatment plant of Latisana Capoluogo (UD).

The ASIA software algorithm (installed in a dedicated computer), based on the Redox signal measured in the oxidation tank, commands continuously the aeration system of the bioreactor.

The objective of the test was to check if the performance of ASIA was up to the standard declared by the designer, that is:

- ✓ ASIA automatically and continuously controls the oxidation and reduction reactions developing in the bioreactor by relying exclusively on the Redox measurements in the aeration tanks
- ✓ ASIA regulates the biological purification process through an on/off control of blowers (and mixers if existing);
- ✓ ASIA is easily applicable to different types of biological reactors, both discontinuous and continuous, whether or not equipped with a nitrogen reduction process;
- ✓ ASIA can be installed simply and quickly, both in plants with PLC automation and in plants with wired logic automation;
- ✓ ASIA provides quickly the following results: a significant reduction in energy consumption, a major increase of purification yields, greater adaptability of the purification process to the variation of polluting loads, greater consistency in complying with the exhaust limits of purified water, the maximization of the potentiality of the plant.

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THE PLANT OF LATISANA CAPOLUOGO

The plant that treats the sewage discharges of Latisana Capoluogo is sized to deal with the polluting load produced by 13,000 A.E. (Equivalent Inhabitants)

The depurative process is a typical "BNR" (Biological Nutrient Removal) process, capable of removing from waste not only the organic load but also Nitrogen and Phosphorus nutrients.

Nitrogen abatement occurs through the pre-denitrification phase, meanwhile phosphorus abatement occurs by precipitation generated by the dosing of ferric chloride in the oxidation and nitrification compartment (before the solid-liquid separation which takes place in the sedimentation station).

The BNR classic process is represented by the following diagram.

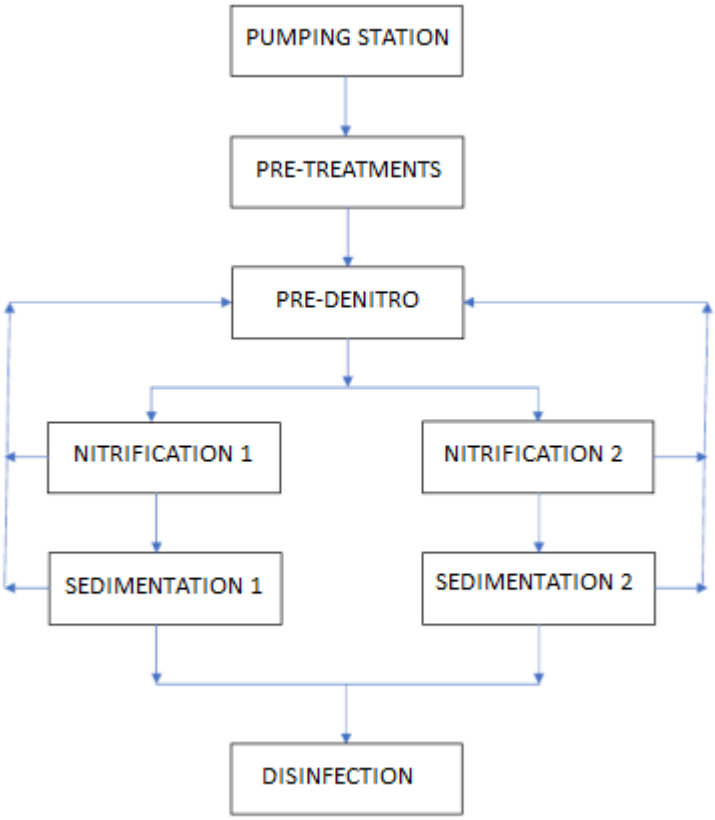

Figure 1: Block diagram of the biological process of the plant of Latisana Capoluogo

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After the pretreatment phase the inflowing sewage enters the pre-denitrification compartment (common to both subsequent and parallel lines of oxidation / nitrification) to which are conveyed both the recirculated sludges from sedimentators, and the recirculated aerated mixture from oxidation / nitrification reactors.

There are therefore two distinct lines of oxidative treatment, fed by one pre-denitrification compartment common to both.

The electric control panels of the purifier are made in wired logic, and the machines work with timers. The aeration blowers are also controlled by the regulation of oxygen concentration (with minimum and maximum threshold values used respectively to start and stop compressors).

This plant has been chosen by CAFC Spa as a test site for ASIA because it presents the following critical factors:

- The area being considered "sensitive", the discharge authorization of the plant imposes strict limits for nitrogen and phosphorus parameters. The values to be complied with are 15 mg/l of total nitrogen and 2,0 mg/l of total phosphorus, both as annual averages;
- wastewater is characterised by generally low inflow COD concentrations, which limits the abatement performance of the pre-denitrification treatment. This condition makes it hard to keep within the prescribed limits;
- the wired logic automation of the plant makes the development and application of any further advanced automation rather awkward, because any upgrading would require the remaking of the entire control-panels with considerable investment costs;
- the BNR process is particularly energy consuming, due to the presence of pumps for the internal recirculation and of submerged mixer installed in denitrification.

Things being so the application of ASIA should be able to give quite a few benefits.

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Operating data of the purifier before applying "ASIA"

The following tables show the chemical-physical characteristics of the inflow (wastewater) and the outflow (treated water) of the plant, resulting from treatment with the classic BNR predenitro/nitro configuration.

Table 1: BNR CLASSIC - 2019 analytical data related to INFLOW (NR = not measured)

Month	COD	Total Nitrogen	Ammoniacal Nitrogen	Nitrous Nitrogen	Nitric Nitrogen
	mgO2/l	*mgN/l*	*mgNH4/l*	*mgN/l*	*mgN/l*
January	115	NR	21	<0,06	<1
February	40	15,3	10	0,35	3,49
March	127	24,6	19	<0,06	<1
April	129	28,8	16	<0,06	<1
May	<10	10,6	6	0,085	3,58
June	49	10,7	9	<0,06	<1
July	47	16,9	13	<0,06	<1
Agust	87	15,4	15	<0,06	<1
September	35	12,7	11,0	0,07	<1
October	117	23,8	22,2	<0,06	1,93
November	40	7,9	NR	0,10	1,5
Dicember	39	10,6	NR	0,16	<1
Average	***75***	***17,5***	***14***	***0,08***	***1,21***
Std. Dev.	***40***	***6,8***	***5,3***	***0,10***	***1,19***

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Table 2: BNR CLASSIC - 2019 analytical data related to OUTFLOW (NR = not measured)

Month	COD	Total Nitrogen	Ammoniacal Nitrogen	Nitrous Nitrogen	Nitric Nitrogen
	mgO2/l	*mgN/l*	*mgNH4/l*	*mgN/l*	*mgN/l*
January	34	19,4	<1	0,06	19,3
February	25	10,4	<1	<0,06	11,3
March	20	14,1	<1	<0,06	14,0
April	19	8,5	<1	<0,06	9,0
May	18	9,7	<1	<0,06	8,9
June	20	12,6	<1	<0,06	11,0
July	11	12,7	<1	<0,06	13,7
Agust	12	14,8	<1	<0,06	16,0
September	16	19,6	<1	<0,06	17,8
Average	***19***	***13,5***	***<1***	***<0,06***	***13,4***
Std. Dev.	***6,9***	***3,9***	***---***	***---***	***3,7***

Upon calculating the abatements achieved it was found that the total nitrogen removal efficiency was very low and that the variation of the efficiency over time was considerable.

Table 3: BNR CLASSIC - percentages of abatement achieved in 2019

Month	COD	Total Nitrogen	Ammoniacal Nitrogen
January	70,4%	ND	97,6%
February	38,1%	32,0%	95,0%
March	84,2%	42,7%	97,4%
April	85,3%	70,5%	96,9%

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May	ND	8,5%	91,7%
June	59,2%	ND	94,4%
July	76,6%	24,9%	96,2%
Agust	86,2%	3,9%	96,7%
September	54,3%	ND	ND
Average	***74,1%***	***22,5%***	***96,5%***

ADD-ON OF THE "ASIA" SYSTEM

Hardware installation

In October 2019 IGP Enginering srl installed ASIA into the Oxidation Line no. 2 of the plant of Latisana Capoluogo.

The dedicated ASIA computer was supplied along with its conveniently small electrical panel which was easily installed on the wall close to the electrical panel of the purifier. By doing so:

- the lack of space in the existing control panel area has been remedied;
- disinstalling ASIA in case of test failure would be very easy;
- the four interconnections set up between the ASIA panel and the existing panel were:
  - an analog output (AO) 4-20 mA measure entering the ASIA logic module from the Redox meter installed in the oxidation tank of line 2;
  - a digital output (DO) command from ASIA, for the switch on/switch off control of the blower of line 2;
  - a digital input (DI) signal entering ASIA, for the status feedback from the blower of line 2;
  - a digital output (DO) alarm signal from ASIA, to trigger an automatic switch from "ASIA logic" to the “existing wired logic”, in case of failure of ASIA.
  - The ASIA panel has then further digital outputs (DO) to enable remote control from CAFC (which has a Remote Control System for all their plants) and a

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second analog output (AO) signal (4-20 mA) of the Redox measurement, available for future needs and currently not used.

The installation of ASIA started on October 11, 2019 (a Friday) and was completed on October 14, 2019 (Monday) with the final system testing and the insertion of basic software configurations. The system started working regularly on October 14, 2019.

ASIA therefore required only 2 days to be installed and put into service.

Changes in the purification process resulting from the application of ASIA

In order to be able to compare the results obtained with the existing BNR Classic process with those obtained with the new BNR & ASIA process, the hydraulic flow entering the purifier has been modified as follows: in the initial pumping station has been added a second pump, operating in parallel with the existing one; in this way the incoming flow has been divided into 2 flows, each equal to 50% of the total flow.

The 1st Line - BNR CLASSIC -, working in accordance with the pre-denitro/nitro process scheme, was fed with half of the incoming flow, which passes through the following compartments in series:
- Pre-denitrification
- 1st Nitrification
- 1st Sedimentation

For the correct functioning of Line 1 the machines that kept working were:
- the 1st denitrification submerged mixer;
- the 1st aeration compressor (which is controlled by oximeter on the basis of minimum and maximum threshold values);
- the 1st recirculation pump of the sludge from the sedimentator;
- the 1st recirculation pump of the aerated mixture between nitrification and denitrification.

The 2nd Line - BNR & ASIA -, following the new ASIA processing scheme, was fed with the other half of the inflow, which passes only through :

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- 2 nd Nitrification
- 2 nd Sedimentation

So the reaction volumes of the 2nd Line (with ASIA), are lower than the reaction volumes of the 1st Line (without ASIA), because the volume of pre-denitrification is missing.

To operate the 2nd Line the machines which kept working were:
- the 2nd aeration compressor (controlled by the ASIA algorithm based on the Redox signal)
- the 2 nd recirculation pump of the sludge coming from the sedimentator.

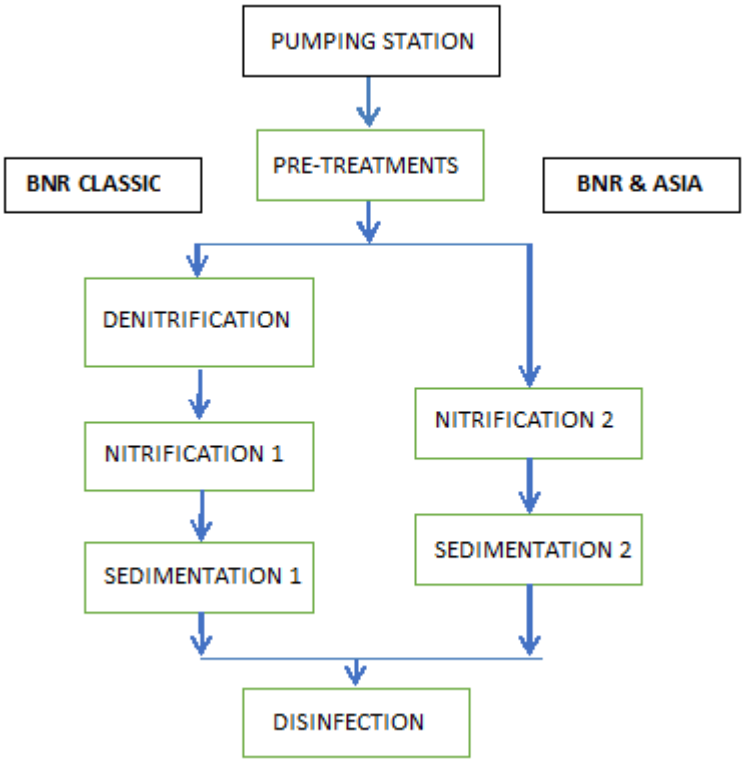

Figure 2: Block diagram comparing the two purification processes; BNR CLASSIC / BNR & ASIA

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Analysis of the collected data.

Efficiency of the purification process

The analytical monitoring of the two Lines (BNR Classic and BNR & ASIA) started a few days after the installation of the ASIA module. The purpose of the monitoring was to ascertain the time needed for the BNR & ASIA process to reach steady operating conditions, and to analyze its performance once fully operative.

The collection and analysis of performance data lasted a total of about 3 and a half months, divided into two phases:
-1st Phase (about 1 month)– comparative analysis of the results obtained individually by the two parallel lines;
-2nd Phase (about 2,5 months)- analysis of the results obtained by the plant as a whole, with the two lines working in parallel;

The first phase also served to verify that ASIA was indeed effective, while the second phase was useful to verify the stability of the BNR & ASIA process in the long run.

During the 1st phase two sets of samples were always taken simultaneously and analysed by the process laboratory of CAFC Spa (located inside the wastewater treatment plant of San. Giorgio di Nogaro - UD) AND by the public Laboratory FRIULAB Srl in Udine, in order to double check the values obtained.

All samples were taken as 3-hour or 24-hour average values, depending on the type of information needed.

Laboratory results on treated water samples, taken at the exit of the two lines and at the final exit from the sewage treatment plant, are shown in the tables below.

Table 4: Water quality at the exit of 1st Line - BNR CLASSIC

Date	COD	Total Nitrogen	Ammoniacal Nitrogen	Nitrous Nitrogen	Nitric Nitrogen
	mgO2/l	*mgN/l*	*mgNH4/l*	*mgN/l*	*mgN/l*
18/10/2019	<10	7,4	<1	<0,06	6,9

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22/10/2019	14	10,9	<1	<0,06	10,6
06/11/2019	38	12,6	12,6	0,14	1,5
07/11/2019	15	7,5	<1	<0,06	6,9
13/11/2019	<10	6,0	<1	<0,06	5,8
Average	***15***	***8,9***	***4,4***	***<0,06***	***6,4***
Std. Dev.	***14***	***2,8***	***7,1***	***---***	***3,3***

Table 5: Water quality at the exit of 2nd Line - BNR & ASIA

Date	**COD**	**Total Nitrogen**	**Ammoniacal Nitrogen**	**Nitrous Nitrogen**	**Nitric Nitrogen**
	mgO2/l	*mgN/l*	*mgNH4/l*	*mgN/l*	*mgN/l*
18/10/2019	<10	6,3	<1	0,22	4,8
22/10/2019	14	6,4	1,0	0,11	5,1
06/11/2019	17	7,1	1,7	0,29	4,3
07/11/2019	10	6,2	<1	<0,06	5,5
13/11/2019	<10	4,1	<1	<0,06	3,7
Average	***10***	***6,0***	***1,2***	***0,14***	***4,7***
Std. Dev.	***6,0***	***1,1***	***0,5***	***0,11***	***0,7***

These data clearly show that the 2nd Line 2 BNR & ASIA produces a constantly better water than that produced by the 1st Line BNR CLASSIC; the standard deviations of the measurements confirm this.

Table 6: quality of water discharged from the plant (Lines 1 + 2)

Date	**COD**	**Total Nitrogen**	**Ammoniacal Nitrogen**	**Nitrous Nitrogen**	**Nitric Nitrogen**
	mgO2/l	*mgN/l*	*mgNH4/l*	*mgN/l*	*mgN/l*
22/10/2019	25	11,6		0,11	2,6
06/11/2019	22	6,7		<0,06	6,2

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07/11/2019	<10	5,0		<0,06	4,7
13/11/2019	23	2,5		<0,06	2,3
20/11/2019	21	7,7		<0,06	6,6
19/12/2019	19	ND		<0,06	6,9
08/01/2020	14	13,8		<0,06	7,0
05/02/2020	15	9,3		<0,06	8,7
Average	***18***	***8,1***		***<0,06***	***5,6***
Std. Dev.	***6,5***	***3,9***		***---***	***2,3***

The quality of the discharged water is intermediate between the quality of the discharge of the two oxidative lines, because it results from the sum of two parallel flows treated with different processes. If ASIA had been installed on both lines the result would have been the best among those shown in Table 5.

On the basis of these qualitative data, the depurative yields of the two lines and of the plant as a whole have been calculated. The results are shown in the following tables.

Table 7: Performance achieved by 1st Line - BNR CLASSIC (after the installation of ASIA on Line 2)

Date	COD	Total Nitrogen
18/10/2019	97,7%	69,7%
22/10/2019	90,7%	59,7%
06/11/2019	60,4%	---
07/11/2019	48,3%	8,5%
13/11/2019	73,7%	9,4%
Average	***76,4%***	***39,8%***

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Table 8: Performance achieved by 2nd Line - BNR & ASIA

Date	COD	Total Nitrogen
18/10/2019	97,7%	74,2%
22/10/2019	90,7%	75,9%
06/11/2019	82,3%	42,3%
07/11/2019	65,5%	24,4%
13/11/2019	73,7%	35,9%
Average	***84,7%***	***59,1%***

These data indicate that the increase in the yield produced by ASIA is, in this case, equal to 10% for the COD and 48% for total nitrogen.

Table 9: Overall performance of the sewage treatment plant after installation of ASIA

Data	COD	Azoto totale
22/10/2019	83,4%	56,1%
06/11/2019	77,1%	45,5%
07/11/2019	82,8%	38,8%
13/11/2019	---	62,6%
20/11/2019	---	---
19/12/2019	58,7%	---
08/01/2020	73,1%	16,4%
05/02/2020	81,9%	52,6%
Media	***71,5%***	***45,2%***

Energy consumption.

From the comparison of the working hours of the machines operating in the two Lines it has been possible to estimate the energy consumption of the BNR CLASSIC pre-denitro/nitro process and those of the BNR process managed with ASIA.

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The Table below shows the list of operating machines in the two different Lines and their respective powers.

1st LINE - BNR CLASSIC		**2 nd LINE - BNR & ASIA**	
Machine	*Power*	*Machine*	*Power*
Mixer	2,2 kW	---	---
Blower	20 kW	Blower	15 kW
Pump (aerated sludge recirculation)	3,1 kW	---	---
Pump (final recirculation)	7,5 kW	Pump (final recirculation)	7,5 kW

In the period following the installation of ASIA (October 2019 - February 2020) the hours of work of the machines were recorded, and on the basis of their power was calculated the energy consumption of each line.
The following tables summarize these results:

Table 10: Electricity consumption of 1st Line - BNR CLASSIC recorded during the test period

LINEA 1 - BNR CLASSIC				
Month	*Mixer*	*Blower*	Pump (aerated sludge recirculation)	Pump (final recirculation)
October 2019				
Working hours	744 h	345 h	526 h	524 h
Energy consumed	1637 kWh	6909 kWh	1630 kWh	3928 kWh
November 2019				
Working hours	720 h	338 h	512 h	500 h
Energy consumed	1584 kWh	6768 kWh	1588 kWh	3753 kWh

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Dicember 2019				
Working hours	744 h	243 h	520 h	510 h
Energy consumed	1637 kWh	4853 kWh	1611 kWh	3824 kWh
January 2020				
Working hours	744 h	214 h	529 h	521 h
Energy consumed	1637 kWh	4274 kWh	1641 kWh	3911 kWh
February 2020				
Working hours	696 h	226 h	493 h	480 h
Energy consumed	1531 kWh	4511 kWh	1528 kWh	3601 kWh
Total Energy consumed	**8026 kWh**	**27315 kWh**	**7998 kWh**	**19017 kWh**
Total Energy consumed 1st Line (BNR CLASSIC)	**62.356 kWh**			

Table 11: Electricity consumption of 2nd Line - BNR & ASIA recorded during the test period

LINEA BNR & ASIA		
Month	*Blower*	Pump (final recirculation)
October 2019		
Working hours	307 h	512 h
Energy consumed	4600 kWh	3836 kWh
November 2019		
Working hours	119 h	533 h
Energy consumed	1782 kWh	3996 kWh

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Dicember 2019		
Working hours	59 h	551 h
Energy consumed	882 kWh	4129 kWh
January 2020		
Working hours	154 h	500 h
Energy consumed	2308 kWh	3753 kWh
February 2020		
Working hours	277 h	345 h
Energy consumed	4157 kWh	2590 kWh
Total Energy consumed	**13729 kWh**	**18304 kWh**
Total Energy consumed 2nd Line (BNR & ASIA)	**32.033 kWh**	

The comparison of these two previous tables shows that ASIA has produced energy savings of 48% on the line in which it was installed.

In order to further investigate energy consumption, the average daily electric consumption of the operating machines of the whole plant have also been recorded. The totals of the two periods, before and after the installation of ASIA, have then been compared. The results are shown in Table 12.

Table 12: Comparison between the energy consumption of the biological section before and after the installation of ASIA on the 2nd Line

Month	*September 2019– October 2019 before the add-on of ASIA* *(2 lines BNR Classic)*	*October 2019– February 2020 after the add-on of ASIA* *(1 Line BNR classic +* *1 lina BNR & ASIA)*
Mixer		

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Working hours	24 h/d	24 h/d
Energy consumed	53 kWh/d	53 kWh/d
Blower 1		
Working hours	9,4 h/d	9,1 h/d
Energy consumed	188 kWh/d	182 kWh/d
Blower 2		
Working hours	9,2 h/d	6,1 h/d
Energy consumed	138 kWh/d	91 kWh/d
Pump (aerated sludge recirculation) 1		
Working hours	16,7 h/d	17,0 h/d
Energy consumed	52 kWh/d	53 kWh/d
Pump (aerated sludge recirculation) 2		
Working hours	17,0 h/d	0 h/d
Energy consumed	53 kWh/d	0 kWh/d
Pump (final recirculation) 1		
Working hours	16,9 h/d	16,7 h/d
Energy consumed	127 kWh/d	125 kWh/d
Pump (final recirculation) 2		
Working hours	16,2 h/d	16,2 h/d
Energy consumed	122 kWh/d	122 kWh/d
Energy consumed daily by the biological stage of the plant	**732 kWh/d**	**625 kWh/d**

Using the data of this table it is possible to simulate the energy that would be spent by inserting ASIA also on the 1st Line.
The simulation result is shown in Table 13.

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Table 13: Simulation of the energy consumption of the biological section with ASIA installed on both Lines.

Month	*Computation in the hypothesis that ASIA is applied to both the Lines*
Mixer	
Working hours	0 h/d
Energy consumed	0 kWh/d
Blower 1	
Working hours	6,1 h/d
Energy consumed	91 kWh/d
Blower 2	
Working hours	6,1 h/d
Energy consumed	91 kWh/d
Pump (aerated sludge recirculation) 1	
Working hours	0 h/d
Energy consumed	0 kWh/d
Pump (aerated sludge recirculation) 2	
Working hours	0 h/d
Energy consumed	0 kWh/d
Pump (final recirculation) 1	
Working hours	16,2 h/d
Energy consumed	122 kWh/d
Pump (final recirculation) 2	
Working hours	16,2 h/d
Energy consumed	122 kWh/d
Energy consumed daily by the biological stage of the plant	**426 kWh/d**

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From this simulation it emerges that the energy saving obtainable by using ASIA on both oxidation Lines would reach 41% of the total. This would allow the pre-denitrification tank to be used for other purposes, thus increasing the potential of the entire plant.

CONSIDERATIONS ON THE VALIDITY OF THE "ASIA" SYSTEM

The objective of the test was to check the veracity of what was declared by the manufacturer of the ASIA System and to quantify the benefits achievable by its application on wastewater treatment plants with biological oxidation.

The points we have verified are those indicated in the introduction, which we are going to recap below:

- ✓ **ASIA automatically and continuously controls the oxidation and reduction reactions developing in the bioreactor on the sole basis of the measurements of the redox in the aeration tanks**.
  TRUE
  The hardware containing the ASIA software receives only one continuous signal (Analog Input), and precisely the Redox signal measured in the aeration tank (through a probe whose position is determined in accordance with the specific geometry of the reactor). Through this signal the algorithm of ASIA continuously controls the biological reactions.
  Should the redox measurement be used also for other purposes, its continuous analog signal can be doubled in 4-20 mA using a simple signal splitter.

- ✓ **ASIA regulates the purification process by acting exclusively on the on/off switch of the blowers.**
  TRUE
  The command output from the dedicated computer ASIA is a single and “clean” contact (Digital Output) controlling the blower. The addition of this contact inside the automation panel of the plant is simple, thanks to the clear instructions provided by the manufacturer of ASIA in the shape of a wiring diagram.
  Depending on the type of automation existing on a plant, and on the type of control of blowers, several wiring diagrams are available for installation.

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In any case there is no need to change the pre-existing logic of automation, which remains in stand-by, ready to intervene if ASIA should no longer regulate the oxidation process.

- ✓ **ASIA is easily applicable to different types of biological reactors, both discontinuous and continuous, whether or not equipped with a nitrogen reduction process.**
  The plant in Latisana Capoluogo is of a continuous type, with a nitrogen reduction process.
  From the test carried out it can be confirmed that ASIA is applicable to continuous biological depurative processes, with or without tertiary treatment of nutrient reduction (in fact, the 2nd Line was composed only of one tank of oxidation followed by a sedimentation tank).
  We cannot say anything about discontinuous processes, except that the first reference of ASIA was its application to a SBR purifier (Sequencing Batch Reactor), serving a wine cellar.

- ✓ **ASIA can be installed simply and quickly, both in plants with PLC automation and in plants with wired logic automation.**
  TRUE.
  In the case under scrutiny ASIA has been added-on electrical panels with wired logic.
  The application has been implemented easily and very quickly.
  The presence of a PLC would not have made any difference because the automation software contained in the PLC would not have to be changed anyway (except eventually for the alarm management).
  In the same way the possible absence of the Redox measurement instrument would not have made any difference because a Redox instrument would have been immediately available on the market and quickly installable.

  It has also been verified that the installation mode adopted and the self-diagnosis functionalities of ASIA make it possible to automatically deal with situations of failure or anomaly.
  In fact specific tests simulating such conditions have demonstrated that ASIA manages to keep the purification process effective in spite of them.
  In particular, the events tested were the following:

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- Lack of voltage of the control instrument, i.e the Redox measurement.
ASIA recognized the event and passed the control of the 2nd Line blower to the wired automation of the electric panel, which handles the biological process control with on-off timers.

- Crash of the ASIA system.
In this case, thanks to the alarm contact (DO) given by the hardware of ASIA, it was possible to switch the operation of the blower to the existing wired logic, keeping the plant working. At the same time the alarm contact (DO) was activated for the CAFC remote control system.

-Recirculation pump failure.
In this case, the ASIA system detected the anomaly affecting the Redox measurement, and passed the control of 2nd Line blower to the automation of the depurator's panel (which control the biological process using on-off timers).

- Failure of 2nd Line blower.
In this case ASIA recognized the lack of feedback from the blower and activated the contact alarm (DO) for the remote control of CAFC.

It has also been verified that all these alarm situations detected by ASIA, were notified remotely in real time (in this case directly to IGP Engineering) by using the SIM card inserted in the system.

So, besides being easily applicable to wired logic panels, ASIA is also a very robust and resourceful tool quite capable of dealing with any anomaly, without delay.

The tests furthermore confirmed both the quick and easy installation of ASIA and the short time needed between the start of operation and the first useful result at the sewage treatment plant discharge (by useful result it is meant the first measurements showing an increased abatement of COD and total nitrogen). It took in fact 2 days for installation and system testing and just 5 days to improve the plant performance.

✓ **ASIA provides in a short time the following results:**

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a significant reduction in energy consumption; an important increase of purification efficiency; a greater adaptability of the purification process to the variation of polluting loads; greater consistency in compliance with the exhaust limits of purified water at final discharge; an optimization of the potential of the purifier.

TRUE

The analysis of the energy consumption data recorded during the test confirms that ASIA has produced important economic benefits. In particular, it was found that:

-The overall energy consumption of the BNR & ASIA line is about 48% lower than that of the BNR CLASSIC process (see Tables 10 and 11);

-By installing ASIA on both Lines the global energy consumption of the biological section would be reduced by 41% compared to that resulting from operating the biological section on two BNR CLASSIC Lines. (see Tables 12 and 13).

In terms of efficiency, 2nd Line (BNR & ASIA) has achieved steady abatement performances of COD and total nitrogen, of respectively 84.7% and 59.1% (see Table 8). These data, when compared with the yields of the BNR CLASSIC (76.4% for COD and 39.8% for total nitrogen see Table 7), show an increase in purification yields of 11% in respect of COD and 49% in respect of nitrogen.

Therefore, thanks to the introduction of ASIA, the overall performance of the biological section of the plant increased significantly (quite in spite of the fact that one of the two lines showed no improvement at all, not being supervised by ASIA.)

Another plus point of ASIA is the standard deviation found on the reference parameters recorded at the discharge of the BNR & ASIA line:

The values of COD, ammoniacal nitrogen, nitrous nitrogen and nitric nitrogen, compared to the average values, have shown in fact an extremely small standard deviation in comparison to the one found for the BNR CLASSIC Line (See Tables 4, 5 and 6), this occurring also with variable polluting loads. (see Table 1).

This confirms the precise and constant control by ASIA of biological reactions and its adaptability to changes in pollutant concentrations.

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CONCLUSIONS

Testing the ASIA system on the wastewater treatment plant of Latisana Capoluogo has proven exhaustive and has demonstrated that ASIA can be easily and quickly added-on to various types of oxidative processes, producing significant reductions in operating costs with a minimum investment.
The application of ASIA to biological purifiers can reduce energy consumption significantly, while improving the overall performance of the plant by increasing the abatement of COD and nitrogen. It furthermore ensures greater flexibility and stability of the biological process, with excellent automatic treatment of anomalies and a continuous automatic control of the depurative efficiency.

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