Zajednica izvršitelja

Institut Ruđer Bošković

Naručitelj

HRVATSKE VODE

Krajnji korisnik

ODVODNJA POREČ

STUDIJA OCJENE I PRAĆENJA UČINKOVITOSTI PROVEDBE PROJEKTA
IZGRADNJE KANALIZACIJSKE MREŽE I ANALIZA UČINKOVITOSTI RADA UREĐAJA
ZA PROČIŠĆAVANJE OTPADNIH VODA U GRADU POREČU – STUDIJA POREČ

IZVJEŠĆE 8d

Modeliranje UPOV-a: validiranje modela – Vrsar

ožujak 2022

STUDIJA OCJENE I PRAĆENJA UČINKOVITOSTI PROVEDBE PROJEKTA IZGRADNJE KANALIZACIJSKE MREŽE I ANALIZA UČINKOVITOSTI RADA UREĐAJA ZA PROČIŠĆAVANJE OTPADNIH VODA U GRADU POREČU – **STUDIJA POREČ**

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IZVJEŠĆE 8 – dio 4/4

Modeliranje UPOV-a: validiranje modela

5. ožujka 2022

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Evaluation and efficiency monitoring of the new implemented sewage network and wastewater treatment construction in the larger city of Poreč.

Report 8.4 – Wastewater treatment model calibration and validation.

WWTP Vrsar

2022 02 28

Definitive Concept

innovative wastewater solutions

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Responsibility

Project Title	:	Evaluation and efficiency monitoring of the new implemented sewage network and wastewater treatment construction in the larger city of Poreč.
Working Title	:	Report 8.4 – Wastewater treatment model calibration and validation WWTP Vrsar.
Project Description:	:	Study of the environmental impact as the result of upgrading and operation of the wastewater system of the larger city of Poreč on coastal sea water quality. Integrated evaluation of the sewer system, wastewater treatment systems, coastal discharge, and sea water quality based on modelling tools.
Document number	:	ASM-20220228-RAP116
Status	:	Definitive Concept
Date	:	2022 02 28
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1 Sažetak izvješća

1.1 Uvod

Infrastrukturno ulaganje "Postrojenja za odvodnju i pročišćavanje otpadnih voda Grada Poreča" – Projekt Poreč, sufinanciran od strane Europske unije, jedna je od najvećih investicija u javnom sektoru u Republici Hrvatskoj. Uključuje sanaciju i proširenje postojećeg kanalizacijskog sustava te izgradnju četiri nova uređaja za pročišćavanje otpadnih voda (UPOV). Cilj je bolja zaštita okoliša u i oko porečkog priobalja. Komplementarno se razvija projekt pod nazivom „Integrirano modeliranje infrastrukturnog sustava otpadnih voda Grada Poreča" – Projekt modeliranja. Ovaj projekt je integrirana procjena utjecaja na okoliš radi boljeg razumijevanja utjecaja performansi sustava na okoliš koji se ocjenjuje u nizu radnih uvjeta. Studija scenarija je razvijena korištenjem najsuvremenijih "state-of-the-art" (modelskih) alata i metoda koje omogućuju holističku procjenu sustava otpadnih voda. Rezultati ovog istraživanja služe kao pomoć budućem poslovanju i gospodarenju otpadnim vodama u regiji te se koriste za podizanje znanja i profesionalnih vještina stručnjaka lokalnog vodnog sektora.

Projekt modeliranja sastoji se od 4 glavne komponente, i to:

• 1. dio: Modeliranje sustava prikupljanja i transporta otpadnih voda Grada Poreča,
• 2. dio: Modeliranje rada i rezultata pročišćavanja na 4 UPOV-a Grada Poreča,
• 3: dio: Model procjene utjecaja morskih ispusta na kvalitetu morske vode,
• 4. dio: Uspostava eksperimentalnog laboratorija za praćenje i optimizaciju upravljanja i rada otpadnih voda.

Uključujući trening organizira se kako bi se proširili kapaciteti stručnjaka u vodnom gospodarstvu u korištenju modeliranja sustava otpadnih voda za buduće procjene. Projekt modeliranja ima holistički sustavni pristup koji pokriva skupljanje, obradu i ispuštanje otpadnih voda u morsko okruženje, međuodnos između različitih sustava otpadnih voda i utjecaj na okoliš, javno zdravlje i kvalitetu obalne morske vode.

Nekoliko scenarija proračunato je kako bi se istražio utjecaj Projekta Poreč na prethodno navedene čimbenike te kako bi se uspostavile najbolje metode upravljanja sustavima otpadnih voda iz integrirane perspektive.

Modeliranjem se demonstrira kako nadogradnja porečkog sustava otpadnih voda poboljšava okoliš. Razvija se daljnji uvid u cjelokupnu interakciju podsustava o kvaliteti morske vode.

Kroz projekt se razvija i znanje o tome kako upravljati i optimizirati različite sustave otpadnih voda, s najboljim ukupnim rezultatima.

1.2 Sadržaj ovog izvješća

Ovo izvješće odnosi se na Projekt modeliranja 2. dio: Modeliranje rada i rada 4 UPOV Grada Poreča. Svaki UPOV se modelira i izvještava zasebno. Projekt modeliranja 2. dio razvijen je u četiri koraka, jedno izvješće po koraku za svaki pojedinačni UPOV.

- Korak 1: Statičko modeliranje UPOV na temelju detaljnog projekta. U ukupnom projektu ovo je izvješće broj 5, koje se sastoji od 4 pod-izvješća po jedno za svaki UPOV (izvješće broj 5.1 do 5.4).
- Korak 2: Dinamičko modeliranje UPOV na temelju dinamičkog mjerenja influenta tijekom zime i ljeta. U ukupnom projektu ovo je izvješće broj 6, koje se sastoji od 4 podizvješća po jedno za svaki UPOV (izvješće broj 6.1 do 6.4).
- Korak 3: Analiza operativnih scenarija UPOV. Ovo izvješće uzima rezultate prethodnih studija te je niz operativnih scenarija razvijeno i kvantificirano po opterećenjima i koncentracijama obalnog protoka (izvješće broj 7.1 do 7.4).
- Korak 4: Validacija modela na temelju operativnih mjerenja (obuhvaćeno ovim izvješćem 8.1 do 8.4). Kalibriranje i validiranje modela temeljeno je na novim mjerenjima tijekom pokretanja UPOV u rad tijekom siječnja 2022 godine. Model je validiran kroz reproduciranje novih podataka o kakvoći ulazne i pročišćene otpadne vode bez potrebe za značajnijom promjenom parametara modela.

1.3 Dosadašnji rezultati

Ovo podizvješće prikazuje process validiranja modela koji je razvijen u prethodnim koracima. Statičko kalibriranje je urađeno je sa uporabom novih podataka iz mjerenja kakvoće ulazne i pročišćene otpadne vode. Metodologija kalibriranja je shodna publiciranoj literaturi po opisu datom u izvješću broj 5 ove Studije. Princip i osnove kalibriranja dinamičkog modela date su u izvješću broj 6 ove Studije. Zaključeno je da je model zahtjevao vrlo malo promjena njegovih parametara, koji nisu kritični za rad modela i dobrano su u okviru standarnih vrijednosti datih BioWin programom. U izvješću broj 7 model je rabljen za izračun scenarija glede projektnog horizonta 2045 godine. Ovo izvješće broj 8 provjerava pretpostavke o vrijednostima parametara i validira njegovu primjenu. Kalibriranje i validiranje modela temeljeno je na novim mjerenjima tijekom pokretanja UPOV u rad tijekom siječnja 2022 godine. U poglavlju broj 3, mjereni dotok na UPOV-e je ocijenjen glede njegove primjene. U poglavlju broj 4, razmatrana je kakvoća ulazne otpadne vode (koncentracije onečišćenja u njoj) i rezultati uzorkovanja i mjerenja su pripremljeni za uporabu modela (privitak 1). Peto poglavlje daje prikaz masenog opterećenja otpadnih voda (privitak 2). Poglavkje broj 6 razmatra karakterizaciju influenta (privitak 3). Poglavlje 7 prikazuje rezultate kalibriranja i validiranja modela (privitak 4 i privitak 5). Mjereni podaci o efluentu iz 2022 godine su poređeni s rezultatima kalibriranog modela. Model je ocijenjen zadovoljavajućim kad su dobijeni rezultati glede kakvoće efluenta ponovljeni bez značajne promjene stoihiometrijskih parametara modela. U sva 4 slučaja u ovoj Studiji, fino kalibriranje nekoliko parametara je bilo neophodno da bi se dobili zadovoljavajući rezultati za određene uvjete rada UPOV. Na primjer, uvjete mješanja ili kontrola aeriranja je trebalo podesiti u procesu validiranja. To je zahtjevalo i blagu promijenu nekih kinetičkih parametara u modelu, ali sve u očekivanim rasponima standardnih vrijednosti datih BioWin programom.

1.4 Opći zaključci

- Model je uspješno provjeren koristeći neovisan paket podataka i svi su rezultati provjereni i potvrđeni bez značajnije promjene parametara u modelu.
- Model je ocijenjen kao postojan i spreman za primjenu za ocjenu scenarija.
- Gornji zaključci su primjenjivi na sve prikazane rezultate u prethodnim koracima modeliranja (izvješće broj 6 i izvješće broj 7).

1.5 Glavna preporuka

Preporuča se nastaviti s daljnjim razvojem studije scenarija i modeliranja morske vode uzimajući u obzir prikazane rezultate i zaključke.

1 Management summary

1.1 General project introduction

The infrastructural investment “Sewerage and Wastewater Treatment Plants of City of Poreč”– Project Poreč, co-funded by European Union, is one of the largest investments in the public sector in Republic of Croatia. It involves rehabilitation and extension of the existing sewerage system and construction of four new wastewater treatment plants (WWTPs). The goal is to better protect the environment in and around the Poreč coastal area. Complementary a project is developed titled “Integrated Modelling of Wastewater Infrastructure System of City of Poreč” – Modelling Project. This project is an integrated environmental assessment to obtain a better understanding of the environmental impact of the system performance which is evaluated under range of operational conditions. A scenario study is developed using state-of-the-art (modelling) tools and methods which allows a holistic assessment of the wastewater system. The results of this study are in assistance of future operations and wastewater management in the region and used to elevate knowledge and professional skills of local water sector professionals.

The Modelling Project consists of 4 main components, namely:

- Part 1: Modelling the sewage collecting and transport system of City of Poreč,
- Part 2: Modelling of operation and performance of 4 WWTPs of City of Poreč,
- Part 3: Model assessment impact offshore outlets on aquatic water quality,
- Part 4: Establishment of the experimental laboratory setup for monitoring and optimization of wastewater management and operation.

Including a training is organized to extend the capacity of water professionals in the use of wastewater modelling for future assessments.

The Modelling project has a holistic system approach covering collection, processing, and aquatic discharge of wastewater, the interrelation between the different wastewater systems and impact on the environment, public health, and coastal seawater quality.

Several scenarios are calculated to explore the impact of Project Poreč on the previous mentioned factors and to and establish the best methods for management of the wastewater systems from an integrated perspective.

Modelling is used to demonstrate how upgrade of the Poreč wastewater system improves the environment. Further insight is developed in the overall interaction of the sub-systems on seawater quality. Knowledge is developed on how to operate and optimize the different wastewater systems, with the best overall results.

1.2 Project goals

The overall objective of the Poreč modelling project is to demonstrate how upgrading the total wastewater system improves the sea water quality in the Poreč costal region. Therefore, the total wastewater system is modelled consisting of several sub-systems. By modelling the WWTP under different (extreme) conditions it is investigated how effluent discharge load and quality will affect the sea water quality. For each studied scenario, effluent concentration and flow profiles are calculated. These data are subsequently used as input for sea water quality modelling from which the environmental impact is calculated.

1.3 Context of this report

This report belongs to the reports in the series "modelling project part 2: Modelling of operation and performance of 4 WWTPs of City of Poreč". Each WWTP is modelled and reported in a series of 4 documents of which this is the final. For accessibility the reports are set up using identical format and methods. Modelling project Part 2 is developed in four steps:

- Step 1: Static WWTP modeling using detailed design data. In the total project this is report number 5 consisting of 4 sub-reports, one for each WWTP (report number 5.1 to 5.4).
- Step 2: Dynamic WWTP modeling based on dynamic winter and summer influent measurements (data 2019). In the total project this is report number 6, consisting of 4 sub-reports, one for each WWTP (report number 6.1 to 6.4).
- Step 3: Analysis of operational WWTP scenarios up to the year 2045. In this step a series of operational scenarios are developed, and the potential coastal discharge loads and concentrations are quantified based on extrapolation simulations. In the total project this is report number 7, consisting of 4 sub-reports, one for each WWTP (report number 7.1 to 7.4).
- Step 4 (this report series): Model calibration and validation based on new operational measurements done in 2022. The model validity is tested by reproducing a new influent and effluent data set without the need of significant model adjustments. In the total project this is report number 8, consisting of 4 sub-reports one for each WWTP (report number 8.1 to 8.4).

1.4 Background and previous investigations

This research is part of an integrated environmental assessment of the wastewater transport, collecting and treatment system including the coastal recipient. The goal of this research is to obtain a better understanding of the environmental impact of modernization of the City of Poreč wastewater system and its performance. This report is part of a series studying the operation of 4 wastewater treatment plants of the larger City of Poreč. Models of the wastewater treatment are developed from detailed design information and influent flow and concentration data are measured in the summer and winter of 2019 and winter of 2022. In previous reports (numbered report 5, 6 and 7) model evaluations have been performed simulating a range of operational conditions and future scenarios. In report number 5 the average performance is evaluated using a static model. In report number 6 models are further developed to test and evaluate operation under realistic dynamic conditions. In report number 7 models are projected towards winter and summer conditions in 2045 including a dynamic scenario with peak loading and rain event. Based on the simulations results, the impact of the upgraded wastewater facilities on the costal seawater quality is assessed. In this report the validity of the previously developed models is further investigated by calibrating the model using a new dataset measured in 2022, including operational performance data. It is tested if the previously developed dynamic model can reproduce measured effluent quality without having to alter critical model parameters. The study adds to the overall validity of the previously performed model calculations and scenario projections.

1.5 Reader

This report presents the validation of the previously developed model. Therefore, a static calibration is performed using a new 2022 operational dataset with influent and effluent measurements. The calibration methodology is according to published literature and explained in report 5 of this series. The setup and calibration of the dynamic model is explained in report 6. It was concluded that the model required little parameter adjustments, all not critical and well within the advised settings (default BioWin). In report 7 the model is used for scenario calculations towards the year 2045. This report tests the assumptions for the parameter settings and validates its application. The model settings are validated by calibrating the model using a new operational dataset with influent and effluent data measured in the winter of 2022. In chapter 3 the 2022 measured flow data is evaluated and presented for model application. In chapter 4 the influent quality sampling (concentrations) is discussed, and measurement results are presented and prepared for model application (appendix 1). Chapter 5 presents the influent (mass) loading profiles (appendix 2). Chapter 6 discusses the influent characterization results (appendix 3). Chapter 7 presents the model calibration and validation (appendix 4 and 5). Measured 2022 effluent results are compared with results of the calibrated model. The model is determined to be valid when effluent values are reproduced without significant adjustment of (stoichiometric) parameters. For all model studies some finetuning is necessary to reproduce specific operational conditions. For example, mixing conditions or aeration controller settings. Therefore, some kinetic parameters are adjusted within a typical range.

1.6 General conclusions

- The model is tested successfully on an independent data set and reproduced all data without significant adjustments.
- The model is tested reliable and validated for use for operational and scenario evaluation.
- The above conclusions apply to all presented results, under which previous WWTP modelling reports published in this series, which have used the validated model.

1.7 Recommendations

It is recommended to proceed with final development of the scenario analysis and sea water modelling taking in account the presented conclusions.

2 Introduction

2.1 Context of this report

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3 Influent flow measurements

3.1 Introduction and methods

The influent flow is measured for 24-hours (1 day) with measurement points produced every 2 hours based on a collected flow sample for all 4 treatment locations. The measurement period for WWTP Poreč-South and WWRP Vrsar starts Monday 17-01-2022 at 9:00 and for WWTP Poreč-North and WWRP Lanterna starts Tuesday 18-01-2022 at 9:00. The measurement day was with dry weather. There are no missing datapoints and the measured did not require data to be reconstructed. From the measured flow profile an hourly average flow is calculated for each hour of the day. The profile is used as an input for dynamic modeling.

3.2 Winter influent flow measurement results

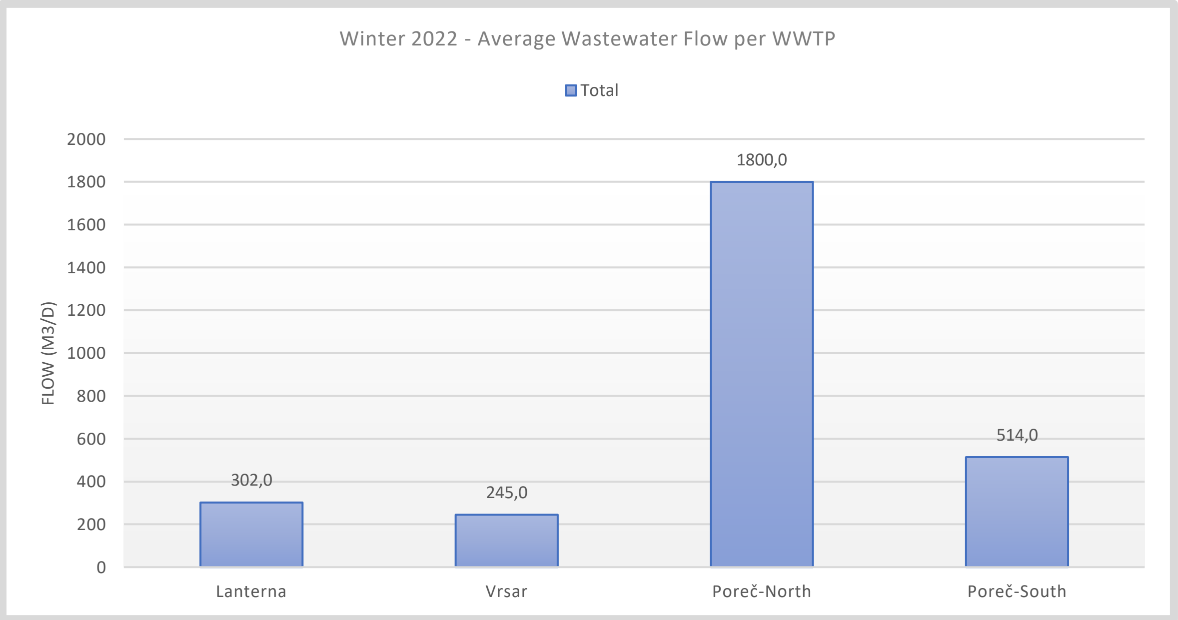


Figure 1. Winter 2022 - Average Dry Weather Wastewater Flow per WWTP.

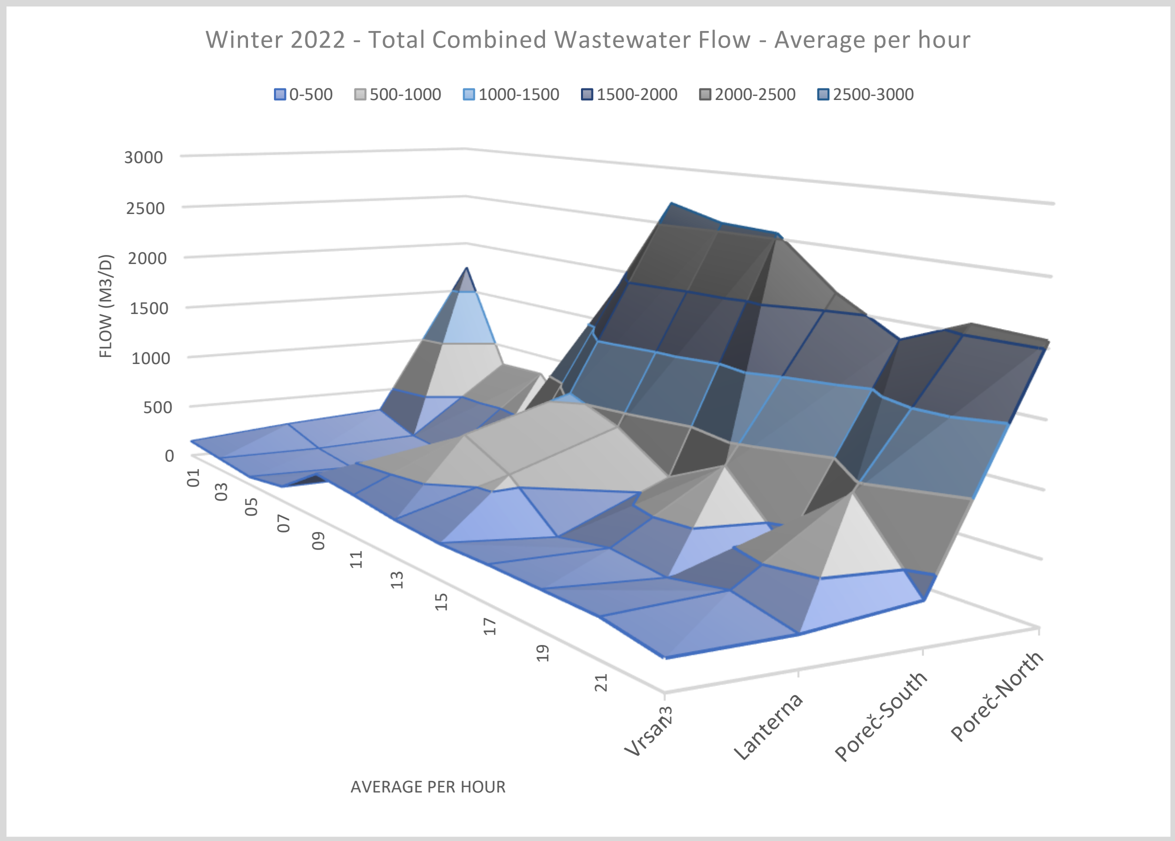
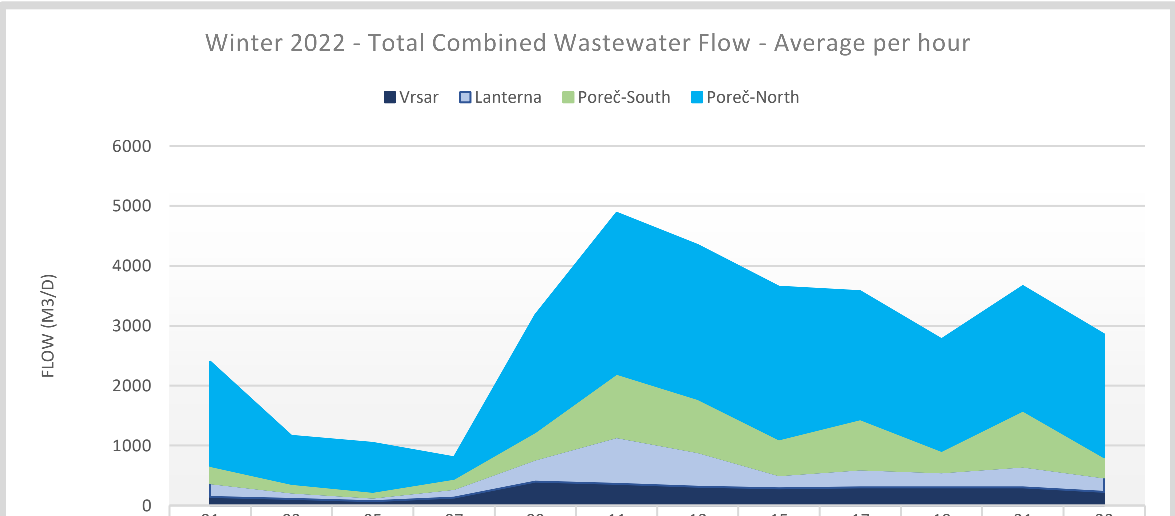


Figure 2. Winter 2022 - Surface plot of the total combined wastewater flow. The order of WWTP's is from lowest to highest wastewater producing community.



	01	03	05	07	09	11	13	15	17	19	21	23
Poreč-North	1740,0	804,0	816,0	360,0	1956,0	2688,0	2568,0	2544,0	2136,0	1860,0	2076,0	2052,0
Poreč-South	288,0	144,0	96,0	168,0	456,0	1056,0	888,0	600,0	840,0	360,0	936,0	336,0
Lanterna	228,0	108,0	60,0	144,0	372,0	780,0	576,0	216,0	300,0	252,0	348,0	240,0
Vrsar	144,0	108,0	72,0	132,0	396,0	360,0	312,0	288,0	300,0	300,0	300,0	228,0

Figure 3. Winter 2022 - Total (sum of WWTP's) of the wastewater flow per hour.

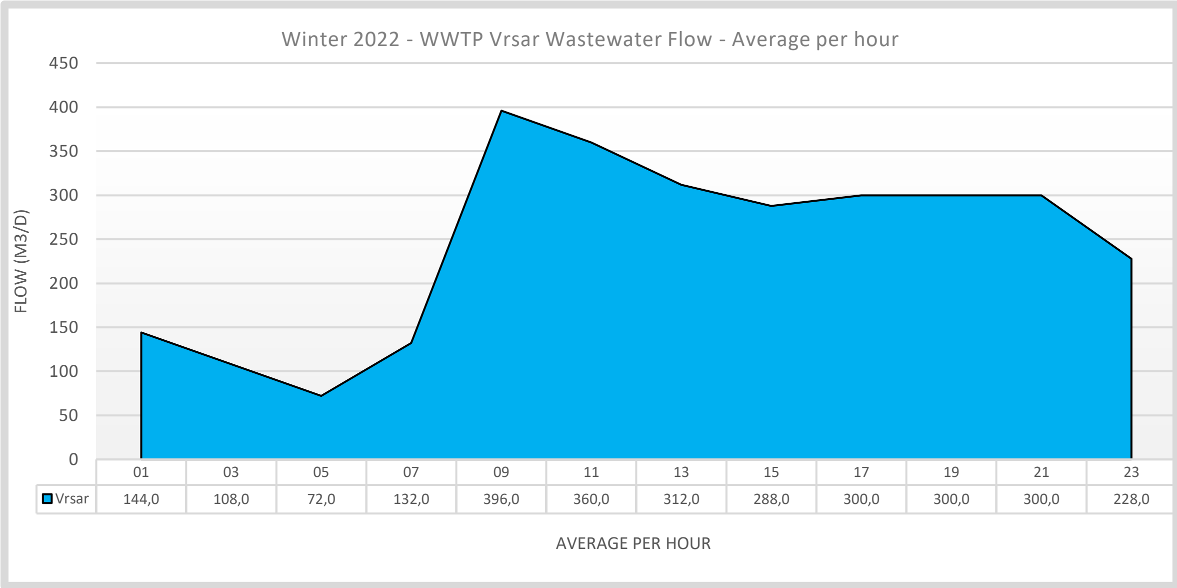


Figure 4. Winter 2022 - WWTP Vrsar Dry Weather Wastewater Flow 24-hour average hourly measurements.

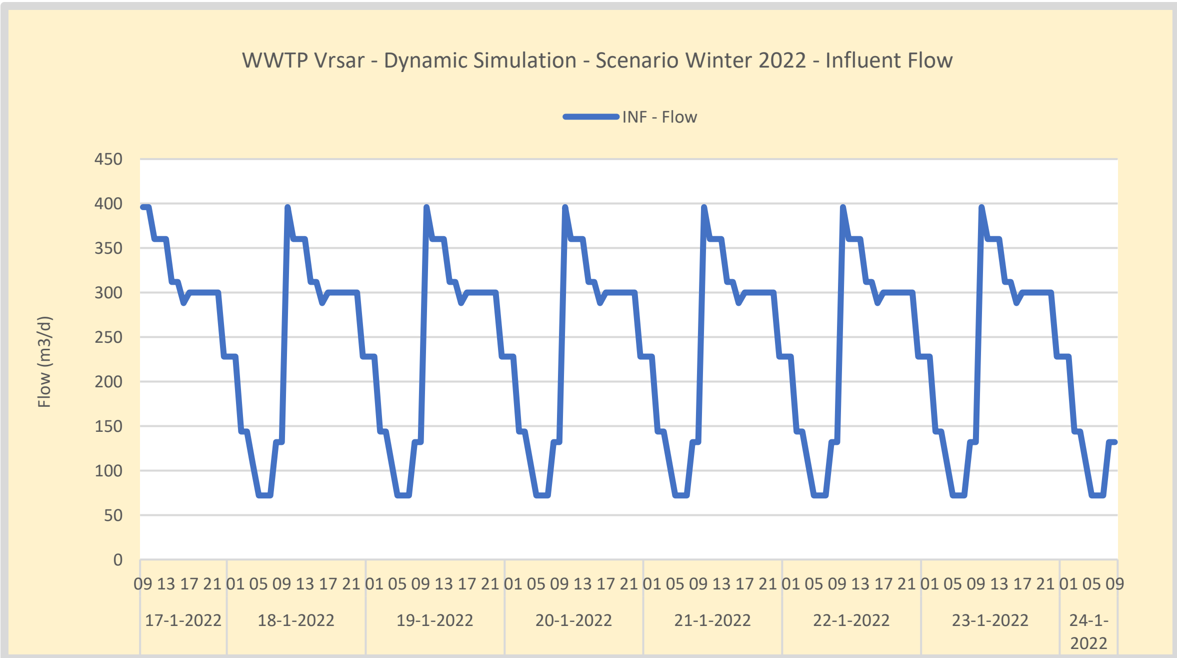


Figure 5. Winter 2022 - BioWin modelling WWTP Vrsar: Wastewater Flow measured 24-hours and repeated for 7-days used for dynamic model input. The data is interpolated in the model on an hourly basis.

3.3 Conclusions flow measurements

Influent dry weather flow data measured in the winter of 2019 and 2022 are comparable. There is similarity in the minimum and maximum flow data as well as the flow distribution pattern over the day on an hourly basis. The profile is used in the calibration study to validate the model performance.

4 Influent quality sampling

4.1 Sampling method

Raw sewage wastewater is sampled at 4 WWTP locations; WWTP Poreč-North, WWTP Poreč-South, WWRP Vrsar and WWTP Lanterna. Continuous 24-hour automated samplers are used for a continued period of 24 hours. Per WWTP approximately 180 samples are collected and analyzed. Some by on-line measurement. The measurement period for WWTP Poreč-South and WWRP Vrsar starts Monday 17-01-2022 at 9:00 and for WWTP Poreč-North and WWTP Lanterna starts Tuesday 18-01-2022 at 9:00. During the measurement period there was absence of rain.

The type of wastewater sampler used is Hach AS950 Portable Sampler and WaterSam Ports. Samples are taken every 9-30 minutes (flow proportional) in bottles of volume 550–800 mL which are rotated automatically every 2 hours, for 24 h (total of 12 vessels collected per 24 hours for each sampling location). After a day of operation, samples are taken to the laboratory for analysis (Zagreb Laboratory for Water Technology at the Faculty of Food Technology and Biotechnology). Samplers are thermally insulated and refrigerated to preserve the samples and reduce occurring reactions.

Table 1. Parameters measured in wastewater.

Parameters determined in the wastewater of the city of Poreč.				
Code	Parameter	2h/24h composite	Filtered / Total	Chemical analysis method
TCOD	Total Chemical Oxygen Demand	2 hour composite	Total sample	ISO 6060-1989
CODMF	Chemical Oxygen Demand in filtrate (1.2 µm)	2 hour composite	Micro filtered	ISO 6060-1989
TN	Total nitrogen	2 hour composite	Total sample	EN ISO 11905-1 decomposition s peroxodisulfate
PO4	Orthophosphate	2 hour composite		DIN EN ISO 6878
NH4	Ammonia	2 hour composite		ISO 7150-1
TSS	Total suspended solids	2 hour composite	Total sample	Filtered, dried, weight
VSS	Volatile suspended solids (organic)	2 hour composite		Total solids minus inorganic fraction
ISS	Inorganic suspended solids	2 hour composite		Filtered, dried, weight, incinerated at 500 C, weight
pH	pH	2 hour composite		
EC	Electrical conductivity	2 hour composite		
BOD	Biological Oxygen demand over 5 days	24 hour composite	Total sample	Test run over 5 days
BODMF	Biological Oxygen demand over 5 days in filtrate (1.2 µm)	24 hour composite	Micro filtered	Test run over 5 days
TP	Total phosphorus	24 hour composite	Total sample	EN ISO 6878
NO3	Nitrate	24 hour composite		ISO 7890-1-2-1986
NO2	Nitrite	24 hour composite		EN ISO 26777

4.2 Measurement adjustments in the raw data

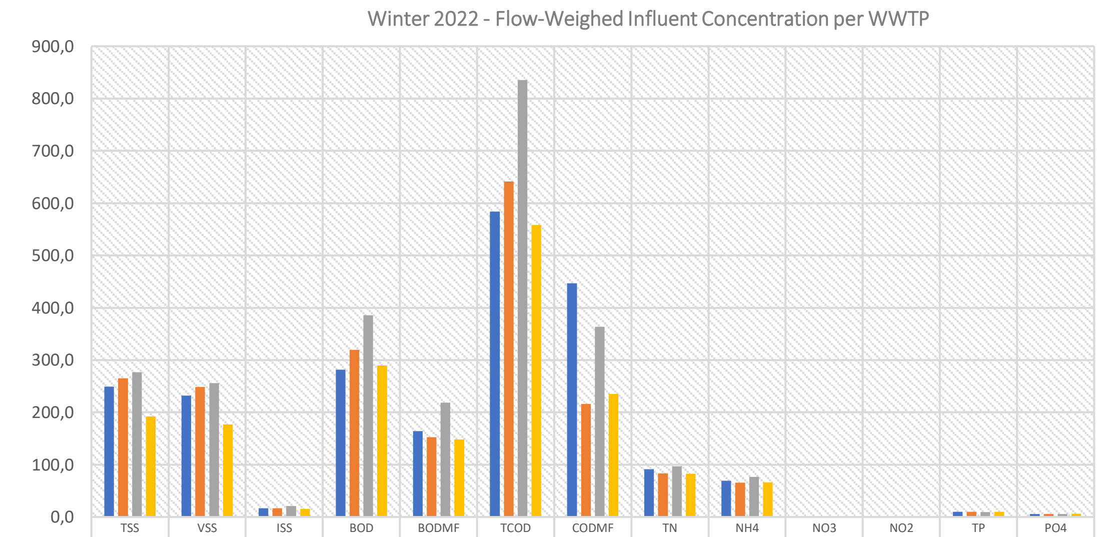
For the influent data some datapoints are corrected.

- TKN measurement 17-01-2022 at 23:00 hour is much too low also related to the measurements of NH4. Therefore, TKN is corrected to fit the average measured TKN/NH4 fraction.

- ISS measurements measured at 17:00, 19:00 17-01-2022 and 3:00 hours 18-01-2022 are much too low and not possible in relation to the measured TSS. These values are corrected to a more realistic TSS/ISS fraction.

4.3 Calculation method for the average influent concentration

For each 2-hour composite sample the flow volume is measured and concentration measured of all parameters in table 1. From these data every 2 hours the influent loads are calculated for each parameter. From the load profile the flow proportional (weighed) influent concentrations are calculated. Only weighed concentration are used in the model calculations. The results are presented in the following graphs.



	TSS (mgTSS/L) - Flow Proportional	VSS (mgVSS/L) - Flow Proportional	ISS (mgISS/L) - Flow Proportional	BOD (mgBOD/L) - Flow proportional	BODMF (mgBOD/L) - Flow proportional	TCOD (mgCOD/L) - Flow Proportional	CODMF (mgCOD/L) - Flow Proportional	TN (mgN/L) - Flow Proportional	NH4 (mgN/L) - Flow Proportional	NO3 (mgN/L) - Flow Proportional	NO2 (mgN/L) - Flow Proportional	TP (mgP/L) - Flow Proportional	PO4 (mgP/L) - Flow Proportional
Lanterna	249,0	232,2	16,8	281,8	163,9	583,9	446,5	91,4	69,3	0,5	0,0	10,2	5,5
Vrsar	265,2	248,8	16,4	319,8	152,6	641,3	216,0	83,5	65,5	0,4	0,2	9,9	5,6
Poreč-North	276,8	255,6	21,2	385,4	218,3	835,7	363,8	96,7	76,6	0,5	0,0	9,4	5,4
Poreč-South	192,2	176,8	15,3	289,7	148,5	558,1	235,2	82,7	66,1	0,3	0,1	9,9	6,0

Figure 6. Winter 2022 - Flow-weighted average influent concentrations per WWTP.

4.4 Influent concentration profiles

The concentration of wastewater varies over time due to all kind of disturbances but most important population behavior. Human regular activity results in a distinctive measurement profile. For each measured parameter daily profiles are calculated and presented in the figures below. Measured concentration peaks are related to the sewage flow. High flow results in short sewer residence time and high concentration peaks early in the day while low flow results in lower peaks occurring later in the day. Transport of particulate material is very much dependent on the flow velocity in the sewer system. During the winter low flow season, it takes longer before particulate material arrives at the WWTP. This material settles overnight in the sewer and is collected in the morning when the flow increases. Ammonia and orthophosphate peaks in the morning as the result of human source urine. The time on which peaks are measured at the WWTP starting from 6 hours in the morning, indicates the residence time in the sewar system. This effect is observed from the data in the figures below.

4.5 COD Influent concentration - Winter 2022

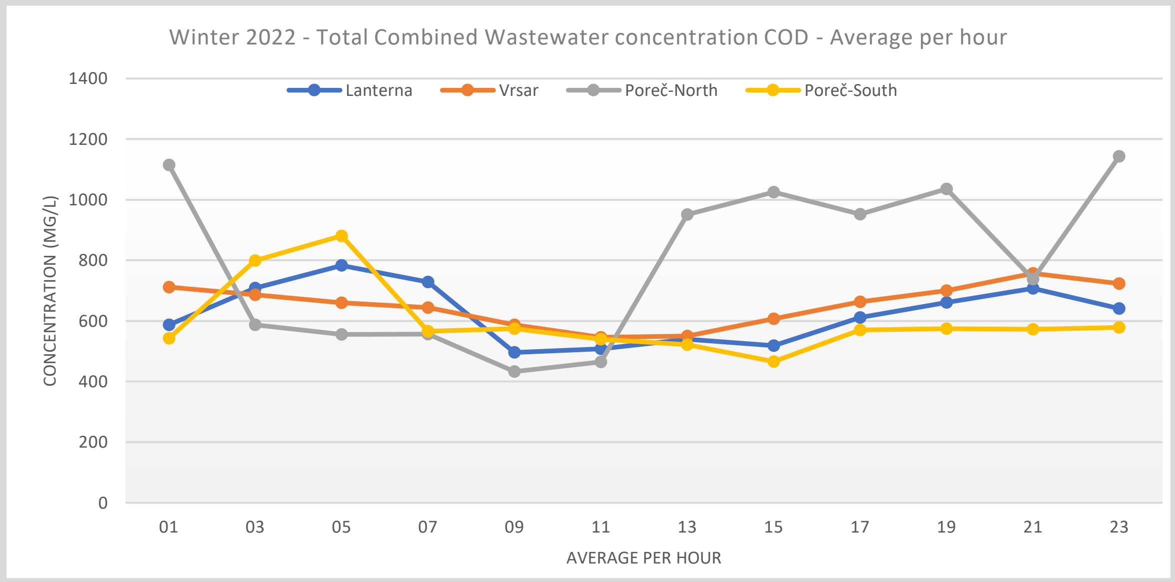
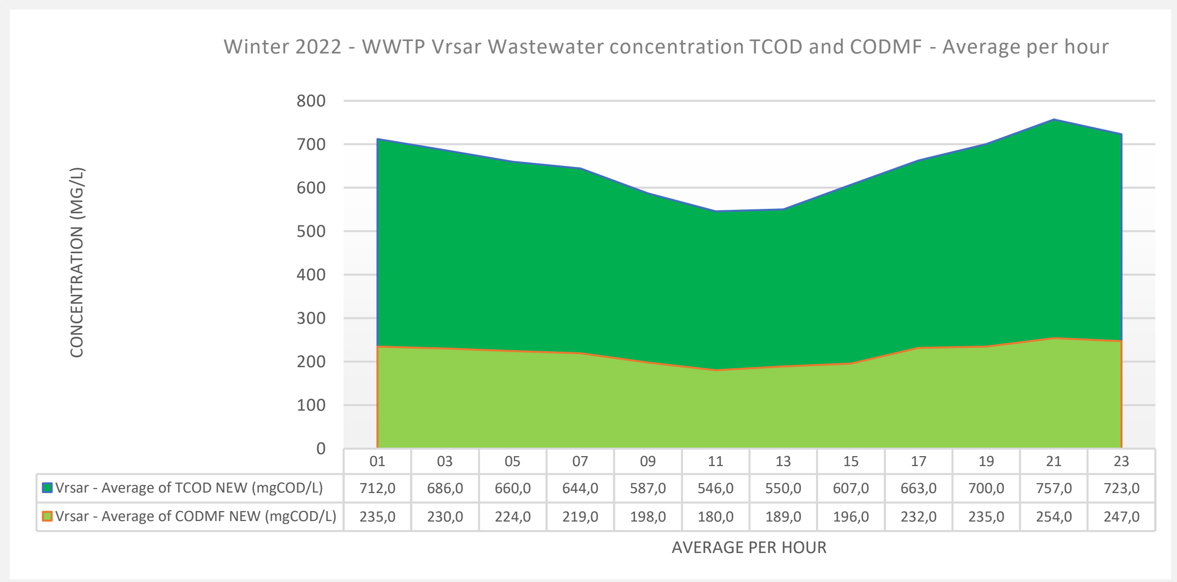


Figure 7. Winter 2022 - 24-hour COD Influent Concentration profile per WWTP.



	01	03	05	07	09	11	13	15	17	19	21	23
Vrsar - Average of TCOD NEW (mgCOD/L)	712,0	686,0	660,0	644,0	587,0	546,0	550,0	607,0	663,0	700,0	757,0	723,0
Vrsar - Average of CODMF NEW (mgCOD/L)	235,0	230,0	224,0	219,0	198,0	180,0	189,0	196,0	232,0	235,0	254,0	247,0

Figure 8. Winter 2022 - WWTP Vrsar 24-hour average COD and COD micro-filtered influent Concentration.

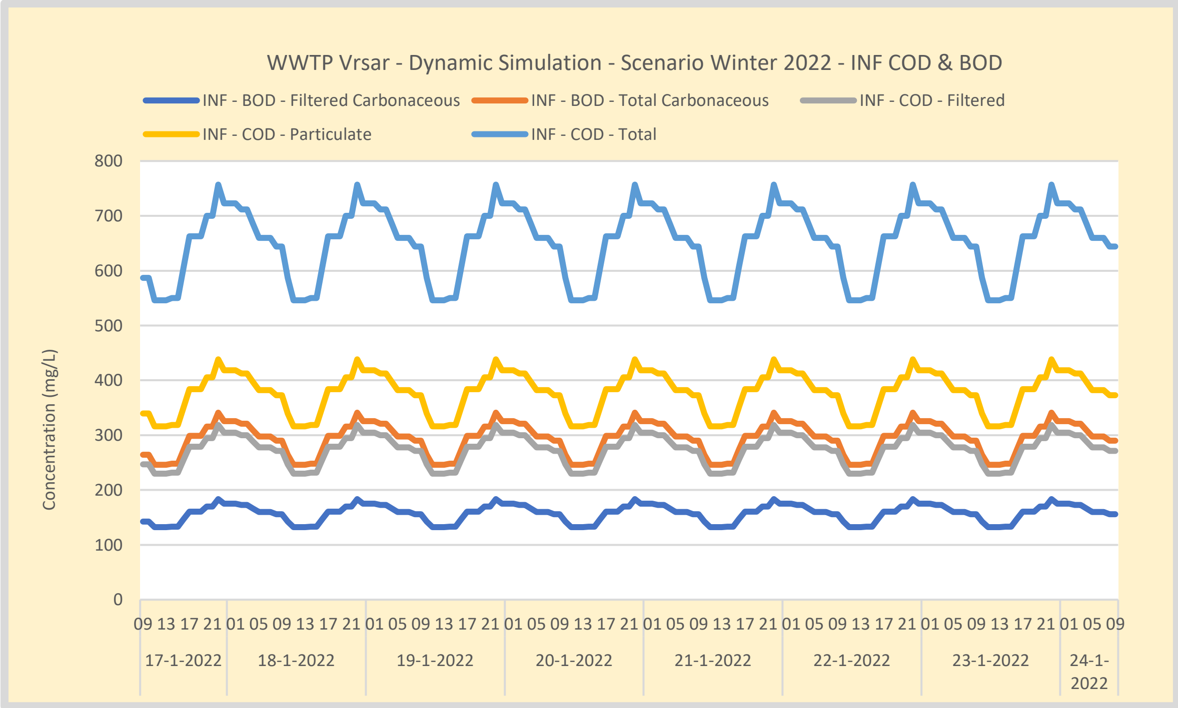


Figure 9. Dynamic Simulation – WWTP Vrsar – Winter 24-hour average COD, COD micro-filtered, COD particulate, BOD and BOD filtered influent concentration. One day of measurement is repeated for 7 days in the dynamic simulation. The model input is the measured total COD concentration. Other fractions are calculated from the influent specification.

4.6 Nitrogen influent concentration – Winter 2022

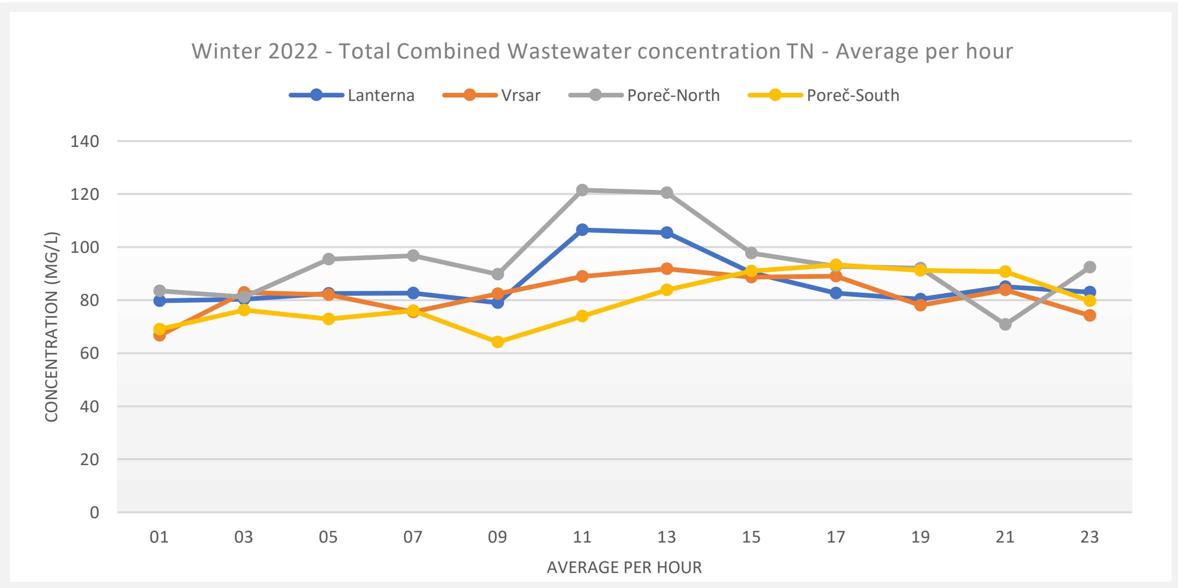
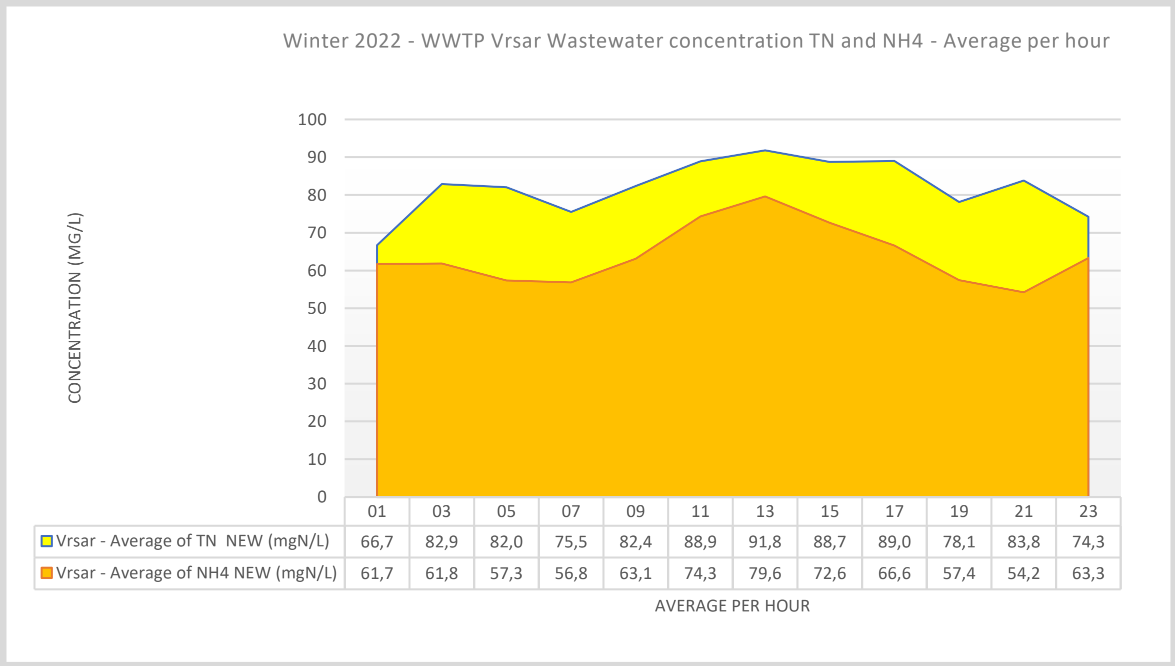


Figure 10. Winter 2022 - 24-hour TN Influent Concentration profile per WWTP.



	01	03	05	07	09	11	13	15	17	19	21	23
Vrsar - Average of TN NEW (mgN/L)	66,7	82,9	82,0	75,5	82,4	88,9	91,8	88,7	89,0	78,1	83,8	74,3
Vrsar - Average of NH4 NEW (mgN/L)	61,7	61,8	57,3	56,8	63,1	74,3	79,6	72,6	66,6	57,4	54,2	63,3

Figure 11. Winter 2022 - WWTP Vrsar 24-hour average TN and NH4 influent Concentration.

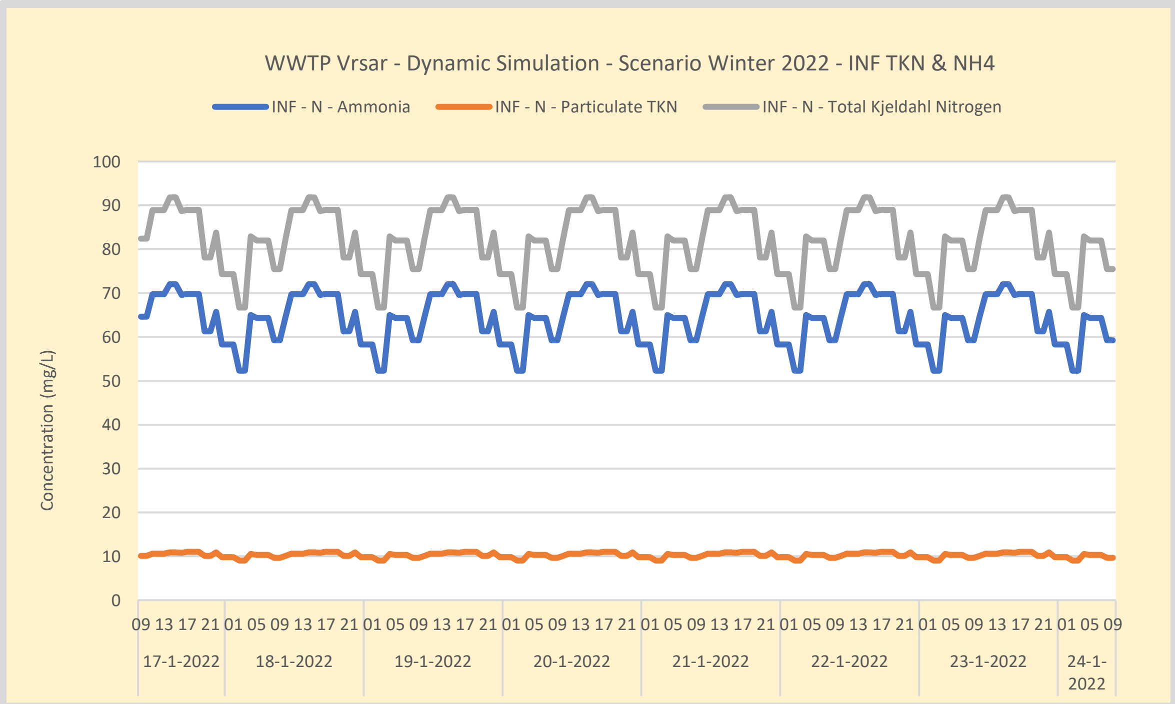


Figure 12. Dynamic Simulation – WWTP Vrsar – Winter 24-hour average TKN, NH4 and particulate TKN influent concentration. One day of measurement is repeated for 7 days in the dynamic simulation. The model input is the measured TKN concentration. The other fractions are determined from the influent specification.

4.7 Phosphorus influent concentration – Winter 2022

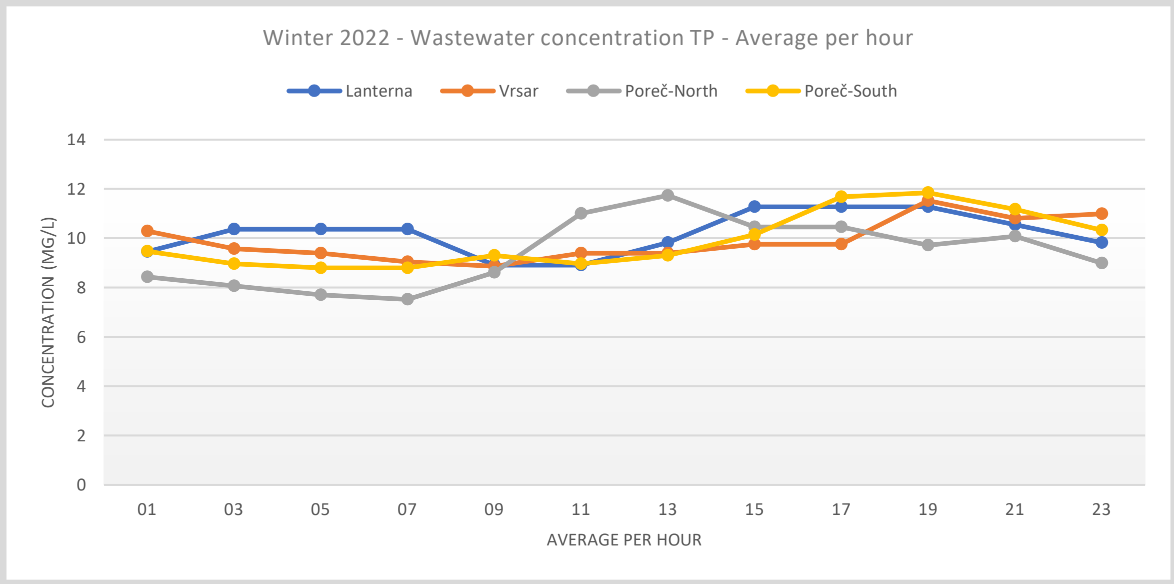
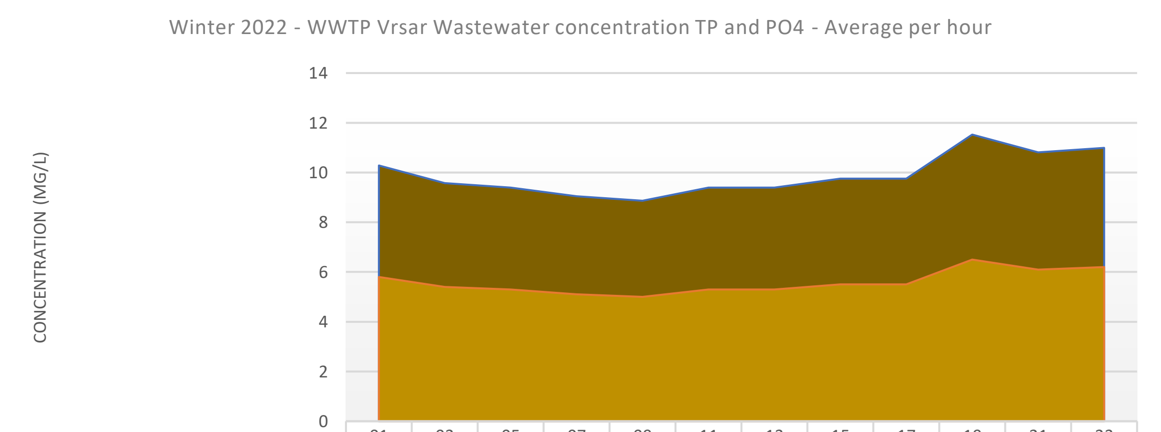


Figure 13. Winter 2022 - 24-hour TP influent concentration profile per WWTP.



	01	03	05	07	09	11	13	15	17	19	21	23
Vrsar - Average of TP NEW2 (mgN/L)	10,3	9,6	9,4	9,0	8,9	9,4	9,4	9,8	9,8	11,5	10,8	11,0
Vrsar - Average of PO4 NEW (mgP/L)	5,8	5,4	5,3	5,1	5,0	5,3	5,3	5,5	5,5	6,5	6,1	6,2

AVERAGE PER HOUR

Figure 14. Winter 2022 - WWTP Vrsar 24-hour average TP and PO4 influent concentration.

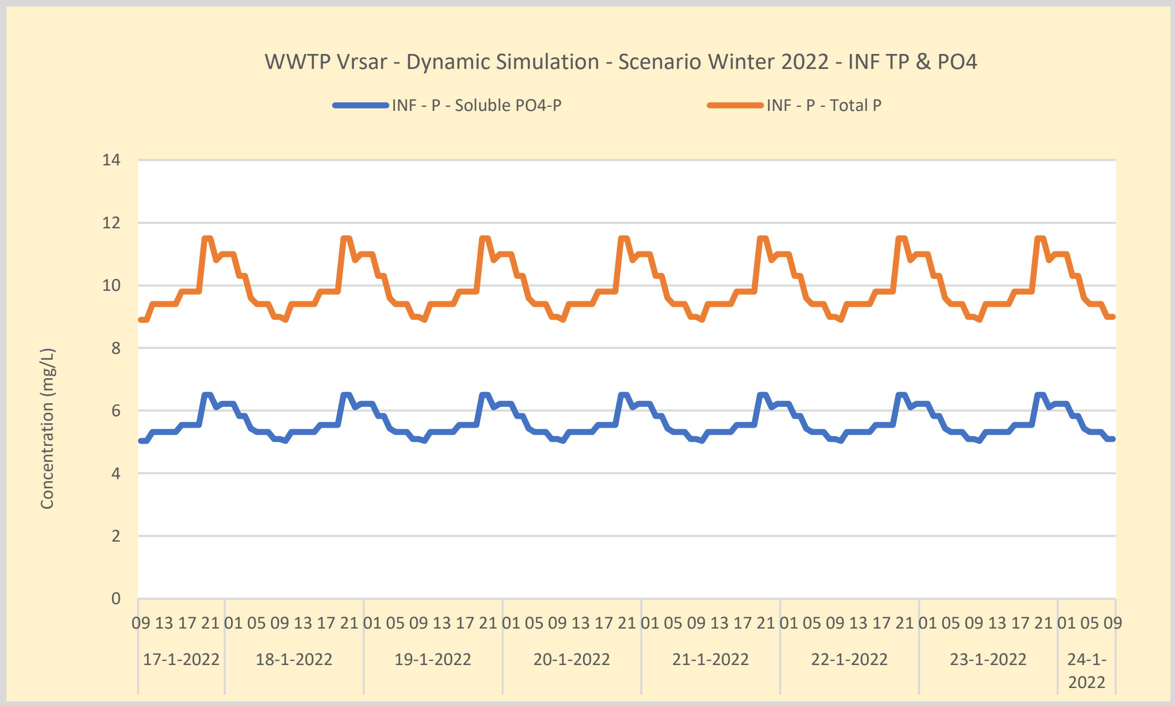


Figure 15. Dynamic Simulation – WWTP Vrsar – Winter 24-hour average TP and PO4 influent Concentration. The model input is the measured TP concentration. One day of measurement is repeated for 7 days in the dynamic simulation. PO4 is determined from the influent specification.

4.8 Total Suspended Solids influent concentration – Winter 2022

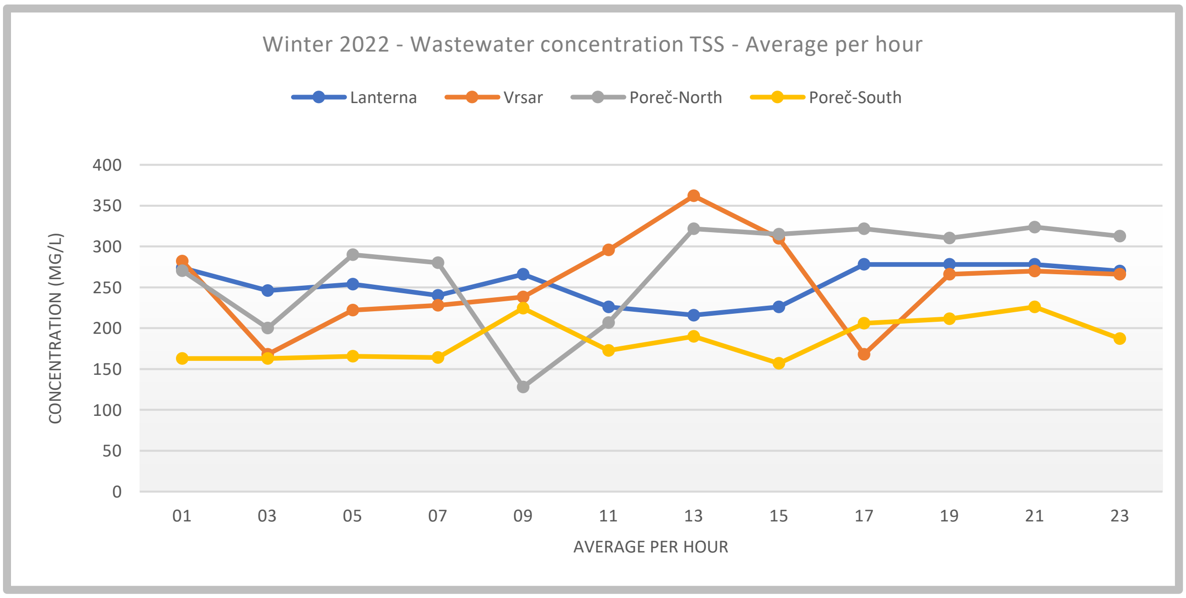
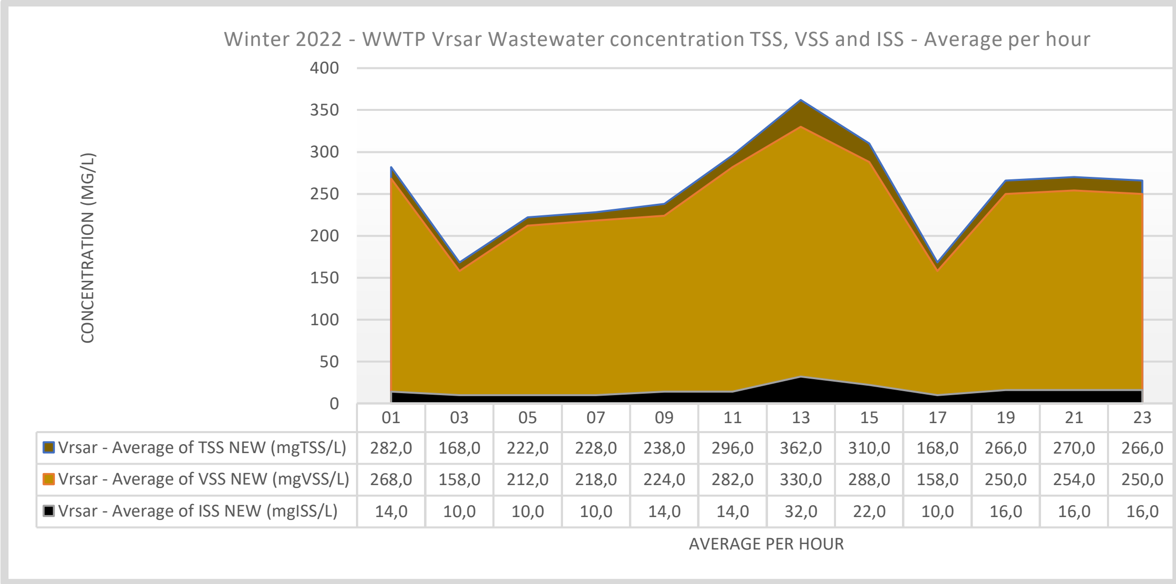


Figure 16. Winter 2022 - 24-hour TSS influent concentration profile per WWTP.



	01	03	05	07	09	11	13	15	17	19	21	23
Vrsar - Average of TSS NEW (mgTSS/L)	282,0	168,0	222,0	228,0	238,0	296,0	362,0	310,0	168,0	266,0	270,0	266,0
Vrsar - Average of VSS NEW (mgVSS/L)	268,0	158,0	212,0	218,0	224,0	282,0	330,0	288,0	158,0	250,0	254,0	250,0
Vrsar - Average of ISS NEW (mgISS/L)	14,0	10,0	10,0	10,0	14,0	14,0	32,0	22,0	10,0	16,0	16,0	16,0

Figure 17. Winter 2022 - WWTP Vrsar 24-hour average TSS, VSS and ISS influent concentration.

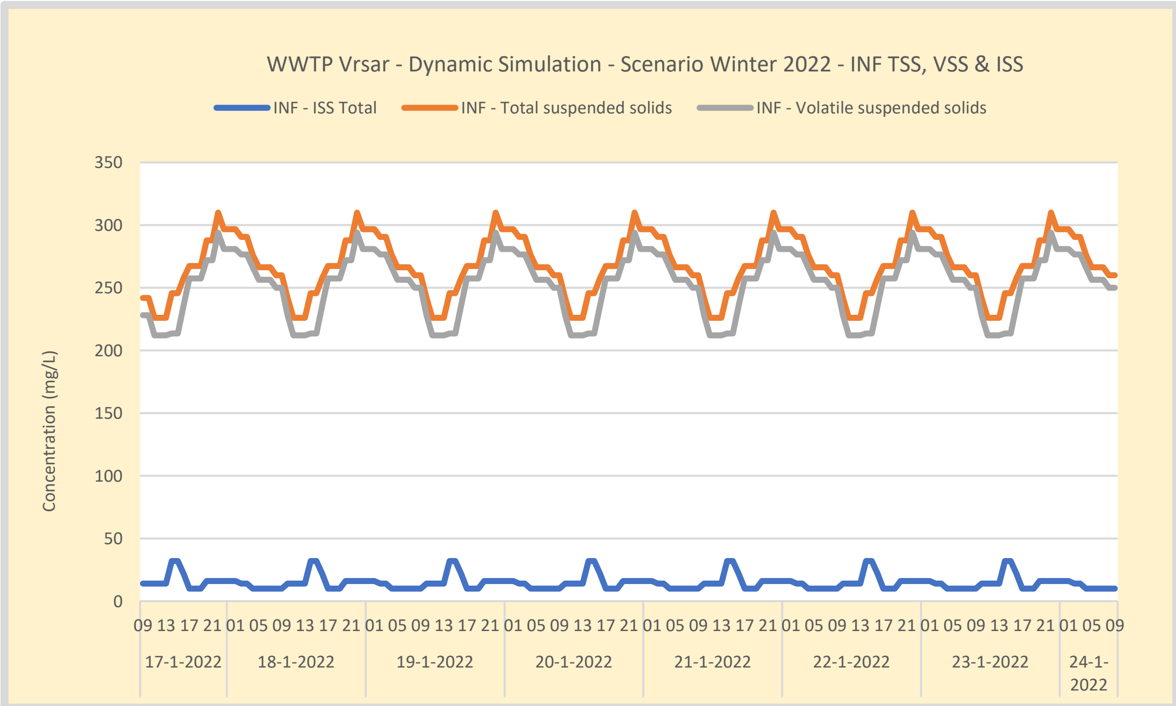
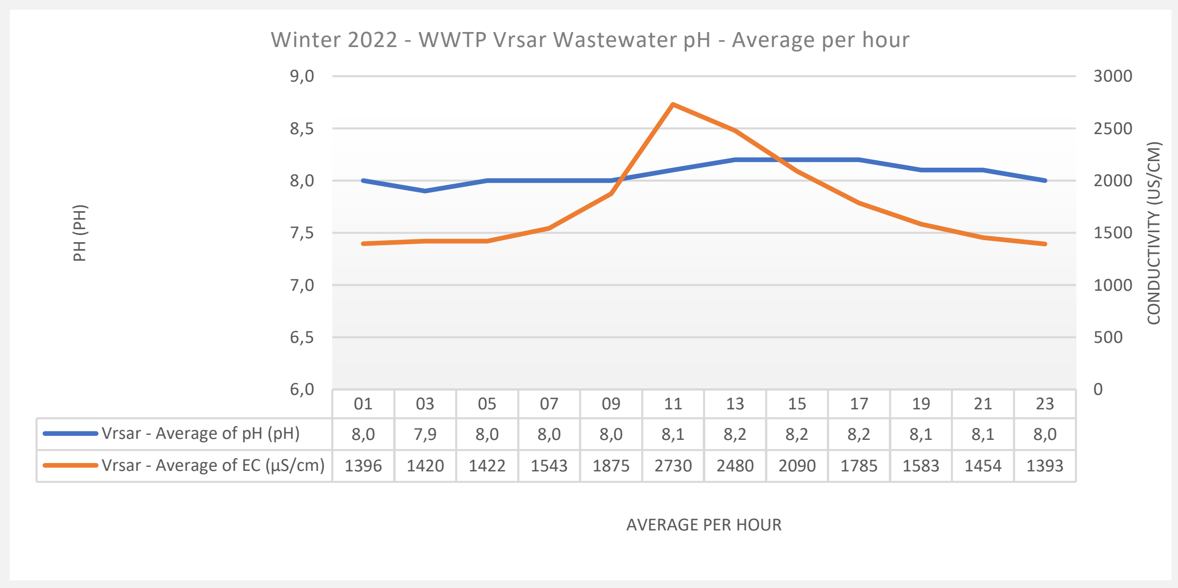


Figure 18. Dynamic Simulation – WWTP Vrsar – Winter 24-hour average TSS, VSS (organic particulate) and ISS (inorganic particulate) influent concentration. One day of measurement is repeated for 7 days in the dynamic simulation. The model input is the measured ISS concentration. VSS is calculated based on (constant) fractions determined in the influent specification. TSS is modelled as the sum of ISS and VSS.

4.9 pH influent measurements - Winter 2022



	01	03	05	07	09	11	13	15	17	19	21	23
Vrsar - Average of pH (pH)	8,0	7,9	8,0	8,0	8,0	8,1	8,2	8,2	8,2	8,1	8,1	8,0
Vrsar - Average of EC (µS/cm)	1396	1420	1422	1543	1875	2730	2480	2090	1785	1583	1454	1393

Figure 19. Winter 2022 - WWTP Vrsar 24-hour average pH influent measurement.

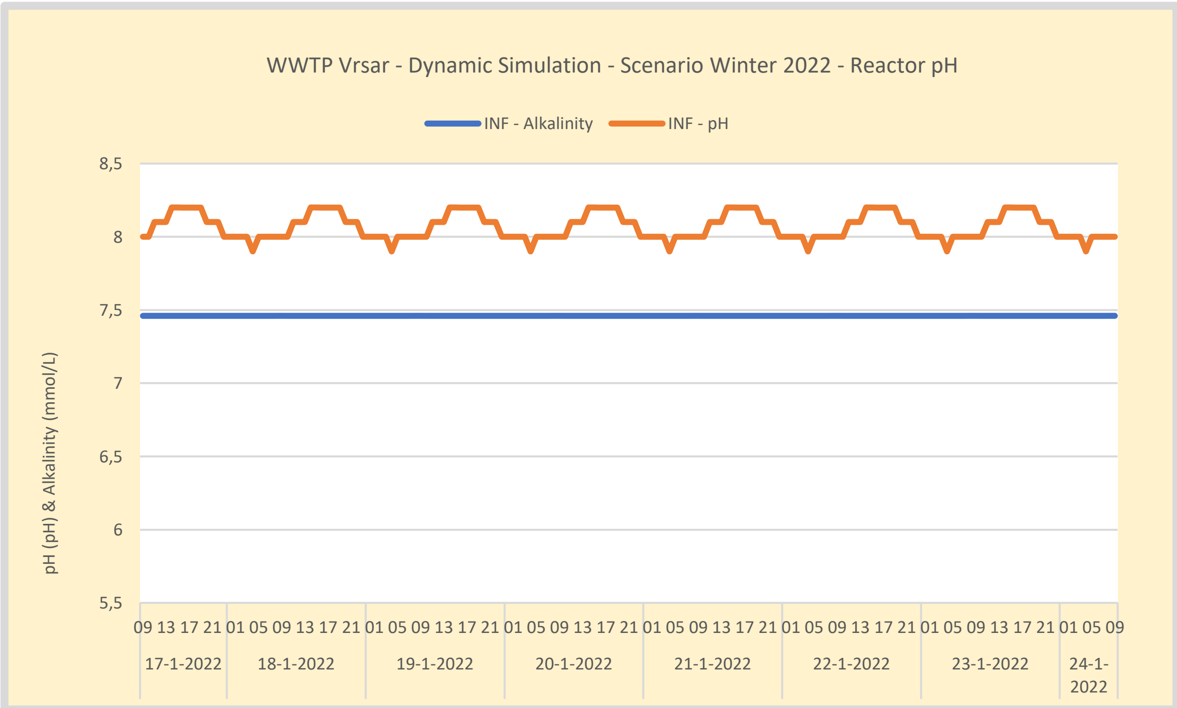
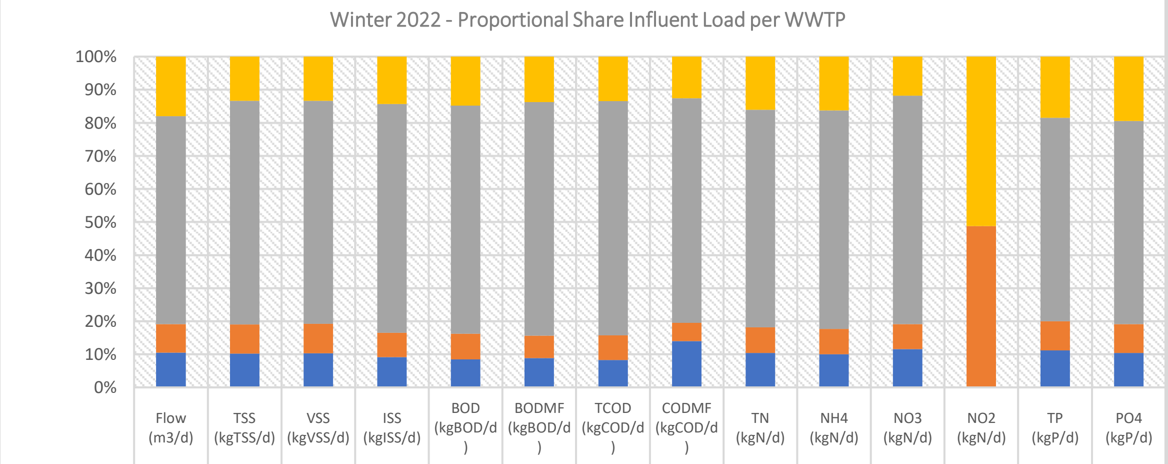


Figure 20. Dynamic Simulation – WWTP Vrsar – Winter 24-hour average influent pH measurement. pH is a dynamic model input. The alkalinity of wastewater is estimated as a constant obtained from Poreč drinking water quality.

5 Influent loading profiles

5.1 Average influent loads

Daily average influent loads are presented in the graph below. The scale (0-100%) represents the total influent (total Poreč area) and the relative influent fractions treated by each WWTP.



	Flow (m3/d)	TSS (kgTSS/d)	VSS (kgVSS/d)	ISS (kgISS/d)	BOD (kgBOD/d)	BODMF (kgBOD/d)	TCOD (kgCOD/d)	CODMF (kgCOD/d)	TN (kgN/d)	NH4 (kgN/d)	NO3 (kgN/d)	NO2 (kgN/d)	TP (kgP/d)	PO4 (kgP/d)
Poreč-South	514,0	98,8	90,9	7,9	148,9	76,3	286,9	120,9	42,5	34,0	0,2	0,1	5,1	3,1
Poreč-North	1800,0	498,3	460,1	38,2	693,7	392,9	1504,2	654,8	174,1	137,9	0,9	0,0	16,9	9,7
Vrsar	245,0	65,0	61,0	4,0	78,4	37,4	157,1	52,9	20,5	16,0	0,1	0,0	2,4	1,4
Lanterna	302,0	75,2	70,1	5,1	85,1	49,5	176,3	134,9	27,6	20,9	0,2	0,0	3,1	1,6

Figure 21. Winter 2022 - Proportional Share Influent Load per WWTP.

5.2 Influent COD 24-hour dynamic loading profile

The loading profile typically follows the flow profile with exception for periods where concentration peaks occur. The combined COD wastewater load for the Poreč area during the winter of 2022 is shown in the figures below. COD is partly particulate material and is transported more slowly through the sewer than soluble compounds. This is effect is increased at low flow conditions. Compared to TN, the morning COD peak typically is lower and has a more gradual loading pattern over the day. The measured COD loading profile is typical for domestic source.

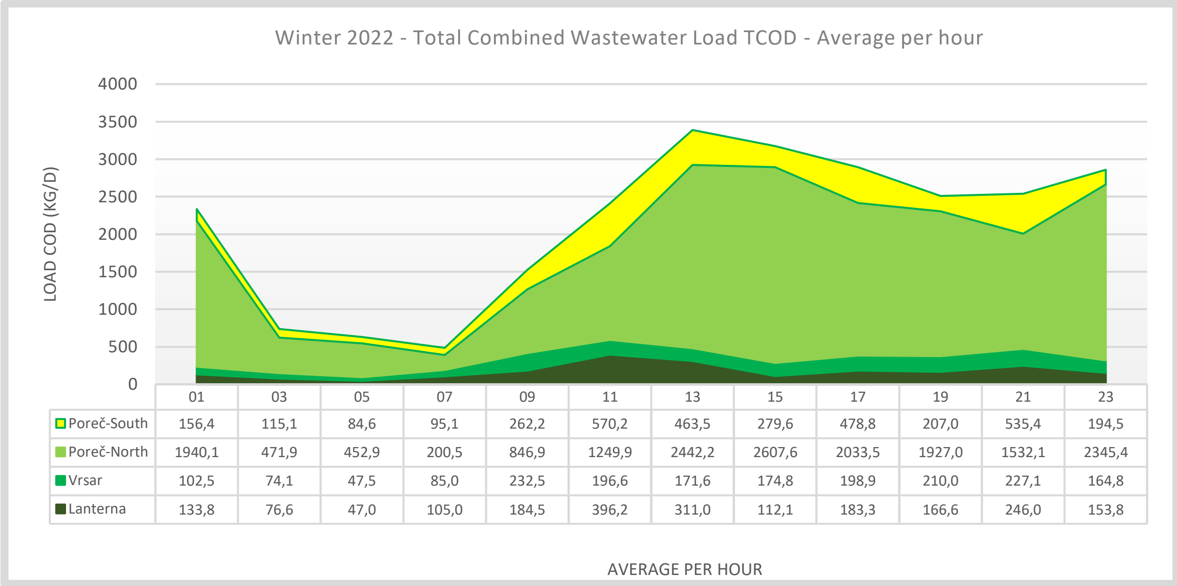


Figure 22. Winter 2022 - Sum of all WWTP's. Hourly average influent TCOD loads based on 1 measurement day, dry weather conditions.

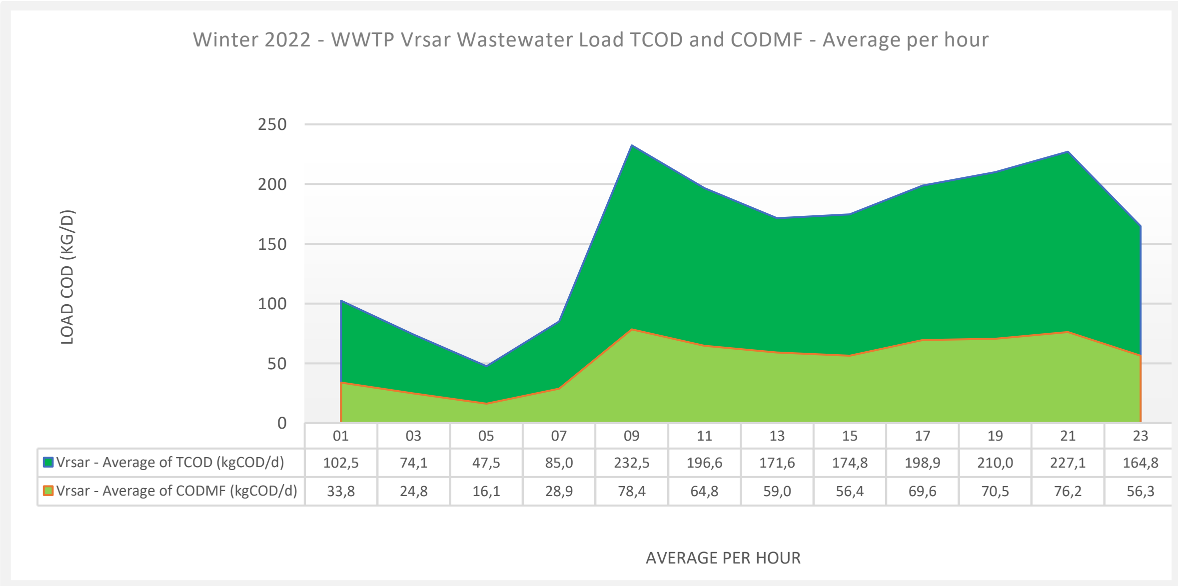
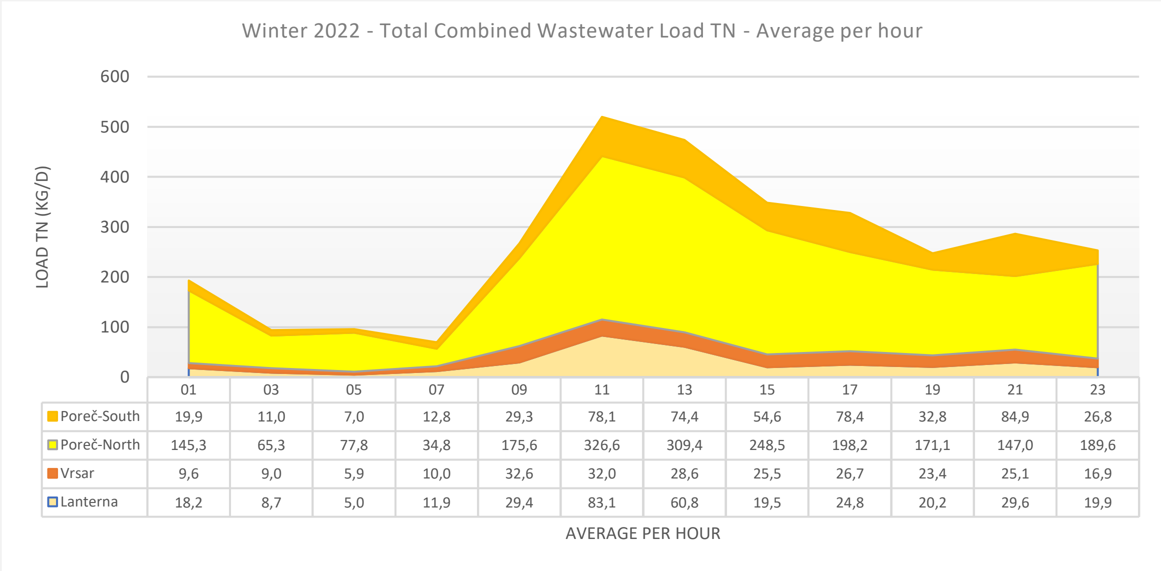


Figure 23. Winter 2022 - WWTP Vrsar hourly average dry weather influent loads of total and filtered COD.

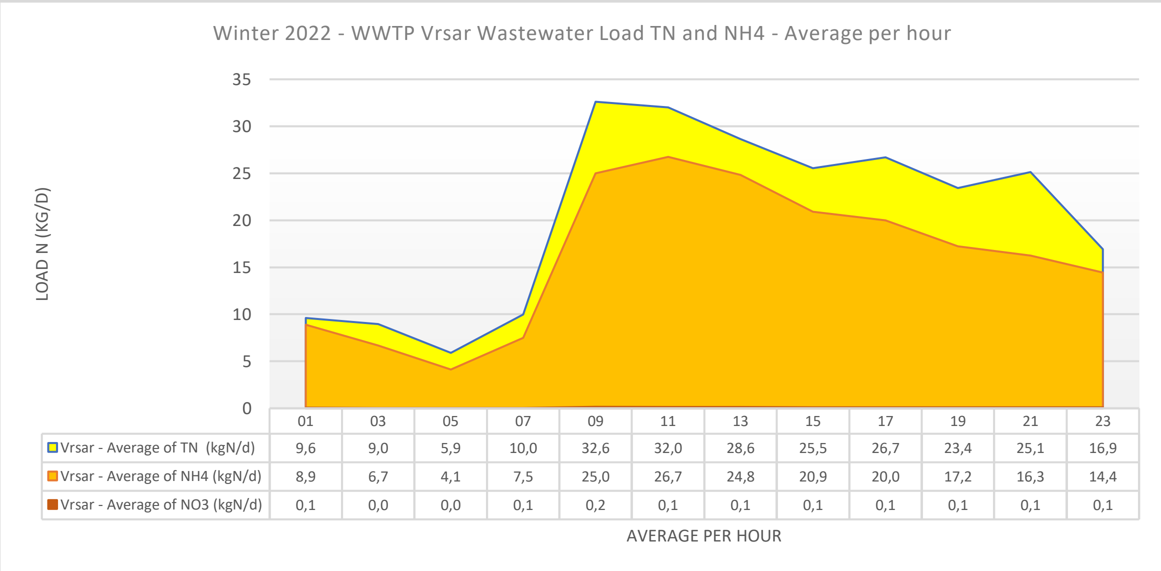
5.3 Influent Nitrogen 24-hour dynamic loading profile

The total nitrogen (TN) loading is presented in the graphs below. The data shows a typical domestical source. A large fraction of TN is soluble ammonium which is easily transported in the sewer. This typically results in a high peak of ammonium in the morning between 11:00 and 13:00, depending on the flow and sewer residence time. Ammonium peaks result in a high oxygen demand at the WWTP because of the nitrification process. Under peak conditions, especially when the wastewater is warm, aeration can be come limiting. Small presence of nitrate is measured in the sewage. Appearance of nitrate in closed sewers could be caused by nitrate rich groundwater infiltration.



	01	03	05	07	09	11	13	15	17	19	21	23
Poreč-South	19,9	11,0	7,0	12,8	29,3	78,1	74,4	54,6	78,4	32,8	84,9	26,8
Poreč-North	145,3	65,3	77,8	34,8	175,6	326,6	309,4	248,5	198,2	171,1	147,0	189,6
Vrsar	9,6	9,0	5,9	10,0	32,6	32,0	28,6	25,5	26,7	23,4	25,1	16,9
Lanterna	18,2	8,7	5,0	11,9	29,4	83,1	60,8	19,5	24,8	20,2	29,6	19,9

Figure 24. Winter 2022 - Sum of all WWTP's. Hourly average influent TN loads based on 1 measurement day under dry weather.

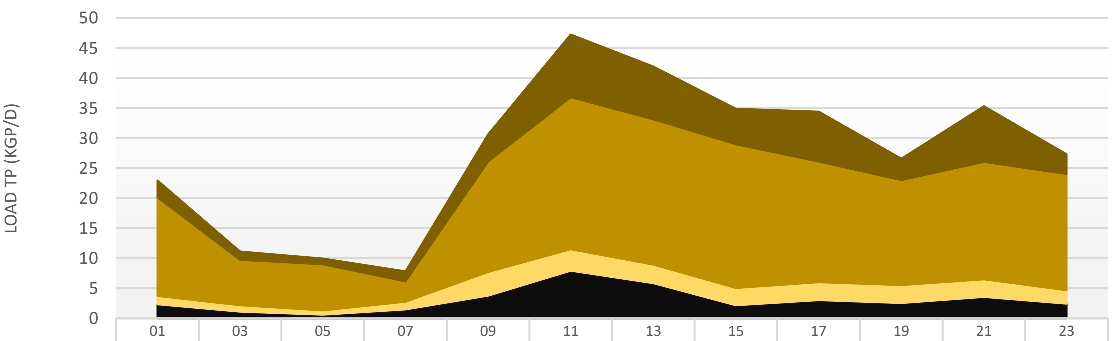


	01	03	05	07	09	11	13	15	17	19	21	23
Vrsar - Average of TN (kgN/d)	9,6	9,0	5,9	10,0	32,6	32,0	28,6	25,5	26,7	23,4	25,1	16,9
Vrsar - Average of NH4 (kgN/d)	8,9	6,7	4,1	7,5	25,0	26,7	24,8	20,9	20,0	17,2	16,3	14,4
Vrsar - Average of NO3 (kgN/d)	0,1	0,0	0,0	0,1	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1

Figure 25. Winter 2022 - WWTP Vrsar hourly average dry weather influent loads TN, NH4 and NO3, based on 1 measurement day under dry weather conditions.

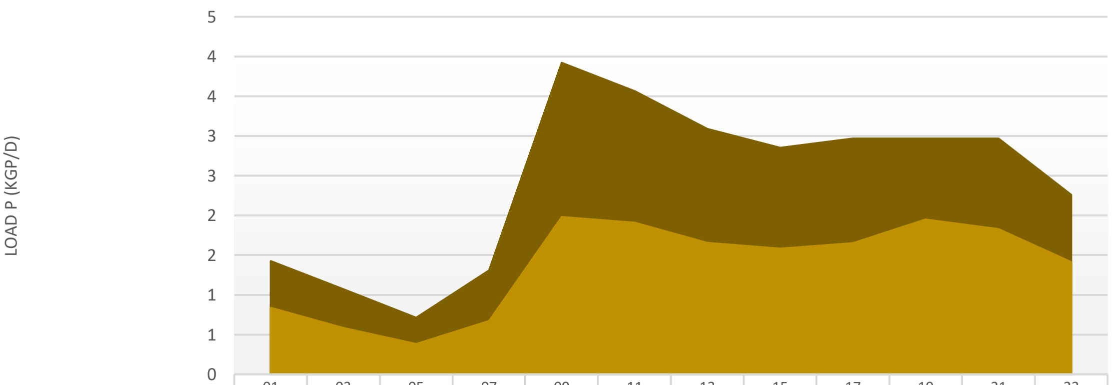
5.4 Influent Phosphorus 24-hour dynamic loading profile

The phosphorus loading is presented in the graphs below. Phosphorus consists of a soluble ortho-phosphate fraction which is easily transported in the sewer system. Typically, a smaller fraction is related to particulate organic material (particulate COD). Orthophosphate originates mostly from domestic source in the form of urine. Phosphate often resembles the ammonium profile, peaking between 11:00 and 13:00.



	01	03	05	07	09	11	13	15	17	19	21	23
Poreč-South	2,9	1,4	1,0	1,7	4,5	10,5	8,8	5,9	8,3	3,6	9,3	3,3
Poreč-North	16,4	7,6	7,7	3,4	18,4	25,3	24,1	23,9	20,1	17,5	19,5	19,3
Vrsar	1,4	1,1	0,7	1,3	3,9	3,6	3,1	2,9	3,0	3,0	3,0	2,3
Lanterna	2,3	1,1	0,6	1,5	3,8	8,0	5,9	2,2	3,1	2,6	3,5	2,4

Figure 26. Winter 2022 - Sum of all WWTP's. Hourly average influent TP load based on 1 measurement day, dry weather conditions.

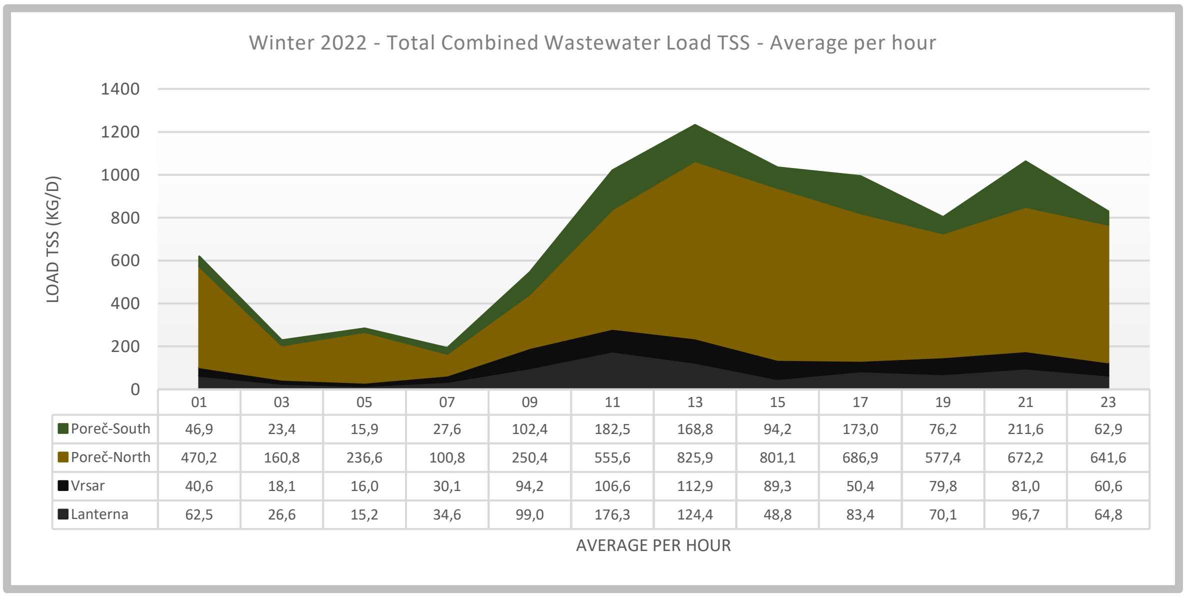


	01	03	05	07	09	11	13	15	17	19	21	23
Vrsar - Average of TP (kgP/d)	1,4	1,1	0,7	1,3	3,9	3,6	3,1	2,9	3,0	3,0	3,0	2,3
Vrsar - Average of PO4 (kgP/d)	0,8	0,6	0,4	0,7	2,0	1,9	1,7	1,6	1,7	2,0	1,8	1,4

Figure 27. Winter 2022 - WWTP Vrsar hourly average influent loads TP and PO4, based on 1 measurement day, dry weather conditions.

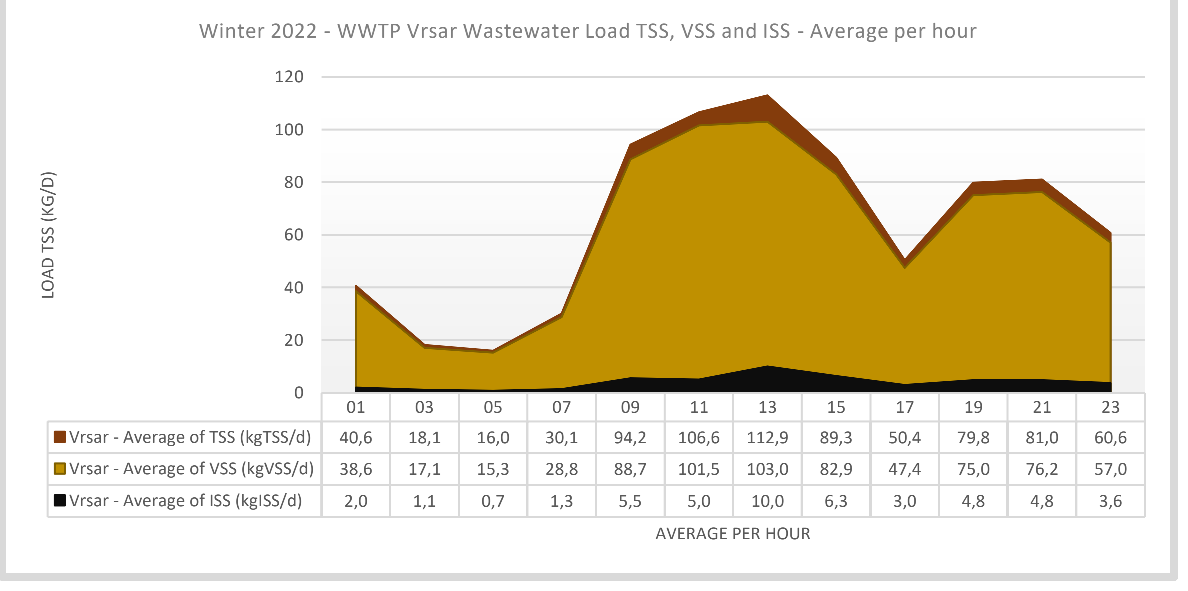
5.5 Influent Total Suspended Solids 24-hour dynamic loading profile

The loading of particulate material (total suspended solids) is presented in the graphs below. Particulate material typically has a longer transportation time in the sewer. Solid materials will settle in the sewer, especially during dry weather and low nighty flow. Therefore, at low flow conditions, TSS concentration measurements usually are underestimated by 15-25%. During peak flow or rain events, the settled TSS fraction is stirred up and transported to the WWTP. Under these conditions, concentration measurements are generally overestimated. As a result, during low season and low flow conditions, usually only one TSS peak is measured during the day, while during high season two peaks are measured: One in the morning and one in the evening coinciding with the flow dynamics. TSS consists largely of organic material (volatile suspended solids or VSS). The inorganic fraction (ISS) is typically 6-9%. TSS is typically organic material from domestic source and solids collected from the pavement during rain events. Typically, half of the domestic TSS source is cellulose originating from toilet paper. Industrial and agricultural TSS usually are fibers with a low biodegradability.



	01	03	05	07	09	11	13	15	17	19	21	23
Poreč-South	46,9	23,4	15,9	27,6	102,4	182,5	168,8	94,2	173,0	76,2	211,6	62,9
Poreč-North	470,2	160,8	236,6	100,8	250,4	555,6	825,9	801,1	686,9	577,4	672,2	641,6
Vrsar	40,6	18,1	16,0	30,1	94,2	106,6	112,9	89,3	50,4	79,8	81,0	60,6
Lanterna	62,5	26,6	15,2	34,6	99,0	176,3	124,4	48,8	83,4	70,1	96,7	64,8

Figure 28. Winter 2022 - Sum of all WWTP's. Hourly average influent TSS load based on 1 measurement day, dry weather conditions.



	01	03	05	07	09	11	13	15	17	19	21	23
Vrsar - Average of TSS (kgTSS/d)	40,6	18,1	16,0	30,1	94,2	106,6	112,9	89,3	50,4	79,8	81,0	60,6
Vrsar - Average of VSS (kgVSS/d)	38,6	17,1	15,3	28,8	88,7	101,5	103,0	82,9	47,4	75,0	76,2	57,0
Vrsar - Average of ISS (kgISS/d)	2,0	1,1	0,7	1,3	5,5	5,0	10,0	6,3	3,0	4,8	4,8	3,6

Figure 29. Winter 2022 - WWTP Vrsar hourly average influent loads TSS, VSS and ISS, based on 1 measurement day, dry weather conditions.

6 Influent specification model

6.1 Determining fractions of influent concentrations

Influent is evaluated based on the BioWin influent specification model, also called influent characterization. This model makes separate calculations to be used as an input for the BioWin activated sludge model. The model is presented in appendix 3. The BioWin influent specification model requires average influent measurement values as input and calculates a set of wastewater parameters presented in the table below. From total COD, N and P the model determines the fractions. For example, the fractions soluble, particulate, and colloidal, biodegradable, and inert and the nitrogen and phosphorus fractions of the different COD fractions. Note that all fractions in the table are in terms of COD. BioWin calculates the influent strength in terms of COD. BOD is fitted to the measured COD using the specification model presented in appendix 3.

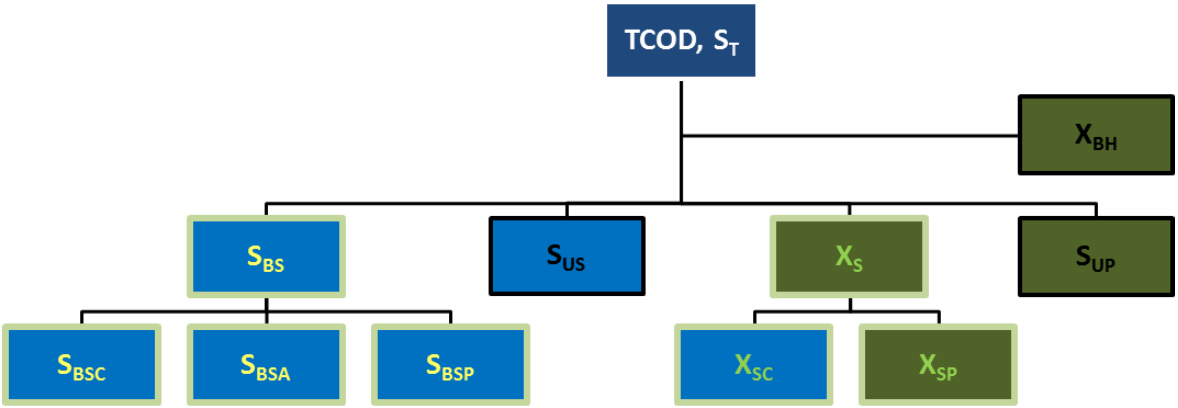


Figure 30. BioWin specification of COD fractions based on total COD in the influent. Blue is soluble (S) and (olive) green particulate or colloidal particulate (X). Green lined boxes are biodegradable and black lined boxes inert. Yellow text indicates readily biodegradable and green text slowly biodegradable.

Table 2. BioWin default influent fractions and calibrated values based on 2022 influent data. Technical note: Setting fractions to zero may result in simulation difficulties.

WWTP Vrsar - Winter 2022 Result Influent Specifier - Initial input COD Influent Fractions				
Name	Description	Unit	Raw Wastewater Defaults	Winter Calibrated Value
Fbs	Readily biodegradable (including Acetate)	[gCOD/g of total COD]	0,160	0,281
Fac	Acetate	[gCOD/g of readily biodegradable COD]	0,150	0,240
Fxsp	Non-colloidal slowly biodegradable	[gCOD/g of slowly degradable COD]	0,750	0,824
Fus	Unbiodegradable soluble	[gCOD/g of total COD]	0,050	0,056
Fup	Unbiodegradable particulate	[gCOD/g of total COD]	0,130	0,165
Fcel	Cellulose fraction of unbiodegradable particulate	[gCOD/gCOD]	0,500	0,500
Fna	Ammonia	[gNH3-N/gTKN]	0,660	0,784
Fnox	Particulate organic nitrogen	[gN/g Organic N]	0,500	0,500
Fnus	Soluble unbiodegradable TKN	[gN/gTKN]	0,020	0,022
FupN	N:COD ratio for unbiodegradable part. COD	[gN/gCOD]	0,070	0,070
Fpo4	Phosphate	[gPO4-P/gTP]	0,500	0,566
FupP	P:COD ratio for unbiodegradable part. COD	[gP/gCOD]	0,022	0,022
Fsr	Reduced sulfur [H2S]	[gS/gS]	0,150	0,150
FZbh	Ordinary heterotrophic COD fraction	[gCOD/g of total COD]	0,020	0,020
FZbm	Methylotrophic COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZao	Ammonia oxidizing COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZno	Nitrite oxidizing COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZaao	Anaerobic ammonia oxidizing COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZppa	Phosphorus accumulating COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZpa	Propionic acetogenic COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZam	Acetoclastic methanogenic COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZhm	Hydrogenotrophic methanogenic COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZso	Sulfur oxidizing COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZsrpa	Sulfur reducing propionic acetogenic COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZsra	Sulfur reducing acetotrophic COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZsrh	Sulfur reducing hydrogenotrophic COD fraction	[gCOD/g of total COD]	1,00E-04	1,00E-04
FZe	Endogenous products COD fraction	[gCOD/g of total COD]	0,0000	0,0000

6.2 Results of the specification model

The table above presents the results of the influent specification model. The parameters are input values for BioWin. Input data for pH, Ca, Mg, and alkalinity are used to calculate pH and chemical precipitation reactions. Estimates of Ca, Mg, and alkalinity are made based on data from local drinking water quality measurements provided by the drinking water company. The unbiodegradable soluble COD and TKN in the influent is estimated based on measurement of effluent soluble COD and TKN. For systems with an SRT larger than 3 days typically 98% of effluent soluble COD is unbiodegradable (Fus, SI). Glass Filtered COD (COD_{GF}) is filtered over a glass fiber filter of 1,2 microns and typically is 40% of TCOD. Membrane Filtered COD (COD_{MF}) is flocculated, and membrane filtered over 0,45 microns and thereby the fraction COD_{MF} is always lower than COD_{GF} which contains some colloidal (particulate) material. BOD measurements are including the nitrification inhibiter ATU (therefore carbonaceous BOD). Volatile fatty acids are typically assumed to be 100% acetate. However also a smaller fraction of propionate may be present in raw sewage.

Table 3. Result of the BioWin influent specification model for all WWTP's.

Influent measurements for BioWin Influent Characterization - Winter 2022						
Main influent measurements	Notations	Unit	Lanterna	Vrsar	Poreč-North	Poreč-South
Flow	Q	m3/d	302	245	1800	514
Total COD	TCOD, ST	mgCOD/L	584	641	836	558
Total Kjeldahl Nitrogen	TKN	mgN/L	91,4	83,5	96,7	82,7
Total P	TP	mgP/L	10,2	9,9	9,4	9,9
Other influent measurements	Notations	Unit	Lanterna	Vrsar	Porec-North	Porec-South
Nitrate N	NO3-N, SNO3	mgN/L	0,5	0,6	0,5	0,4
pH	pH	-	8,0	8,1	7,9	8,2
Alkalinity (CaCO3 equivalent)	Alk	mgCaCO3/L	373	373	373	373
Calcium	Ca, SCa	mg/l	80	80	80	80
Magnesium	Mg, SMg	mg/l	15	15	15	15
Dissolved oxygen	DO, (SO2)	mgO2/l	0,1	0,1	0,1	0,1
Additional measurements for modeling	Notations	Unit	Lanterna	Vrsar	Porec-North	Porec-South
Effluent filtered COD	CODS_EFF	mgCOD/L	35	36	32	48
Influent filtered COD (including colloidal)	CODGF_INF, CODS_INF	mgCOD/L	279	270	455	294
Influent FF COD (excluding colloidal)	CODMF_INF	mgCOD/L	223	216	364	235
Influent acetate	HAc, VFA, SA	mgCOD/L	44,7	43,2	72,8	47,0
Influent ammonia	NH4-N, SNH4	mgN/l	69,3	65,5	76,6	66,1
Influent ortho-phosphate	PO4-P, SPO4	mgP/l	5,5	5,6	5,4	6,0
Influent carbonaceous BOD5	TCBOD, TBOD, BOD5	mgO2/l	282	288	385	290
Influent filtered cBOD5	SCBOD, SBOD, BODS	mgO2/l	164	153	273	149
Influent VSS	VSS	mgVSS/L	232	249	281	186
Influent TSS	TSS	mgTSS/L	249	265	305	202
Derived model fractions	Notations	Unit	Lanterna	Vrsar	Porec-North	Porec-South
Fraction unbiodegradable Soluble COD	Fus	-	#REF!	#REF!	#REF!	#REF!
Particulate COD non-colloidal	CODp, CODX	mgCOD/l	305	371	381	264
Readily biodegradable COD including VFA	Fbs	-	#REF!	#REF!	#REF!	#REF!
Acetate fraction of readily biodegradable COD (SBS)	Fac	-	#REF!	#REF!	#REF!	#REF!
fraction ammonia of TKN	Fna	-	0,76	0,78	0,79	0,80
fraction phosphate of TP	Fpo4	-	0,54	0,56	0,57	0,60
TCOD/BOD, total COD over BOD ratio	TCOD/BOD5	-	2,07	2,23	2,17	1,93
CODX/VSS, particulate (non-colloidal) COD/VSS ratio	Fcv	-	1,31	1,49	1,35	1,42
Inorganic suspended solids (ash fraction of TSS)	ISS	mg/l	17	16	23	16

6.3 Conclusions

The measured influent data results in a well fitted specification model within acceptable range of parameter settings. Influent data is tested reliable and validated as wastewater of mainly domestic source applicable for WWTP modelling. The result of the specification model is a set of BioWin model input parameters and is part of the model calibration procedure which is further discussed in the following chapter. The specification model and calculation method are presented in appendix 3.

7 Model calibration and validation

7.1 Static calibration

The model is calibrated based on average 24-hour dynamic winter 2022 influent and effluent measurements. Model parameters are adjusted to reproduce the measured average effluent performance of COD, N and P. The parameter adjustments for calibration are presented in the table below. No stoichiometric parameters are adjusted. This indicates the model is valid. Some kinetic parameters are adjusted to finetune the model performance on the specific dataset and correct for approximations used in the simulation of operational conditions. Finetuning of kinetic parameters is allowed within acceptable margin and typically required for each new simulated condition.

Table 4. BioWin model calibration parameter adjustments.

WWTP Vrsar - 2022 - Calibrated parameters			
Parameter Name	BW Default	Calibrated	Affecting
Ordinary heterotrophic DO half sat. [mgO2/L]	0,15	0,7	Simultaneous nitrification and denitrification
Ammonia oxidizing DO half sat. [mgO2/L]	0,25	0,7	Reduces nitrification at low DO
Nitrite oxidizing DO half sat. [mgO2/L]	0,5	0,25	Improves Nitrite oxidation at low DO
Anoxic growth factor OHO [-]	0,5	0,8	Adaptation to anoxic conditions
Anoxic growth factor PAO [-]	0,33	0,33	Adaptation to anoxic conditions
Particulate substrate COD:VSS ratio [mgCOD/mgVSS]	1,6327	1,5	Solids accumulation from influent
Particulate inert COD:VSS ratio [mgCOD/mgVSS]	1,6	1,2	Solids accumulation from influent
Anoxic P/PHA uptake [mgP/mgCOD]	0,35	0,635	Updated yield according to TUDP-model
P/Ac release ratio [mgP/mgCOD]	0,51	0,53	Updated yield according to TUDP-model

7.2 Parameters PAO updated to TUDP-model

In BioWin the parameter for Anoxic P/PHA uptake and P/Ac release ratio are updated to the published TUDP-model. It is found that the anoxic performance of PAO’s is less conservative than assumed in the default BioWin parameter settings. The PAO parameters are updated according to the latest research.

7.3 Anoxic growth factors for OHO and PAO

This parameter represents the fraction of heterotrophic organisms that can grow under both aerobic and anoxic conditions. The parameter proportionally reduces the growth rate under anoxic conditions. Substrate and nutrient limitations may further reduce the growth rate. Anoxic growth factors are adjusted to fit the model on the measured denitrification and effluent nitrogen concentration. The growth factors typically are increased for WWTP's designed with pre-denitrification where biomass is adapted to grow under full anoxic conditions (this in contrary to simultaneous nitrification and denitrification often observed in carousel type processes). By increasing the growth factor, a larger fraction of heterotrophic biomass (PAO and OHO) will have denitrifying capacity. In systems without pre-denitrification these factors are usually set to the lower (default) value. The applied model adjustments are well within the acceptable range and do not affect the model reliability. These parameters also can change because of operation (e.g., applied anoxic recycle flow rate).

7.4 DO half saturation

The DO half saturation is a kinetic parameter determining the sensitivity for oxygen. It is adjusted to compensate for partial unaerated zones or unaerated periods which are the result of the oxygen control settings. By increasing the DO half saturation for denitrification, more simultaneous nitrification and denitrification (SND) will occur under low DO conditions. The parameter adjustment simulates the effect of partial aerated tanks. Under normal settings nitrite (NO2) is formed in the model. Most likely as result of the simplified oxygen modeling because no nitrate is measured in the effluent. To compensate for this, the DO half saturation for nitrification is decreased to finetune the formation of nitrite. This has no significant effect on the model reliability and is mainly applied for fine tuning effluent results. The DO half saturation for nitrification did not need adjustment to reduce the nitrification rate at low DO concentration.

7.5 Particulate influent COD/VSS ratio

These parameters are the result of the influent specification calculation (appendix 3). The COD/VSS ratio determines how much solids accumulate in the WWTP and how much is biodegraded. The adjustments are directly derived from the applied influent measurements and well within the acceptable range and do not affect the model reliability.

Table 5. BioWin model calibration – Results model and measured effluent.

WWTP Vrsar - Scenario Winter 2022 - Result static calibration			
Attribute	Unit	EFF Simulated	EFF-measurement
COD - Total	mg/L	46,1	58,6
BOD - Total Carbonaceous	mg/L	1,0	10,3
N - Total N	mgN/L	7,0	6,9
N - Ammonia	mgN/L	2,4	2,2
N - Nitrate	mgN/L	1,3	0,6
P - Total P	mgP/L	0,7	0,7
Total suspended solids	mg/L	0,0	0,0

7.6 Calibration results and discussion

In the table below, the results of the model and the effluent measurements are compared. The model predicts the effluent within a reasonable range. In the calibration procedure the model is fitted primarily to NH4 by adjusting the aeration control, and it is attempted to find the most optimal overall dynamic fit with the least parameter adjustment required. There are however some small deviations between the measurements and model results which are here discussed. Typically, measurements have a margin of error and show a spread as the result of small errors. However, measured and modelled effluent BOD shows a consistent deviation and is not predicted accurately. In general BOD is not a very reliable measurement especially in the low concentration range. Moreover, high soluble BOD in the effluent is unlikely for systems with sufficient aerobic SRT, which is the case for this WWTP (table 9). Therefore, it is assumed the measured BOD is overestimated (and consequently also total COD). Or the sample may be contaminated. The concentration values of NH4, NO3 and NO2 are reasonably predicted taking in account these concentrations vary depending on the operation and time of day. Effluent NH4, NO3 and NO2 are strongly dependent on the applied aeration and recirculation controls. Operational data was not available, and these controls are estimated in the model. This may also explain the (slight) formation of NO2 in the model which also is consistently overestimated compared to the measurements, which generally are zero. Most likely NO2 is not measured accurately for it is complicated to preserve and store samples properly and NO2 quickly can convert before being measured. Considering the relatively high measured NH4 some NO2 is expected to be formed. This is supported by TN which does not add up with other measured nitrogen components. This may indicate a measurement error. As the result of a model artifact TN in the model is underestimated; Filtered COD has no individual parameter to set the nitrogen fraction. In the MBR filtered COD is the only effluent COD fraction and this also partly can explain the (small) gap between measured and modeled TN.

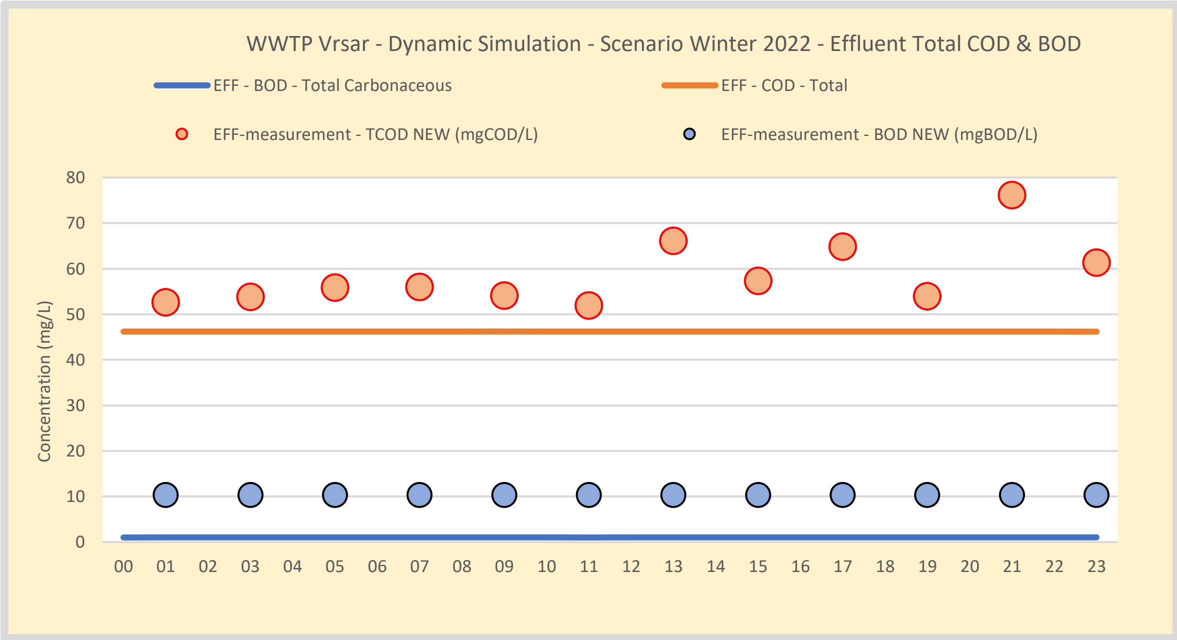


Figure 31. Winter 2022 – WWTP Vrsar – Model validation based on 24-hour dynamic effluent COD and BOD data. For all measured effluent results the model underpredicts measured effluent BOD. Typical effluent BOD for systems operated at SRT > 3 days BOD is below 3 mg/L. The BOD measurements are likely unreliable.

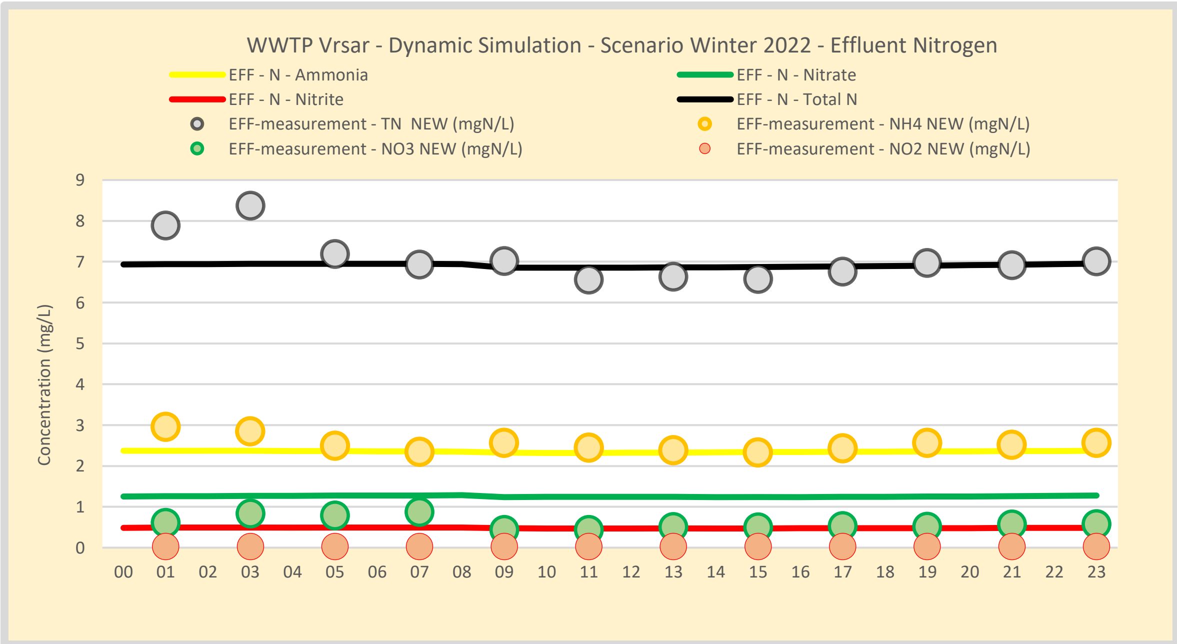


Figure 32. Winter 2022 – WWTP Vrsar – Model validation based on 24-hour dynamic effluent TN, NH4 and NO3 data. The model is fitted to the effluent NH4 concentration. In the model 100% of effluent is buffered in the storage tank and measured variation in effluent TN is not well simulated. Formation of NO2 in the model is overestimated.

7.7 Model validation

The model is validated based on the presented calibration results; No stoichiometric or other critical parameters are adjusted to reproduce measured conditions. This indicates the model is valid and suited to simulate (dynamic) operational conditions and valid to be used for extrapolation to (future) load conditions (as is done in report 6 and 7). Validation is supported by dynamic model results. In the figures above the dynamic effluent performance is plotted against the measurements. The effluent is measured coming from the effluent buffer and is reasonably well reproduced by the model.

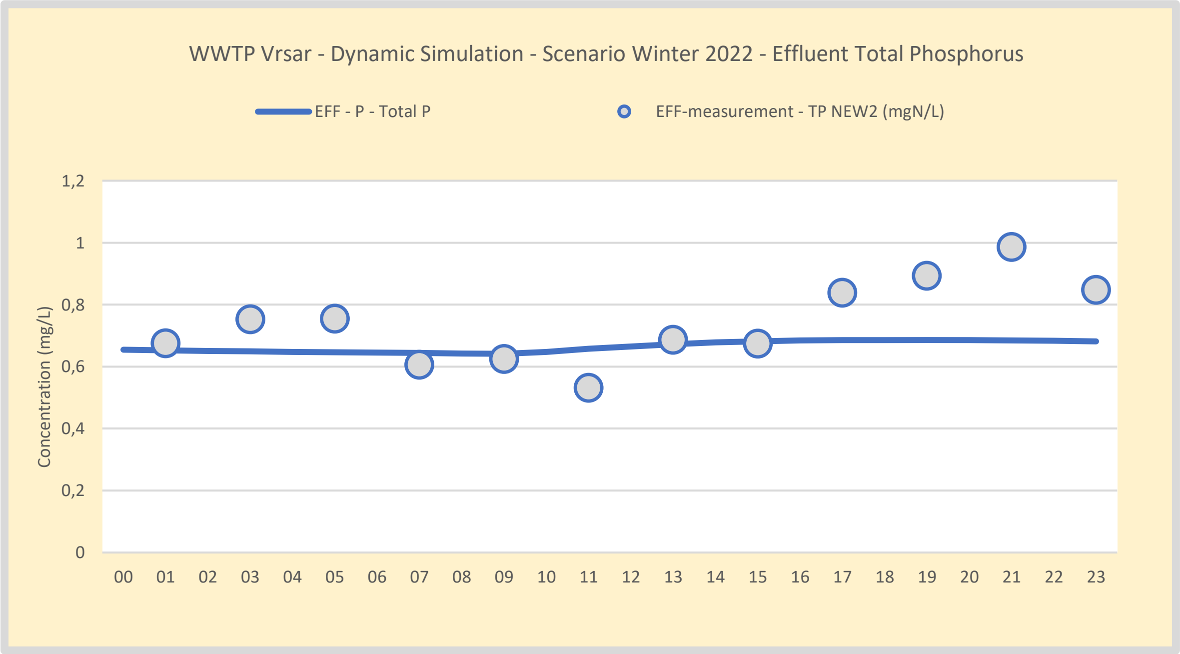


Figure 33. Winter 2022 – WWTP Vrsar – Model validation based on 24-hour dynamic effluent TP.

7.8 Conclusion dynamic simulations

The WWTP result of the 2022 calibrated model (appendix 4) is largely identical to the results of the 2019 7-day dynamic winter simulation presented in report 7. The effluent concentration is simulated within the projected effluent limits. Due to operational differences of aeration, SRT, and internal recycles, operational hour to hour effluent results can differ considerably. However, the overall performance of COD, N and P-removal is largely identical for both the 2019 and 2022 models. This is explained by the minor parameter adjustments required to simulate both conditions. This indicates the model is well developed, has no gross shortcomings, and is tested valid for application in this research project.

7.9 Conclusions

- The model is calibrated based on the provided operational data.
- Parameters are all adjusted within the typical and acceptable range.
- No stoichiometric parameters are adjusted.
- All adjustments are used to fit the model to specific operational conditions and typically required for each performed simulation study.
- Based on the presented calibration results the model is validated for interpolation to study operational dynamics and extrapolation for scenario analysis.
- Additional validation is provided by the dynamic simulation.
- The 2019 and 2022 calibrated model results are in accordance.
- The model is tested valid for use in this research project.

8 Conclusions and recommendations

8.1 General conclusions

- The model is tested successfully on an independent data set and reproduced all data without significant adjustments.
- The model is tested reliable and validated for use for operational and scenario evaluation.
- The above conclusions apply to all presented results, under which previous WWTP modelling reports published in this series, which have used the here validated model.

8.2 Summary of technical conclusions

- Influent dry weather flow data measured in the winter of 2019 and 2022 are comparable.
- There is similarity in the minimum and maximum flow data as well as the flow distribution pattern over the day on an hourly basis.
- The measured profile is successfully used in the calibration study to validate the model performance.
- The measured influent data results in a well fitted model within acceptable range of parameter settings.
- Some measurements are inconsistent and corrected based on typical influent fractions.
- The total influent data set is tested reliable and validated as wastewater of mainly domestic source useful for WWTP modelling.
- The result of the specification model is used in the model calibration procedure.
- The model is calibrated based on the provided operational data.
- Parameters are all adjusted within the typical and acceptable range.
- No stoichiometric parameters needed to be adjusted.
- All adjustments are used to fit the model to specific operational conditions and typically required for each performed simulation study.
- Based on the calibration results the model is validated for interpolation, to study operational dynamics and for extrapolation and future scenario analysis.
- Additional model validation is provided by dynamic simulations.
- The 2019 and 2022 calibrated model results are in accordance.
- The model is tested valid for use in this research project.

8.3 Recommendations

It is recommended to proceed with final development of the scenario analysis and sea water modelling taking in account the presented conclusions.

Appendix 1. Influent Concentrations Winter 2022

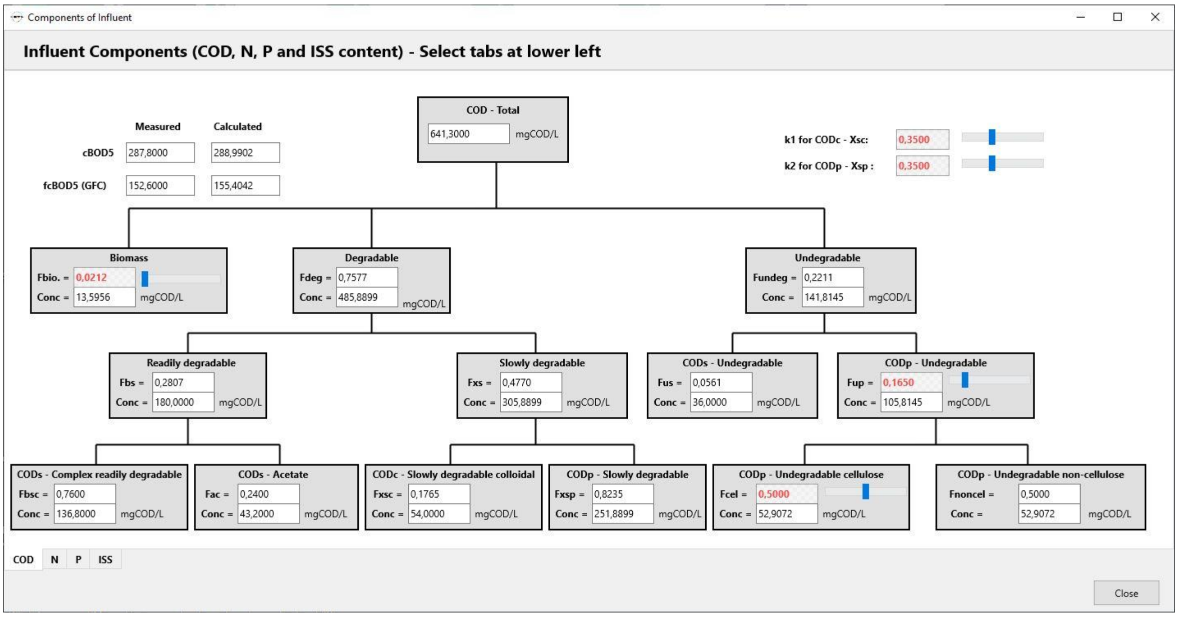
Winter 2022 - Average Concentrations; Time Average and Flow Proportional				
	Lanterna	Vrsar	Poreč-North	Poreč-South
TSS (mgTSS/L) - Flow Proportional	249,0	265,2	276,8	192,2
VSS (mgVSS/L) - Flow Proportional	232,2	248,8	255,6	176,8
ISS (mgISS/L) - Flow Proportional	16,8	16,4	21,2	15,3
BOD (mgBOD/L) - Flow proportional	281,8	319,8	385,4	289,7
BODMF (mgBOD/L) - Flow proportional	163,9	152,6	218,3	148,5
TCOD (mgCOD/L) - Flow Proportional	583,9	641,3	835,7	558,1
CODMF (mgCOD/L) - Flow Proportional	446,5	216,0	363,8	235,2
TN (mgN/L) - Flow Proportional	91,4	83,5	96,7	82,7
NH4 (mgN/L) - Flow Proportional	69,3	65,5	76,6	66,1
NO3 (mgN/L) - Flow Proportional	0,5	0,4	0,5	0,3
NO2 (mgN/L) - Flow Proportional	0,0	0,2	0,0	0,1
TP (mgP/L) - Flow Proportional	10,2	9,9	9,4	9,9
PO4 (mgP/L) - Flow Proportional	5,5	5,6	5,4	6,0
pH (-) - Flow proportional	8,0	8,1	7,9	8,2
TSS (mgTSS/L) - Time Average	254,3	256,3	273,3	185,9
VSS (mgVSS/L) - Time Average	238,6	241,0	255,4	168,5
ISS (mgISS/L) - Time Average	15,8	15,3	18,0	17,3
BOD (mgBOD/L) - Time Average	281,8	319,8	385,4	289,7
BODMF (mgBOD/L) - Time Average	163,9	152,6	218,3	148,5
TCOD (mgCOD/L) - Time Average	624,3	652,9	796,4	599,0
CODMF (mgCOD/L) - Time Average	465,3	219,9	347,1	235,9
TN (mgN/L) - Time Average	86,5	82,0	94,5	80,2
NH4 (mgN/L) - Time Average	68,3	64,1	73,6	64,6
NO3 (mgN/L) - Time Average	0,5	0,4	0,5	0,3
NO2 (mgN/L) - Time Average	0,0	0,2	0,0	0,1
TP (mgP/L) - Time Average	10,2	9,9	9,4	9,9
PO4 (mgP/L) - Time Average	5,6	5,6	5,1	5,9
pH (-) - Time Average	8,0	8,1	7,9	8,2

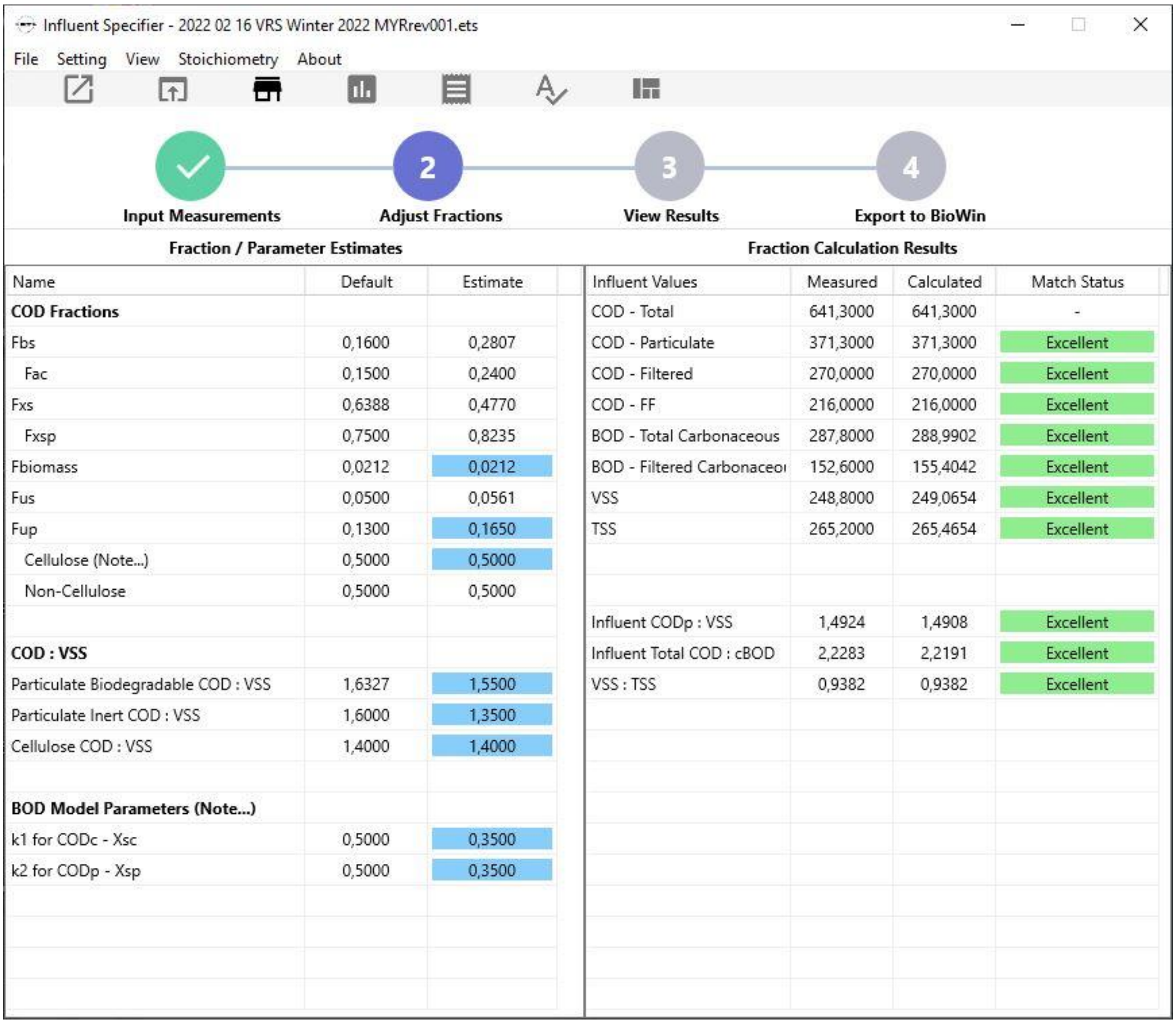
Appendix 2. Influent Load Winter 2022

Winter 2022 - Average Influent Loads per WWTP				
	Lanterna	Vrsar	Poreč-North	Poreč-South
Flow (m3/d)	302,0	245,0	1800,0	514,0
TSS (kgTSS/d)	75,2	65,0	498,3	98,8
VSS (kgVSS/d)	70,1	61,0	460,1	90,9
ISS (kgISS/d)	5,1	4,0	38,2	7,9
BOD (kgBOD/d)	85,1	78,4	693,7	148,9
BODMF (kgBOD/d)	49,5	37,4	392,9	76,3
TCOD (kgCOD/d)	176,3	157,1	1504,2	286,9
CODMF (kgCOD/d)	134,9	52,9	654,8	120,9
TN (kgN/d)	27,6	20,5	174,1	42,5
NH4 (kgN/d)	20,9	16,0	137,9	34,0
NO3 (kgN/d)	0,2	0,1	0,9	0,2
NO2 (kgN/d)	0,0	0,0	0,0	0,1
TP (kgP/d)	3,1	2,4	16,9	5,1
PO4 (kgP/d)	1,6	1,4	9,7	3,1

Appendix 3. BioWin Model Influent Specification

Results of the influent specification model





Influent Specifier - 2022 02 16 VRS Winter 2022 MYRrev001.ets

File Setting View Stoichiometry About

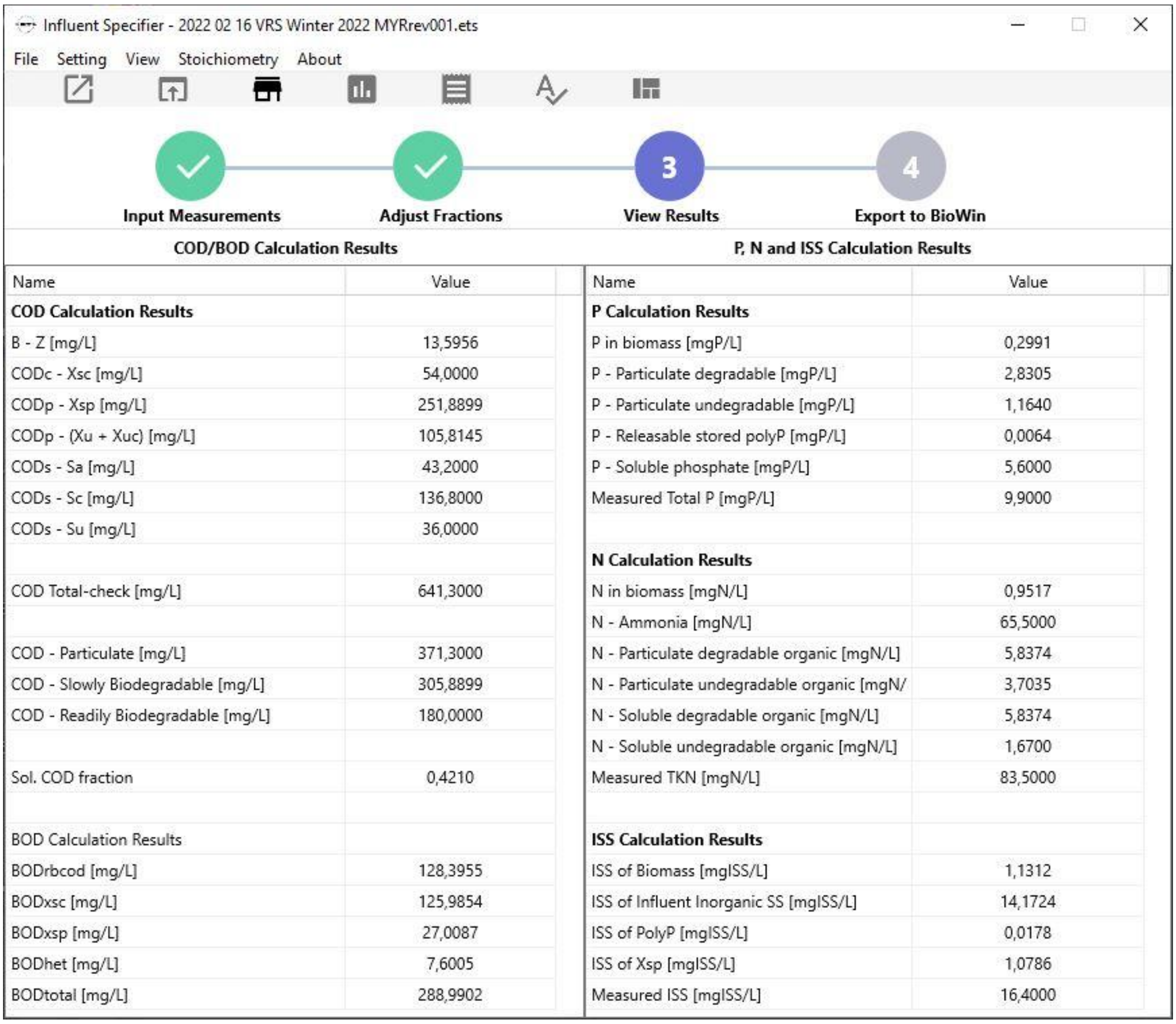
Input Measurements — Adjust Fractions — View Results — Export to BioWin

Fraction / Parameter Estimates

Name	Default	Estimate
COD Fractions		
Fbs	0,1600	0,2807
Fac	0,1500	0,2400
Fxs	0,6388	0,4770
Fxsp	0,7500	0,8235
Fbiomass	0,0212	0,0212
Fus	0,0500	0,0561
Fup	0,1300	0,1650
Cellulose (Note...)	0,5000	0,5000
Non-Cellulose	0,5000	0,5000
COD : VSS		
Particulate Biodegradable COD : VSS	1,6327	1,5500
Particulate Inert COD : VSS	1,6000	1,3500
Cellulose COD : VSS	1,4000	1,4000
BOD Model Parameters (Note...)		
k1 for CODc - Xsc	0,5000	0,3500
k2 for CODp - Xsp	0,5000	0,3500

Fraction Calculation Results

Influent Values	Measured	Calculated	Match Status
COD - Total	641,3000	641,3000	-
COD - Particulate	371,3000	371,3000	Excellent
COD - Filtered	270,0000	270,0000	Excellent
COD - FF	216,0000	216,0000	Excellent
BOD - Total Carbonaceous	287,8000	288,9902	Excellent
BOD - Filtered Carbonaceo	152,6000	155,4042	Excellent
VSS	248,8000	249,0654	Excellent
TSS	265,2000	265,4654	Excellent
Influent CODp : VSS	1,4924	1,4908	Excellent
Influent Total COD : cBOD	2,2283	2,2191	Excellent
VSS : TSS	0,9382	0,9382	Excellent

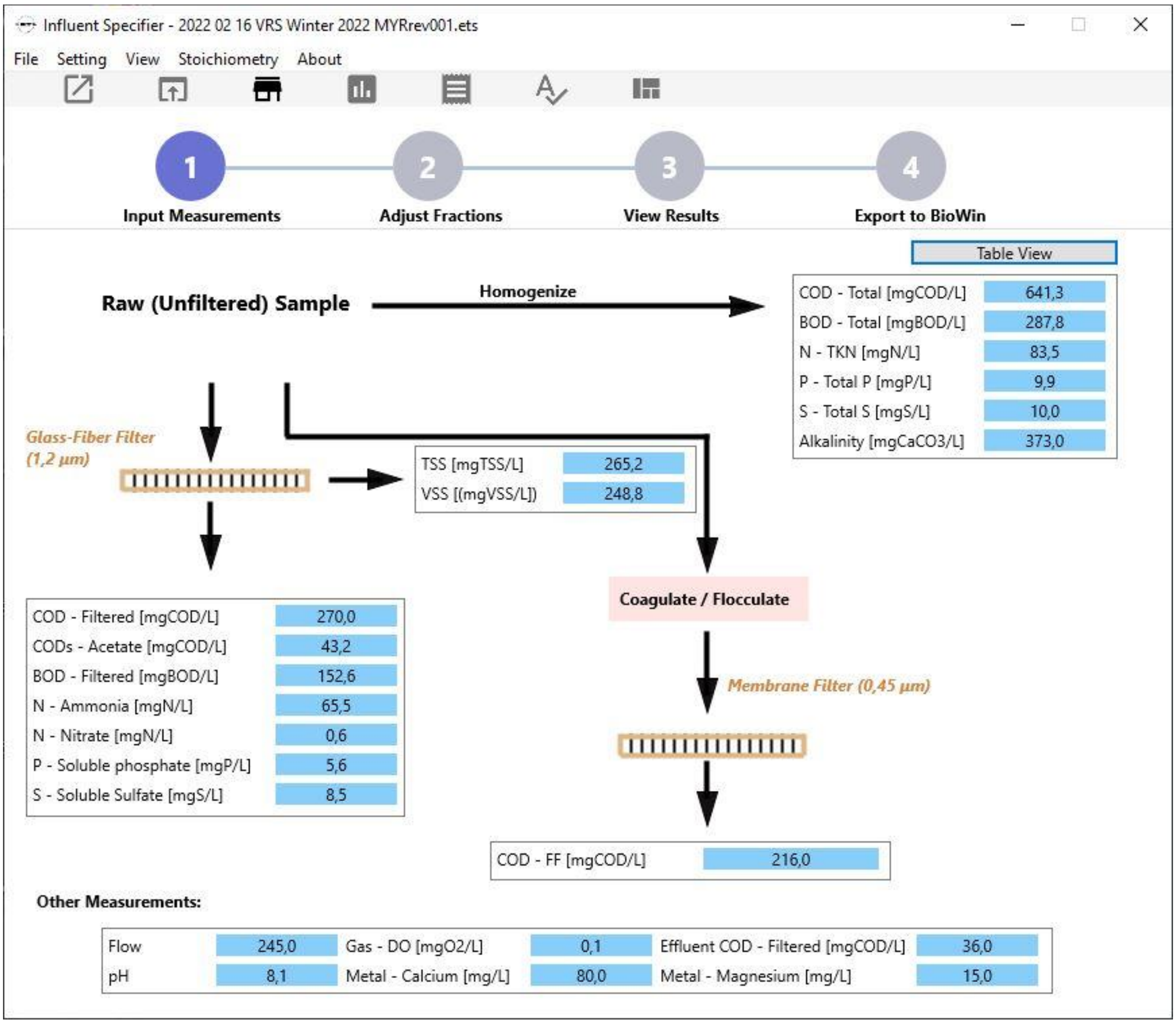


COD/BOD Calculation Results

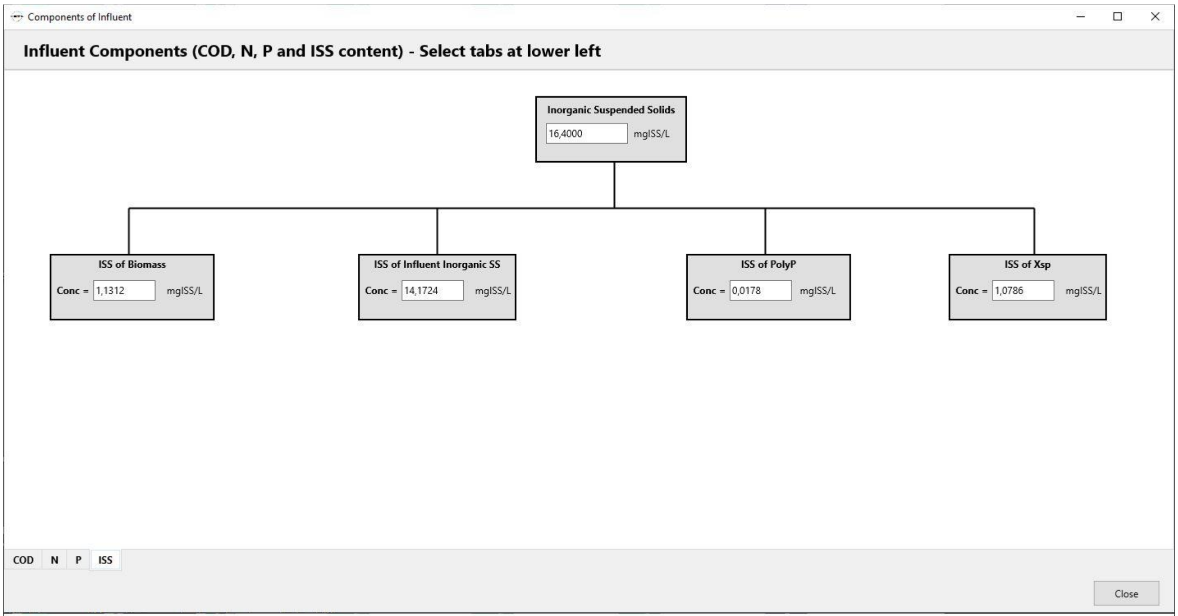
Name	Value
COD Calculation Results	
B - Z [mg/L]	13,5956
CODc - Xsc [mg/L]	54,0000
CODp - Xsp [mg/L]	251,8899
CODp - (Xu + Xuc) [mg/L]	105,8145
CODs - Sa [mg/L]	43,2000
CODs - Sc [mg/L]	136,8000
CODs - Su [mg/L]	36,0000
COD Total-check [mg/L]	641,3000
COD - Particulate [mg/L]	371,3000
COD - Slowly Biodegradable [mg/L]	305,8899
COD - Readily Biodegradable [mg/L]	180,0000
Sol. COD fraction	0,4210
BOD Calculation Results	
BODrbcod [mg/L]	128,3955
BODxsc [mg/L]	125,9854
BODxsp [mg/L]	27,0087
BODhet [mg/L]	7,6005
BODtotal [mg/L]	288,9902

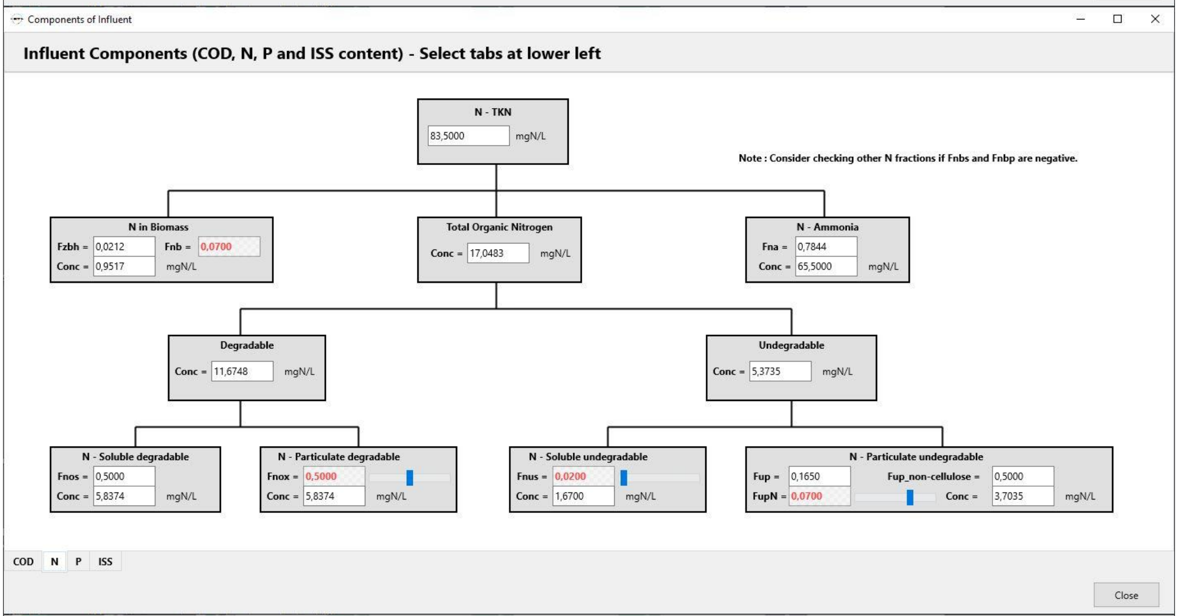
P, N and ISS Calculation Results

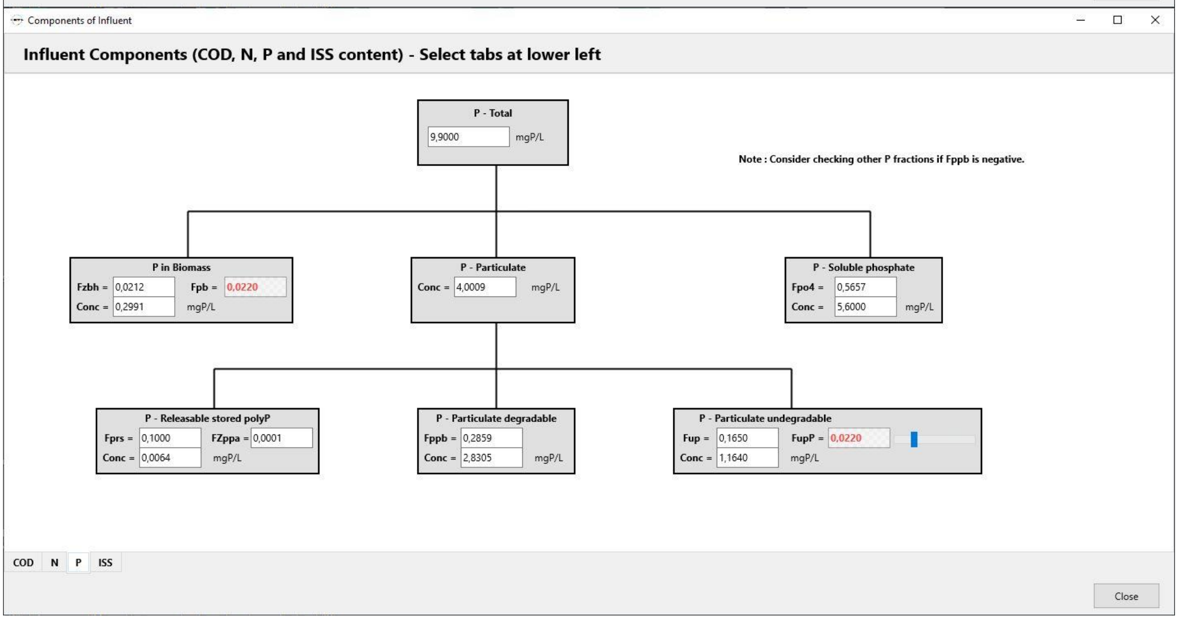
Name	Value
P Calculation Results	
P in biomass [mgP/L]	0,2991
P - Particulate degradable [mgP/L]	2,8305
P - Particulate undegradable [mgP/L]	1,1640
P - Releasable stored polyP [mgP/L]	0,0064
P - Soluble phosphate [mgP/L]	5,6000
Measured Total P [mgP/L]	9,9000
N Calculation Results	
N in biomass [mgN/L]	0,9517
N - Ammonia [mgN/L]	65,5000
N - Particulate degradable organic [mgN/L]	5,8374
N - Particulate undegradable organic [mgN/	3,7035
N - Soluble degradable organic [mgN/L]	5,8374
N - Soluble undegradable organic [mgN/L]	1,6700
Measured TKN [mgN/L]	83,5000
ISS Calculation Results	
ISS of Biomass [mgISS/L]	1,1312
ISS of Influent Inorganic SS [mgISS/L]	14,1724
ISS of PolyP [mgISS/L]	0,0178
ISS of Xsp [mgISS/L]	1,0786
Measured ISS [mgISS/L]	16,4000



Influent Specifier - 2022 02 16 VRS Winter 2022 MYRrev001.ets
File
Setting
View
Stoichiometry
About
1
Input Measurements
2
Adjust Fractions
3
View Results
4
Export to BioWin
Table View
Raw (Unfiltered) Sample
Homogenize
COD - Total [mgCOD/L] 641,3
BOD - Total [mgBOD/L] 287,8
N - TKN [mgN/L] 83,5
P - Total P [mgP/L] 9,9
S - Total S [mgS/L] 10,0
Alkalinity [mgCaCO3/L] 373,0
Glass-Fiber Filter
(1,2 μm)
TSS [mgTSS/L] 265,2
VSS [(mgVSS/L]) 248,8
Coagulate / Flocculate
COD - Filtered [mgCOD/L] 270,0
CODs - Acetate [mgCOD/L] 43,2
BOD - Filtered [mgBOD/L] 152,6
N - Ammonia [mgN/L] 65,5
N - Nitrate [mgN/L] 0,6
P - Soluble phosphate [mgP/L] 5,6
S - Soluble Sulfate [mgS/L] 8,5
Membrane Filter (0,45 μm)
COD - FF [mgCOD/L] 216,0
Other Measurements:
Flow 245,0
Gas - DO [mgO2/L] 0,1
Effluent COD - Filtered [mgCOD/L] 36,0
pH 8,1
Metal - Calcium [mg/L] 80,0
Metal - Magnesium [mg/L] 15,0


Components of Influent
Influent Components (COD, N, P and ISS content) - Select tabs at lower left
Inorganic Suspended Solids
16,4000 mgISS/L
ISS of Biomass
Conc = 1,1312 mgISS/L
ISS of Influent Inorganic SS
Conc = 14,1724 mgISS/L
ISS of PolyP
Conc = 0,0178 mgISS/L
ISS of Xsp
Conc = 1,0786 mgISS/L
COD N P ISS
Close


Components of Influent
Influent Components (COD, N, P and ISS content) - Select tabs at lower left
N - TKN
83,5000 mgN/L
Note : Consider checking other N fractions if Fnbs and Fnbp are negative.
N in Biomass
Fzbh = 0,0212 Fnb = 0,0700
Conc = 0,9517 mgN/L
Total Organic Nitrogen
Conc = 17,0483 mgN/L
N - Ammonia
Fna = 0,7844
Conc = 65,5000 mgN/L
Degradable
Conc = 11,6748 mgN/L
Undegradable
Conc = 5,3735 mgN/L
N - Soluble degradable
Fnos = 0,5000
Conc = 5,8374 mgN/L
N - Particulate degradable
Fnox = 0,5000
Conc = 5,8374 mgN/L
N - Soluble undegradable
Fnus = 0,0200
Conc = 1,6700 mgN/L
N - Particulate undegradable
Fup = 0,1650 Fup_non-cellulose = 0,5000
FupN = 0,0700 Conc = 3,7035 mgN/L
COD N P ISS
Close


Components of Influent
Influent Components (COD, N, P and ISS content) - Select tabs at lower left
P - Total
9,9000 mgP/L
Note : Consider checking other P fractions if Fppb is negative.
P in Biomass
Fzbh = 0,0212 Fpb = 0,0220
Conc = 0,2991 mgP/L
P - Particulate
Conc = 4,0009 mgP/L
P - Soluble phosphate
Fpo4 = 0,5657
Conc = 5,6000 mgP/L
P - Releasable stored polyP
Fprs = 0,1000 FZppa = 0,0001
Conc = 0,0064 mgP/L
P - Particulate degradable
Fppb = 0,2859
Conc = 2,8305 mgP/L
P - Particulate undegradable
Fup = 0,1650 FupP = 0,0220
Conc = 1,1640 mgP/L
COD N P ISS
Close

Presenting the BioWin influent specification model

The influent is divided in its fractions and used in the BioWin model calculations. Therefore, several influent fractions are introduced to facilitate the calculations in the model (Table 27, BW-influent tab). An overview of the fractions is presented below including relation to actual analytical measurements.

The influent unbiodegradable COD (S_{US}) for systems with a SRT > 3 days is based on the effluent measurement of soluble (glass filtered) COD according to:

$$S_{US} = COD_{S,EFF} = COD_{GF,EFF}$$

(Eq. 1)

The fraction unbiodegradable COD is calculated according to:

$$F_{US} = \frac{S_{US}}{TCOD} = \frac{COD_{GF,EFF}}{TCOD_{INF}}$$

(Eq. 2)

Soluble COD is including the colloidal and expressed as COD_S as the sum of all soluble model fractions. It can be measured from glass filtered COD according to:

$$COD_S = S_{BSA} + S_{BSP} + S_{BSC} + X_{SC} + S_{US} = COD_{GF,INF}$$

(Eq. 3)

Particulate (non-colloidal) COD (CODp or COD_X) is the sum of particulate (non-colloidal) COD, particulate unbiodegradable COD and active biomass in the influent (X_{BH} is often assumed zero) given by:

$$COD_X = X_{SP} + S_{UP} + X_{BH} \approx X_{SP} + S_{UP}$$

(Eq. 4)

COD_X is calculated by subtracting the total COD and the soluble COD (COD_S) which is calculated based on the glass filtered COD according to:

$$COD_X = TCOD - COD_S = TCOD_{INF} - COD_{GF,INF}$$

(Eq. 5)

Soluble COD excluding the colloidal is expressed as COD_{MF} and measured from membrane filtering the COD according to:

$$COD_{MF} = S_{BSA} + S_{BSP} + S_{BSC} + S_{US} = COD_{MF,INF}$$

(Eq. 6)

The total soluble readily biodegradable COD (the total of acetate, propionate, and complex soluble COD but without slowly colloidal COD) is calculated from the measured micro filtered fraction COD_{MF} according to:

$$S_{BS} = S_{BSA} + S_{BSP} + S_{BSC} = COD_{MF} - S_{US} = COD_{MF,INF} - COD_{GF,EFF}$$

(Eq. 7)

The fraction of soluble readily biodegradable COD is given by:

$$F_{BS} = \frac{S_{BS}}{TCOD} = \frac{(S_{BSA} + S_{BSP} + S_{BSC})}{TCOD} = \frac{COD_{MF,INF} - COD_{GF,EFF}}{TCOD_{INF}}$$

(Eq. 8)

Influent acetate (+ propionate) is direct measured as VFA:

$$S_{BSA} + S_{BSP} = VFA_{INF}$$

(Eq. 9)

The fraction of readily biodegradable COD which is acetate is given by:

$$F_{AC} = \frac{S_{BSA}}{S_{BS}} = \frac{S_{BSA}}{(S_{BSA} + S_{BSP} + S_{BSC})} = \frac{VFA_{INF}}{COD_{MF,INF} - COD_{GF,EFF}}$$

(Eq. 10)

From the difference between the glass and membrane filtered COD, the colloidal fraction can be calculated according to:

$$X_{SC} = COD_S - COD_{MF} = COD_{GF,INF} - COD_{MF,INF}$$

(Eq. 11)

The last soluble parameter to be calculated is the complex soluble COD S_{BSC} calculated from the measurements according to:

$$S_{BSC} = COD_{MF} - S_{BSA} - S_{BSP} - S_{US} = COD_{MF,INF} - VFA_{INF} - COD_{GF,EFF}$$

(Eq. 12)

The total soluble (readily and slow colloidal) biodegradable COD (S_S) is the total of acetate, propionate, complex soluble COD and colloidal COD (influent methanol is assumed zero) given by:

$$S_S = S_{BSA} + S_{BSP} + S_{BSC} + X_{SC}$$

(Eq. 13)

And calculated according to:

$$S_S = COD_S - S_{US} = COD_{GF,INF} - COD_{GF,EFF}$$

(Eq. 14)

In the figure below biodegradable COD (S_S) is divided in fractions. BioWin notation of S_S should not be confused with IAWQ S_S which equals BioWin S_{BS}.

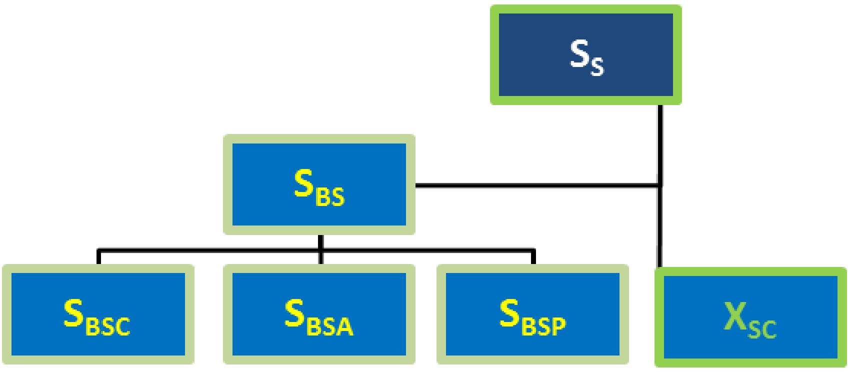


Figure 34. BioWin wastewater fractions of soluble biodegradable COD (S_S). The fraction is measured by glass filtering and includes all soluble and colloidal material. Blue fractions are soluble and (olive) green fractions (colloidal) particulate.

The last two influent fraction that need to be calculated are related to the solids: particulate biodegradable COD and unbiodegradable COD according to (Eq. 4):

$$COD_X = X_{SP} + S_{UP} + X_{BH} \approx X_{SP} + S_{UP}$$

These fractions are estimated from the BOD measurements in the influent as explained in the following sections of this chapter.

The BioWin influent tab the fraction of slowly biodegradable influent COD which is particulate is given by:

$$F_{XPS} = \frac{X_{SP}}{X_{SC} + X_{SP}}$$

(Eq. 15)

VSS is often calculated from ISS (Ash) measurement according to:

$$VSS = TSS - ISS$$

(Eq. 16)

The influent ratio of particulate (non-colloidal) COD to VSS is given by:

$$F_{CV} = \frac{COD_X}{VSS} = \frac{TCOD - COD_S}{VSS} = \frac{TCOD_{INF} - COD_{GF,INF}}{TSS - ISS}$$

(Eq. 17)

Ammonia is given by:

$$NH_3 = F_{NA} \times TKN$$

(Eq. 18)

Soluble unbiodegradable organic nitrogen is given by:

$$N_{US} = F_{NUS} \times TKN$$

(Eq. 19)

Nitrogen from organisms present in the influent is calculated by the sum of the products of the various organism concentrations and their respective nitrogen fractions, i.e.:

$$Organisms, N = \sum Zb_x - f_{N,Zbx}$$

(Eq. 20)

Unbiodegradable particulate nitrogen is given by:

$$X_{IN} = F_{UP,N} \times F_{UP} \times TCOD$$

(Eq. 21)

The remaining organic nitrogen is broken into particulate and soluble components. Particulate biodegradable organic nitrogen is given by:

$$X_{ON} = (TKN - NH_3 - N_{US} - X_{IN} - Organisms, N) \times F_{NOX}$$

(Eq. 22)

Soluble biodegradable organic nitrogen is given by:

$$N_{OS} = (TKN - NH_3 - N_{US} - X_{IN} - Organisms, N) \times (1 - F_{NOX})$$

(Eq. 23)

Similarly, an explanation of the fractionation of influent phosphorus is as follows. Soluble orthophosphate is given by:

$$PO_4 = F_{PO4} \times TP$$

(Eq. 24)

Phosphorus from organisms present in the influent is calculated by the sum of the products of the various organism concentrations and their respective phosphorus fractions, i.e.:

$$Organisms, P = \sum Zb_x - f_{P,Zbx}$$

(Eq. 25)

Unbiodegradable particulate phosphorus is given by:

$$X_{IN} = F_{UP,P} \times F_{UP} \times TCOD$$

(Eq. 26)

The remaining particulate biodegradable organic phosphorus is given by:

$$X_{OP} = TP - PO_4 - X_{IP} - Organisms, P$$

(Eq. 27)

Appendix 4. Winter 2022 results dynamic model validation

Winter operation process flow diagram

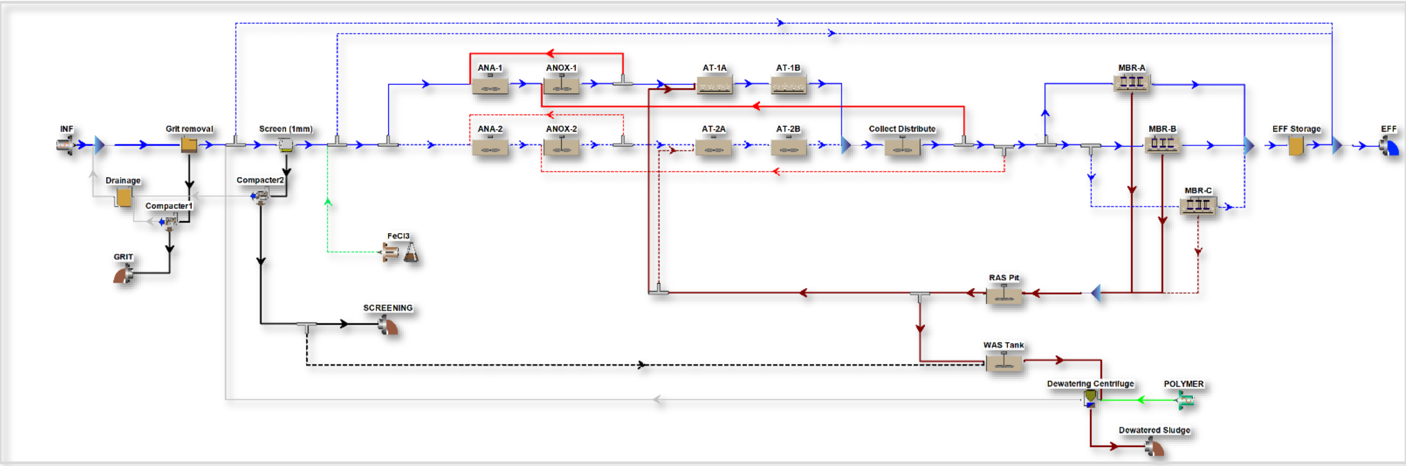


Figure 35. WWTP Vrsar - BioWin model winter operation. One line and one MBR are taken out of operation (dashed lines not operated). Operational adjustments are made to accommodate dynamic modelling. MBR-C is taken out of operation to avoid stripping of alkalinity.

Average performance overview

Based on the total dataset the average WWTP performance is calculated and presented in the tables below. The effluent performance and aerobic SRT is well within the design criteria. There are no solids measured in the effluent because of the MBR technology. Total nitrogen is well below the effluent standard. Effluent COD is largely inert soluble material.

Table 6. WWTP Vrsar - Winter 2019 - Dynamic average effluent concentration (mg/L)

WWTP Vrsar - Scenario Winter 2022 - Dynamic average effluent concentration (mg/L)			
EFF	Temperature	Concentration	10,0
EFF	COD - Total	Concentration	46,1
EFF	N - Total N	Concentration	7,0
EFF	P - Total P	Concentration	0,7
EFF	Total suspended solids	Concentration	0,0

Table 7. WWTP Vrsar - Winter 2019 - Dynamic average Air flow rate (m3/h)

WWTP Vrsar - Scenario Winter 2022 - Dynamic average Air flow rate (m3/h)			
AT-1A	Air flow rate	Flow	0,0
AT-1B	Air flow rate	Flow	102,9
AT-2A	Air flow rate	Flow	0,0
AT-2B	Air flow rate	Flow	0,0
MBR-A	Air flow rate	Flow	110,0
MBR-B	Air flow rate	Flow	110,0
MBR-C	Air flow rate	Flow	0,0

Table 8. WWTP Vrsar - Winter 2019 - Dynamic average Flows (m3/d)

WWTP Vrsar - Scenario Winter 2022 - Dynamic average Flows (m3/d)			
ANA-R1	Flow (S)	Flow	1.250,0
ANA-R2	Flow (S)	Flow	0,0
ANOX-R1	Flow (S)	Flow	1.923,4
ANOX-R2	Flow (S)	Flow	0,0
AS Emergency Bypass	Flow (S)	Flow	0,0
Dewatering Centrifuge	Flow (U)	Flow	0,2
Grit removal	Flow (U)	Flow	0,1
MBR-A	Flow (U)	Flow	1.919,8
MBR-B	Flow (U)	Flow	1.919,8
MBR-C	Flow (U)	Flow	0,0
Screen (1mm)	Flow (U)	Flow	0,0
Screen Emergency Bypass	Flow (S)	Flow	0,0
WAS Splitter	Flow (S)	Flow	18,5

Table 9. WWTP Vrsar - Winter 2019 - Dynamic average sludge production SRT and HRT

WWTP Vrsar - Scenario Winter 2022 - Dynamic average SRT and HRT		
Temperature	10	°C
Average waste sludge production	41,1	kgTSS/d
SRT Total	45,0	d
SRT Aerobic	13,4	d
SRT AT+ANOX	26,3	d
WAS Tank HRT	2,6	hour
ANA HRT to influent	20,0	hour

Table 10. WWTP Vrsar - Winter 2019 - Dynamic average Iron and Polymer (mg/L, kg/d, m3/d)

WWTP Vrsar - Scenario Winter 2022 - Dynamic average Iron and Polymer (mg/L & kg/d)			
FeCl3	Flow	Flow	0,000
FeCl3	Total iron (all forms)	Concentration	150.000
FeCl3	Total iron (all forms)	Load	0,000
POLYMER	COD - Total	Concentration	18.180
POLYMER	COD - Total	Load	0,461
POLYMER	Flow	Flow	0,025

Influent modelling results

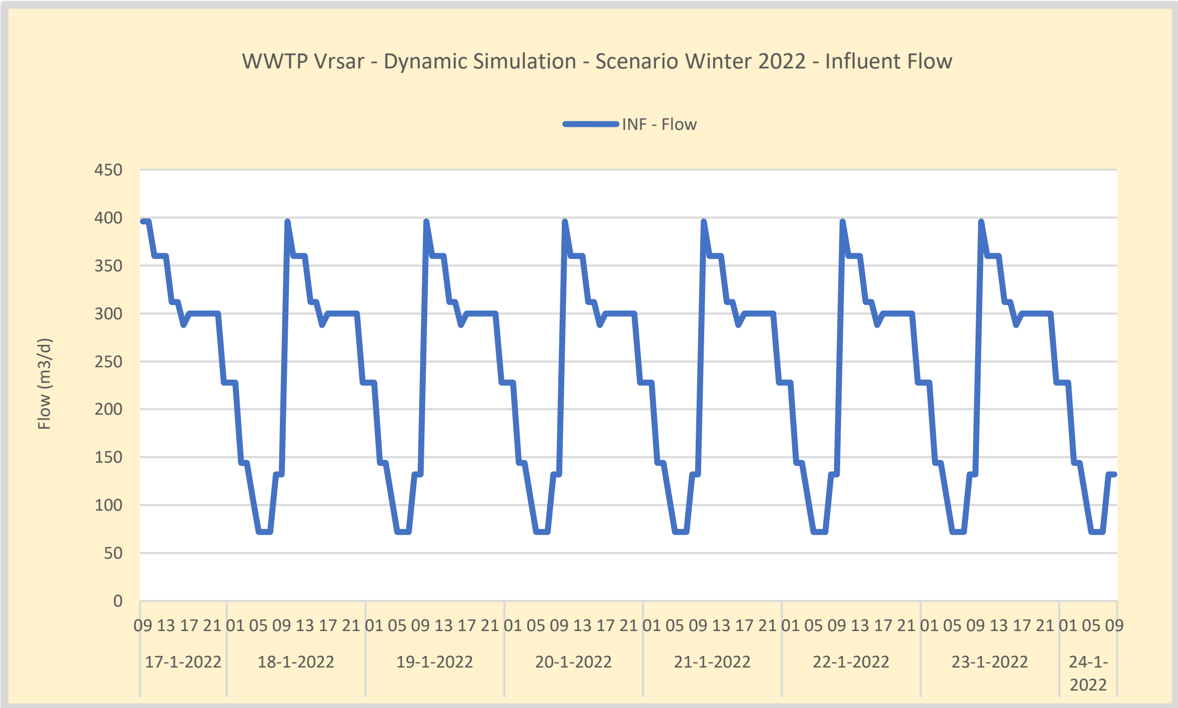


Figure 36. Winter 2022 - WWTP Vrsar dynamic model Influent flow.

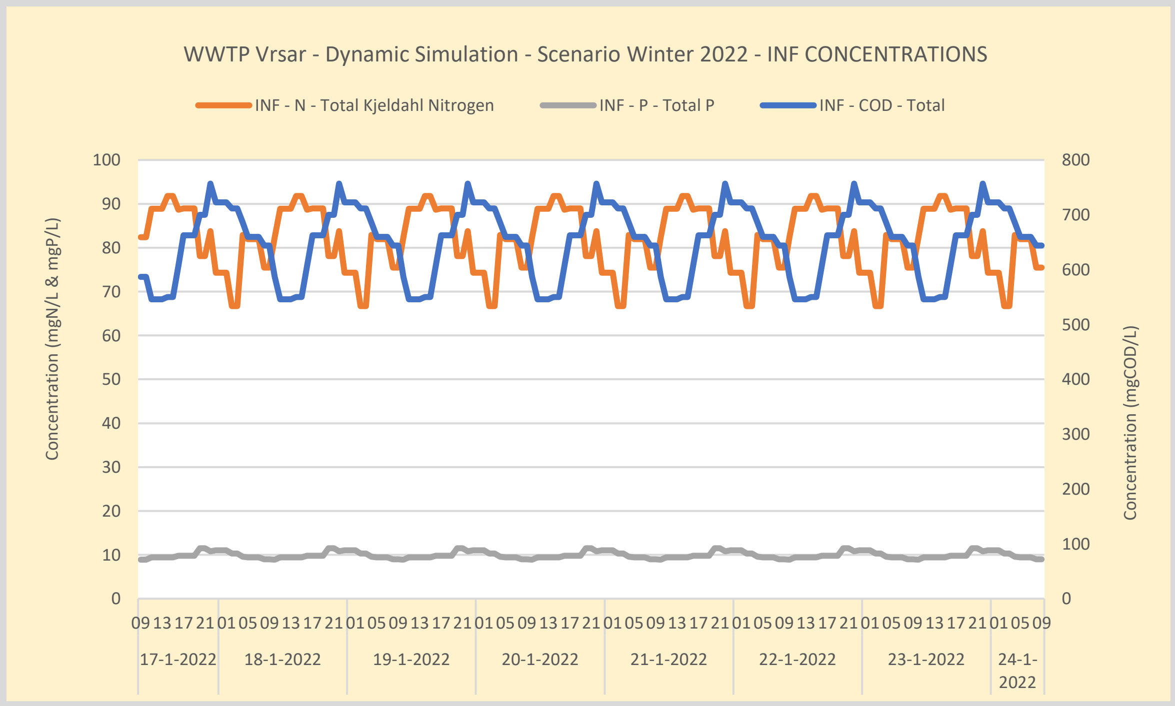


Figure 37. Winter 2022 - WWTP Vrsar dynamic Influent load COD, TKN and TP.

Process and recycle flows modelling results

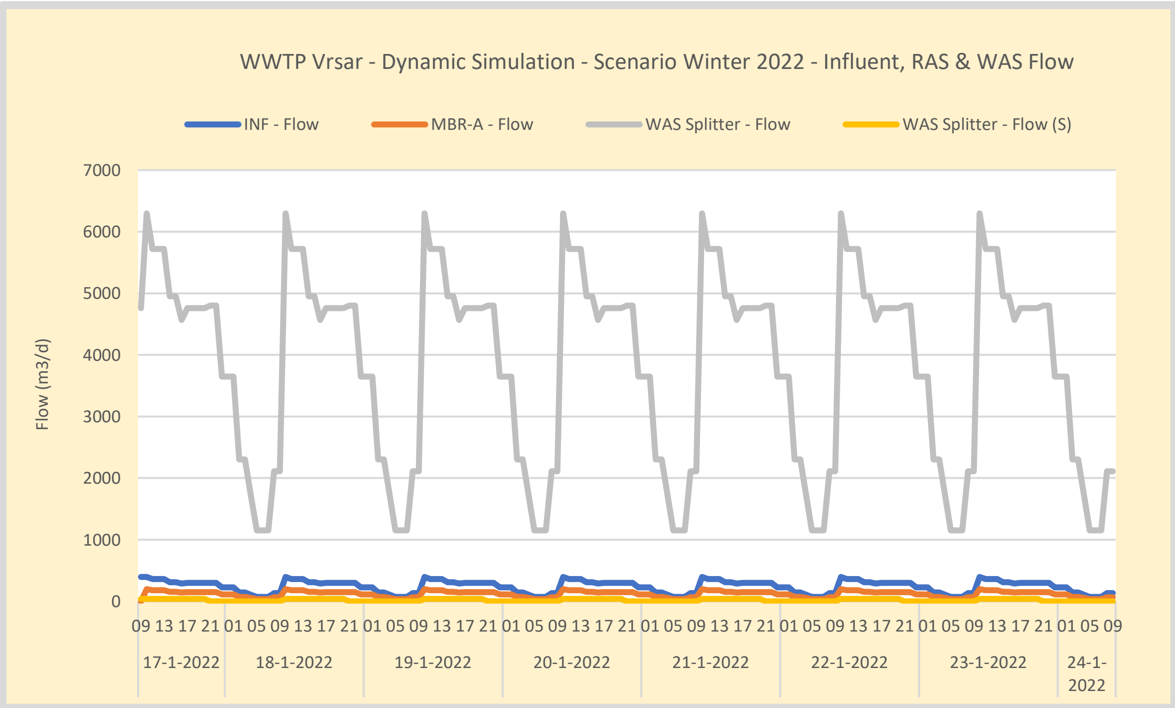


Figure 38. Winter 2022 - WWTP Vrsar flow rate settings and control. The MLSS sludge return flow (WAS splitter flow) is set to 800% proportionate to the influent flow. The WAS flow is operated 10 hours a day on a constant flow to the dewatering.

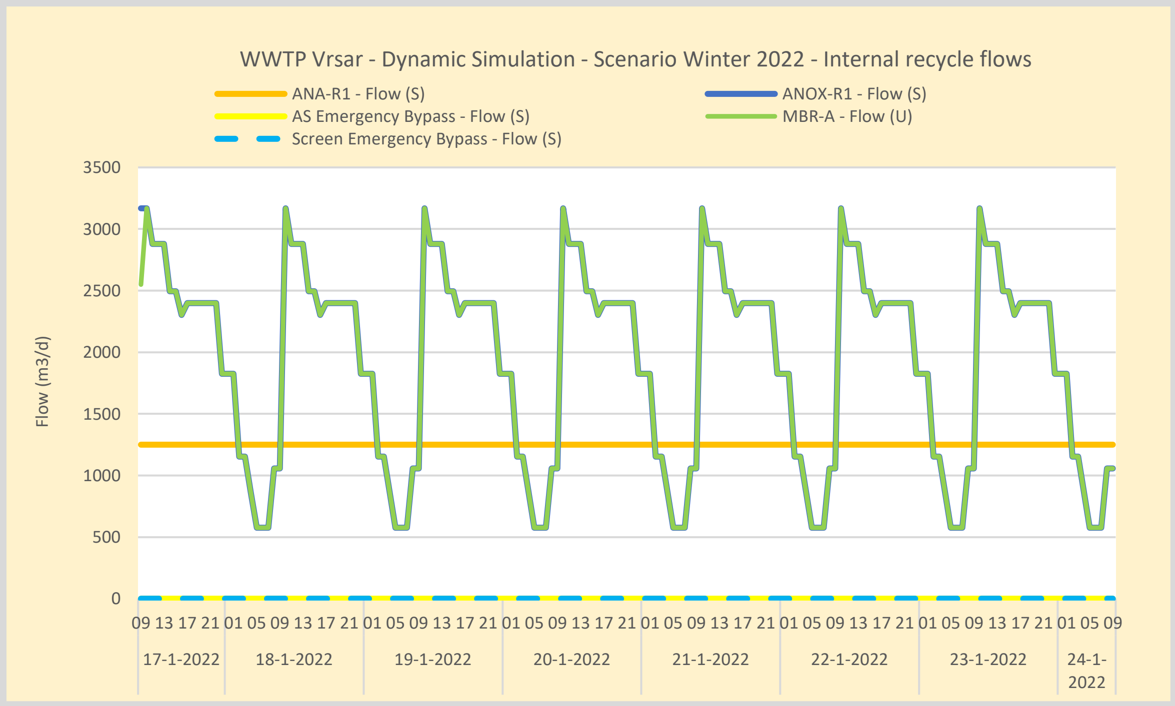


Figure 39. Winter 2022 - WWTP Vrsar flow rate settings and control. The bypasses are not used. The upper bound of the anaerobic recycle is according to the max design. The anoxic recycle is set to 800% relative to the influent flow. The line overlaps with MBR-A which is also 800% of the influent.

Waterline operation modelling results

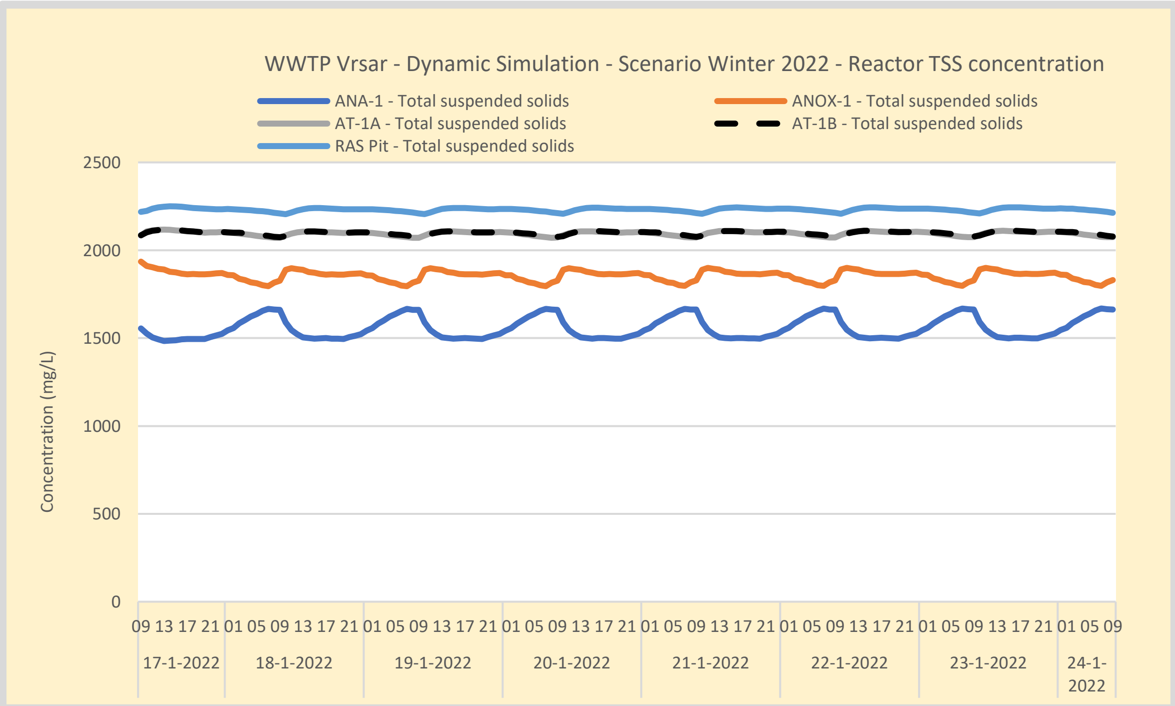


Figure 40. Winter 2022 - WWTP Vrsar TSS profile in the waterline. TSS in the MBR is controlled on approximately 2 gTSS/L by adjusting the WAS flow and SRT. In the winter, the reactor volume relative to the influent loading is very high. This results in low sludge production and a too long SRT. The process is therefore operated with a lower TSS concentration during the winter.

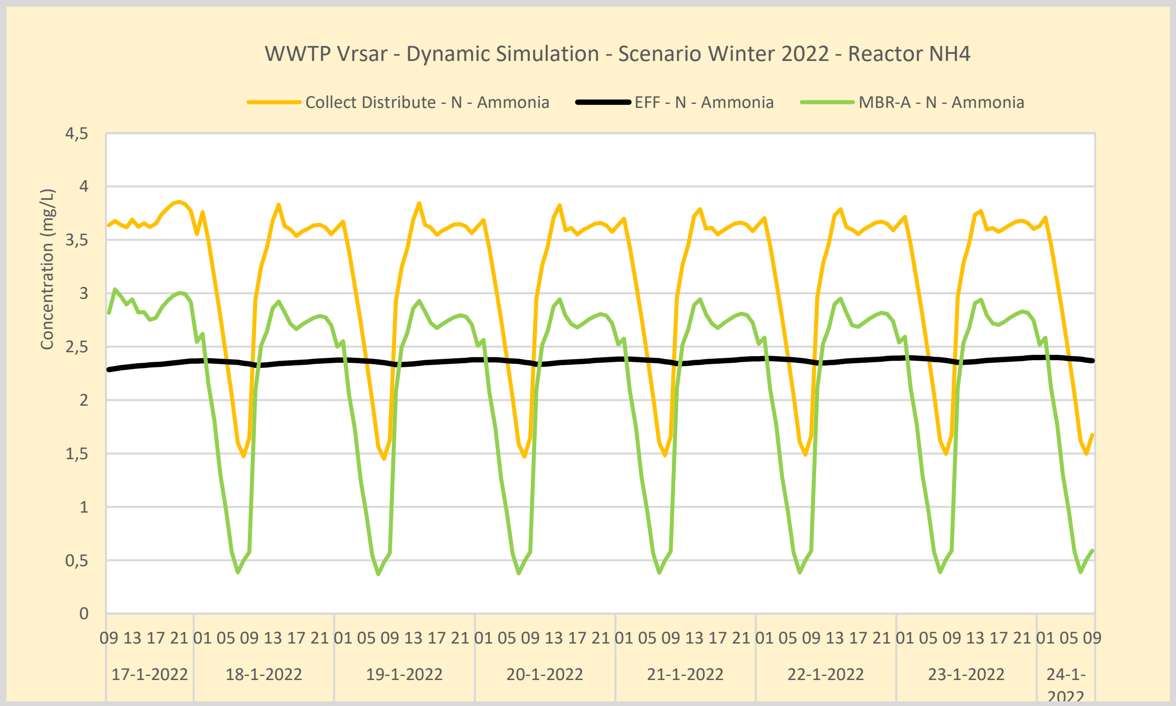


Figure 41. Winter 2022 - WWTP Vrsar ammonium profile in the waterline. The air input of AT-B is step-controlled based on the NH4 concentration. AT-A is unaerated.

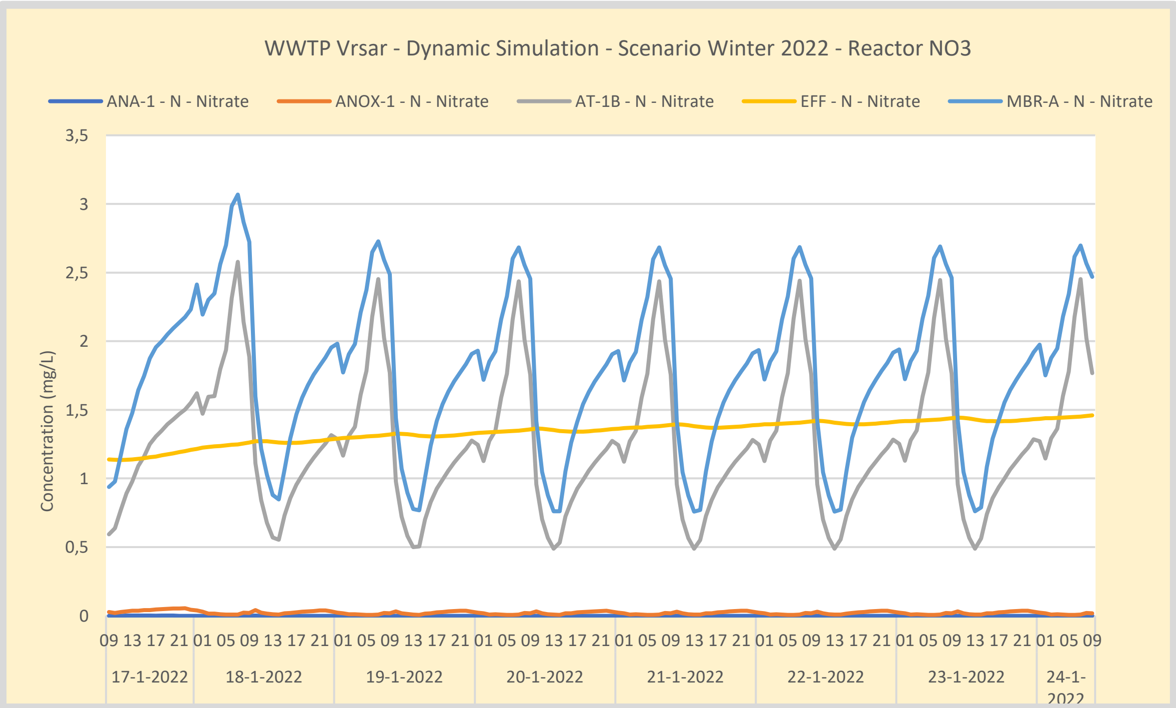


Figure 42. Winter 2022 - WWTP Vrsar nitrate in the different tank reactors.

Waterline concentration profiles modelling results

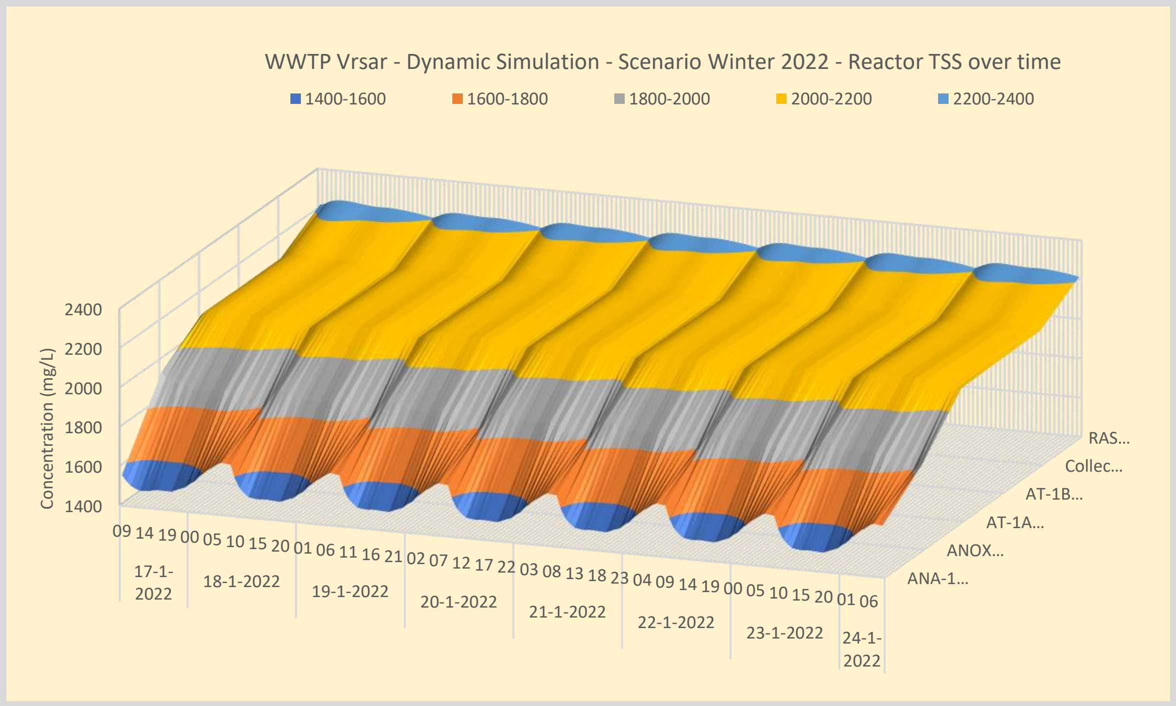


Figure 43. Winter 2022 - WWTP Vrsar TSS concentration profile over the waterline.

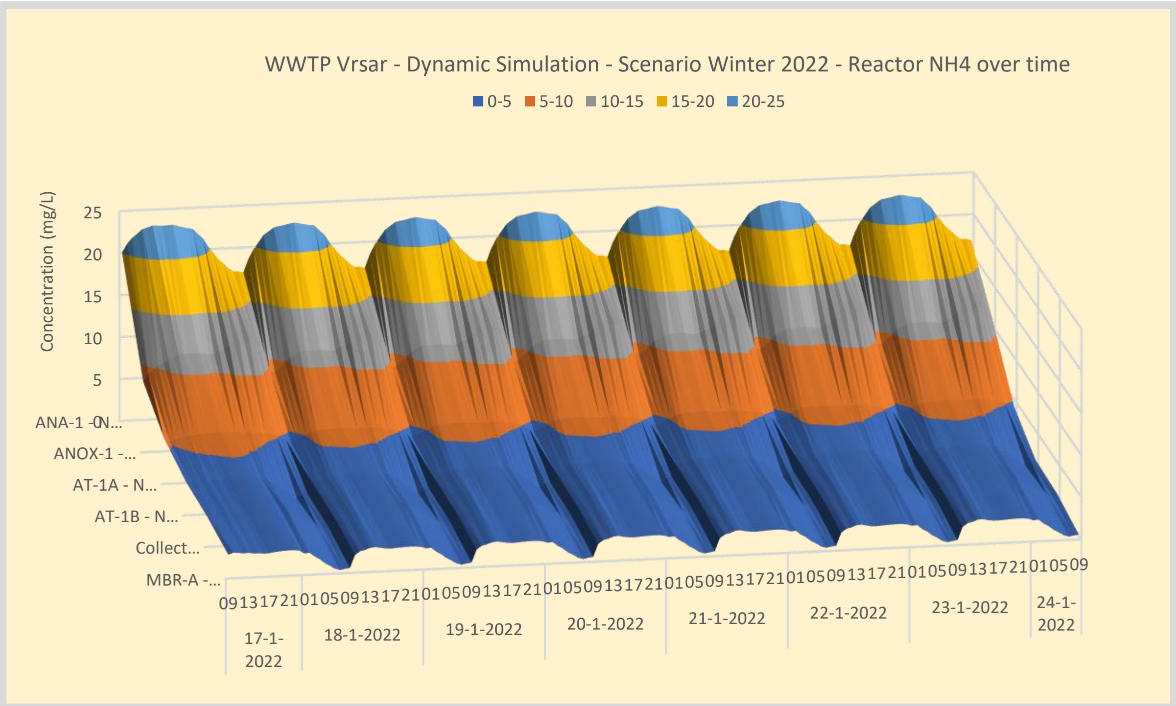


Figure 44. Winter 2022 - WWTP Vrsar NH4 concentration profile over the waterline.

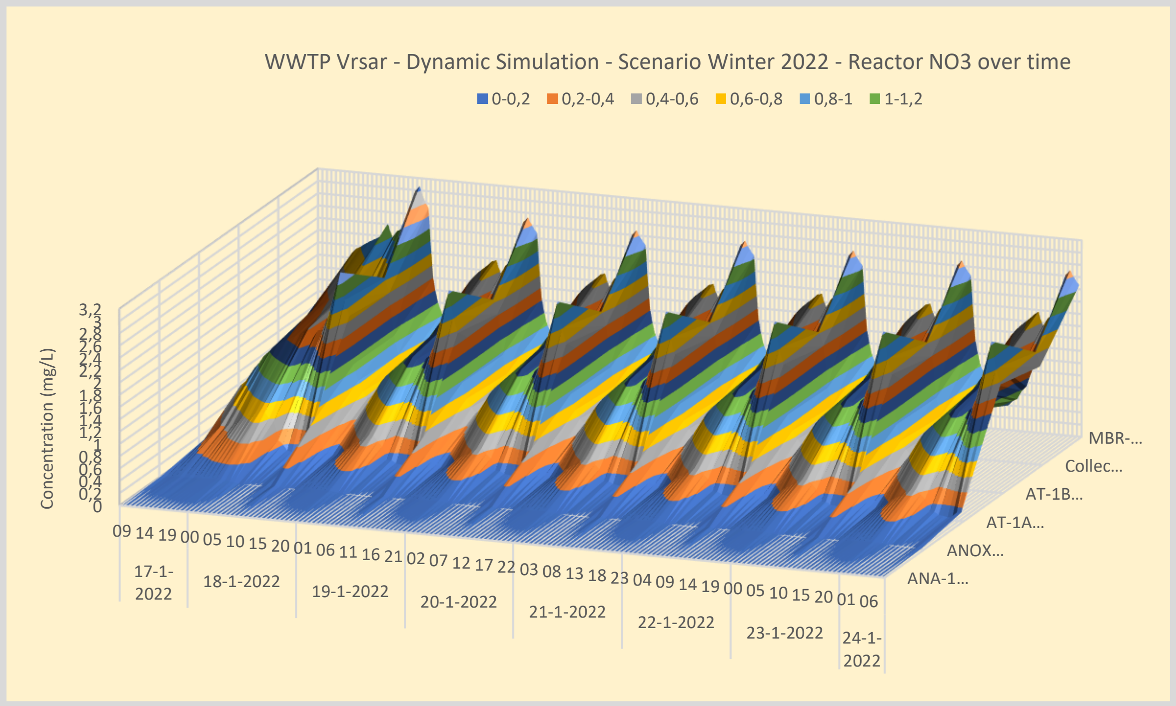


Figure 45. Winter 2022 - WWTP Vrsar NO3 concentration profile over the waterline.

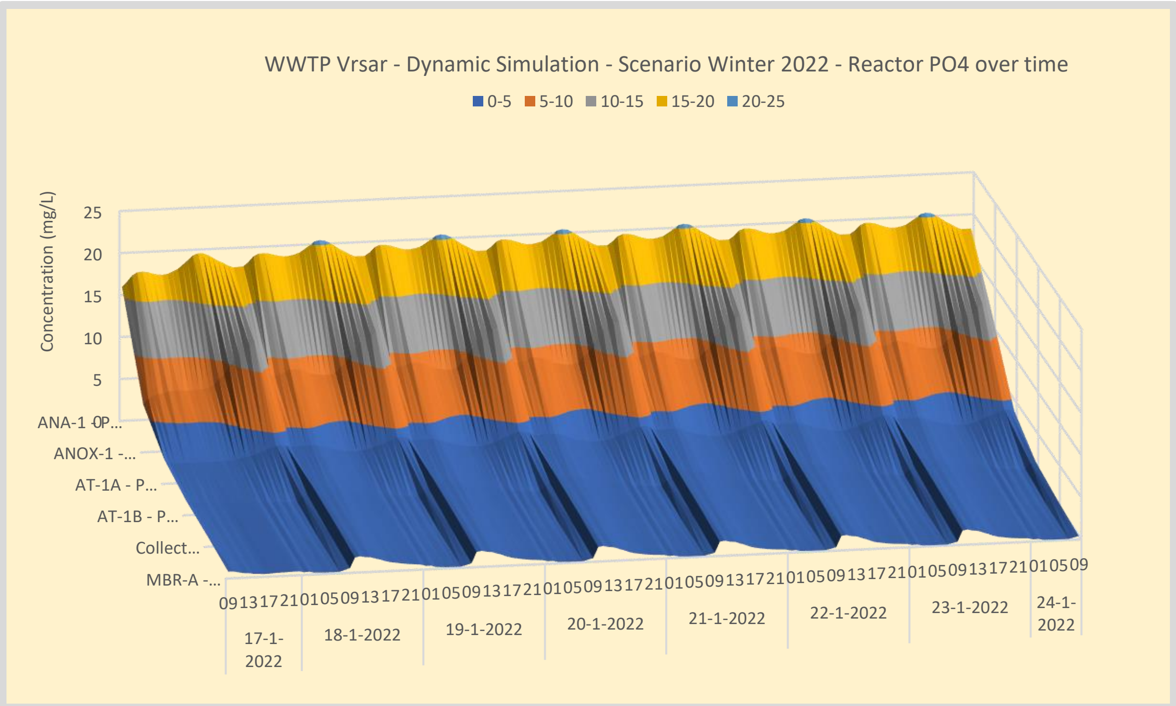


Figure 46. Winter 2022 - WWTP Vrsar PO4 concentration profile over the waterline.

Aeration and DO concentration modelling results

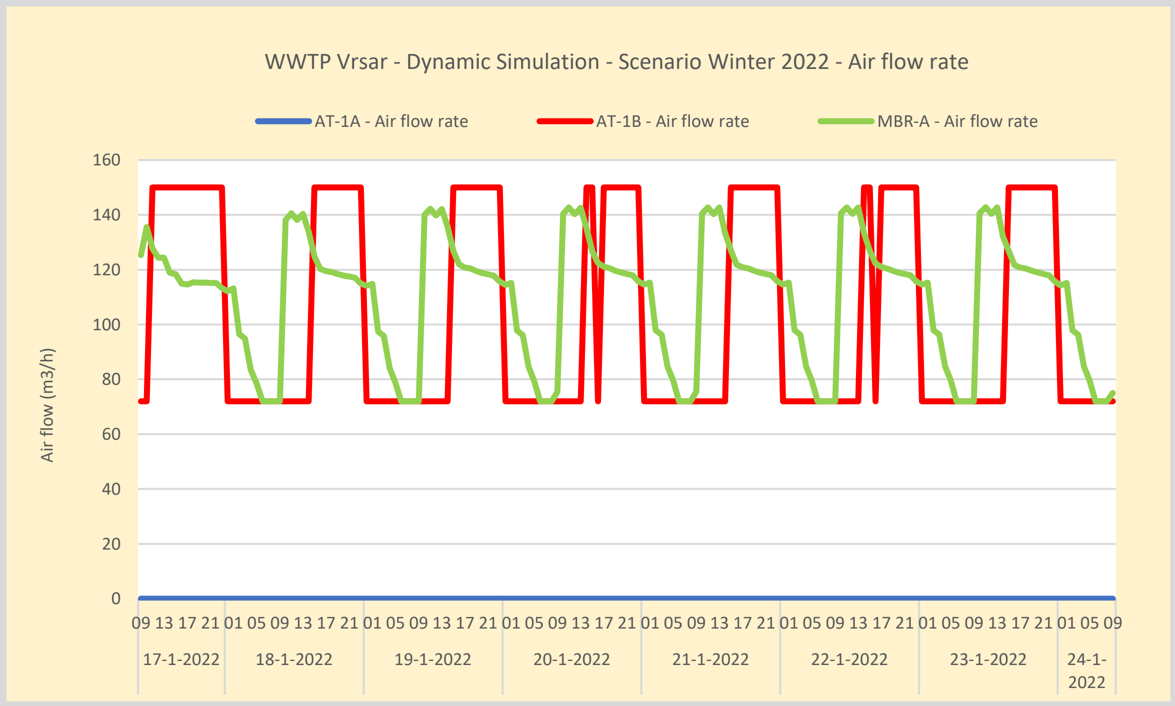


Figure 47. Winter 2022 - WWTP Vrsar air input in the different aerated reactors. AT-A is non aerated. AT-B is step airated based on measurement of NH4. MBR-A and B are DO setpoint controlled.

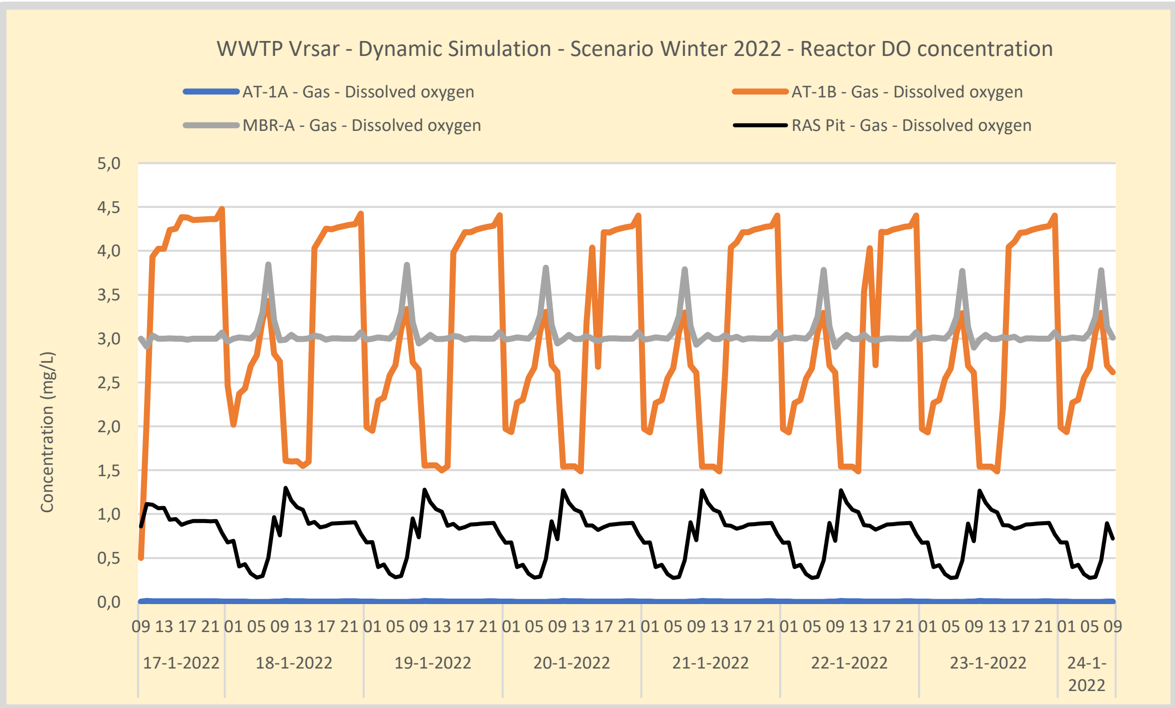


Figure 48. Winter 2022 - WWTP Vrsar DO concentration gradients. DO is controlled in the AT and MBR. DO is the result of the designed air input.

pH and alkalinity profiles modelling results

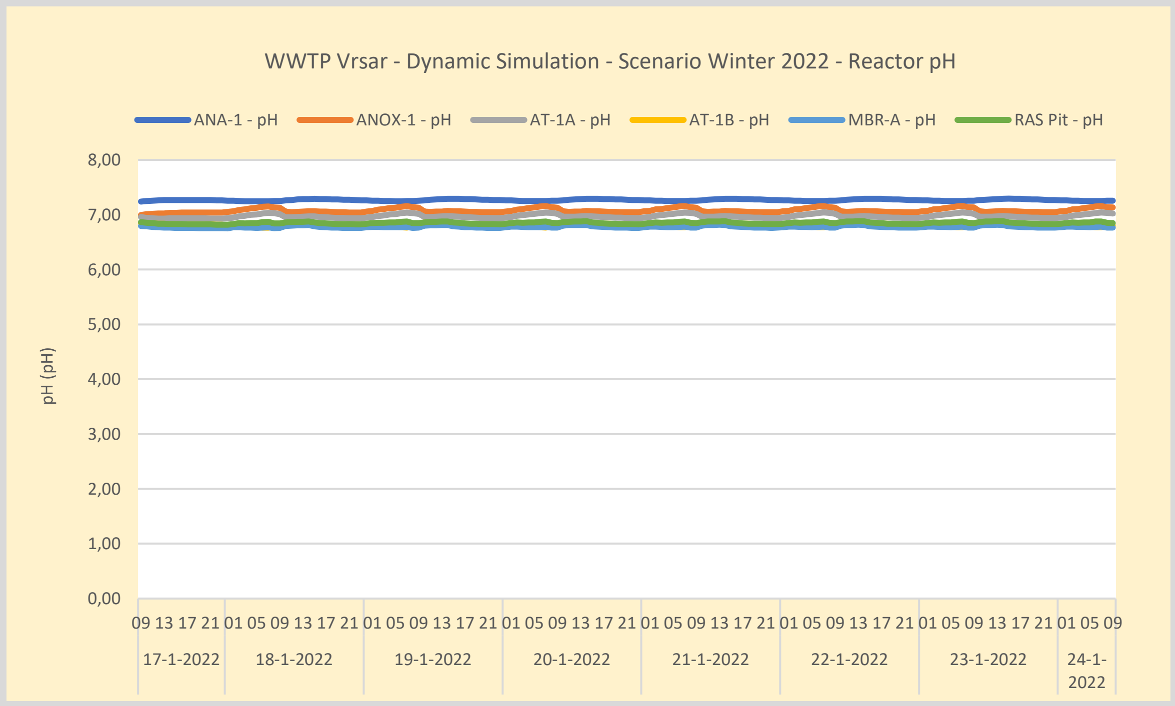


Figure 49. Winter 2022 - WWTP Vrsar pH profile over the activated sludge reactors.

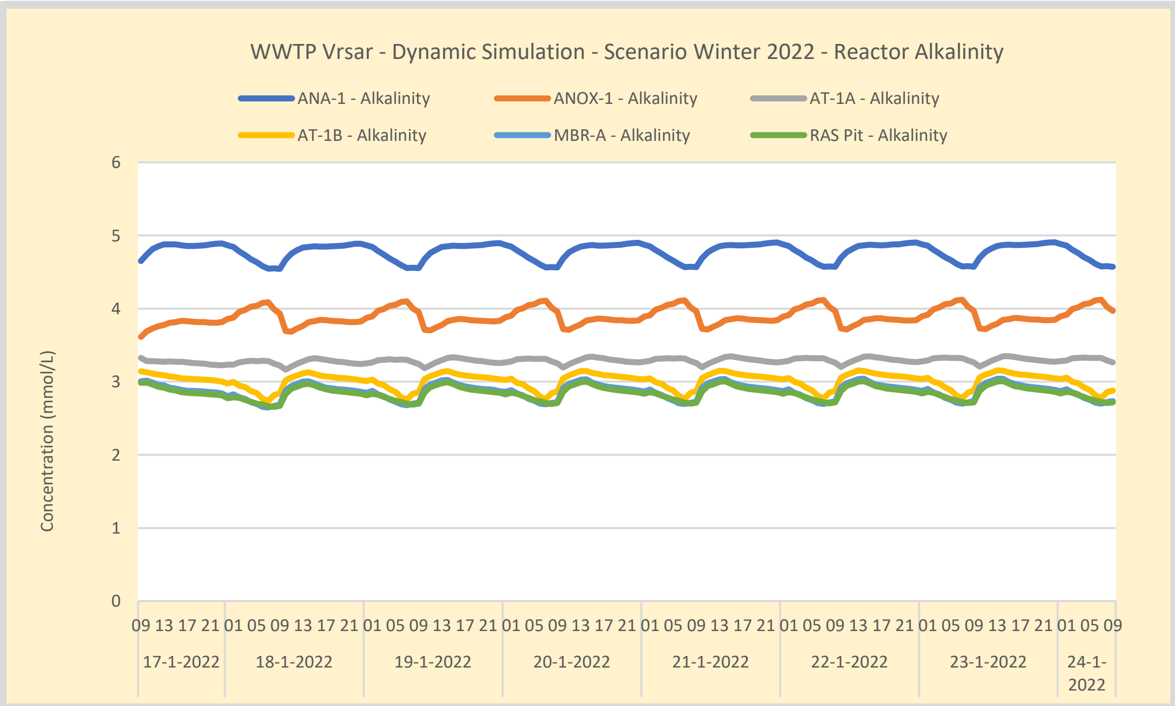


Figure 50. Winter 2022 - WWTP Vrsar alkalinity profile over the activated sludge reactors. Influent alkalinity is estimated from local drinking water quality measurements at 7,46 mmol/L. Alkalinity is not limiting.

Chemical load and flow modelling results

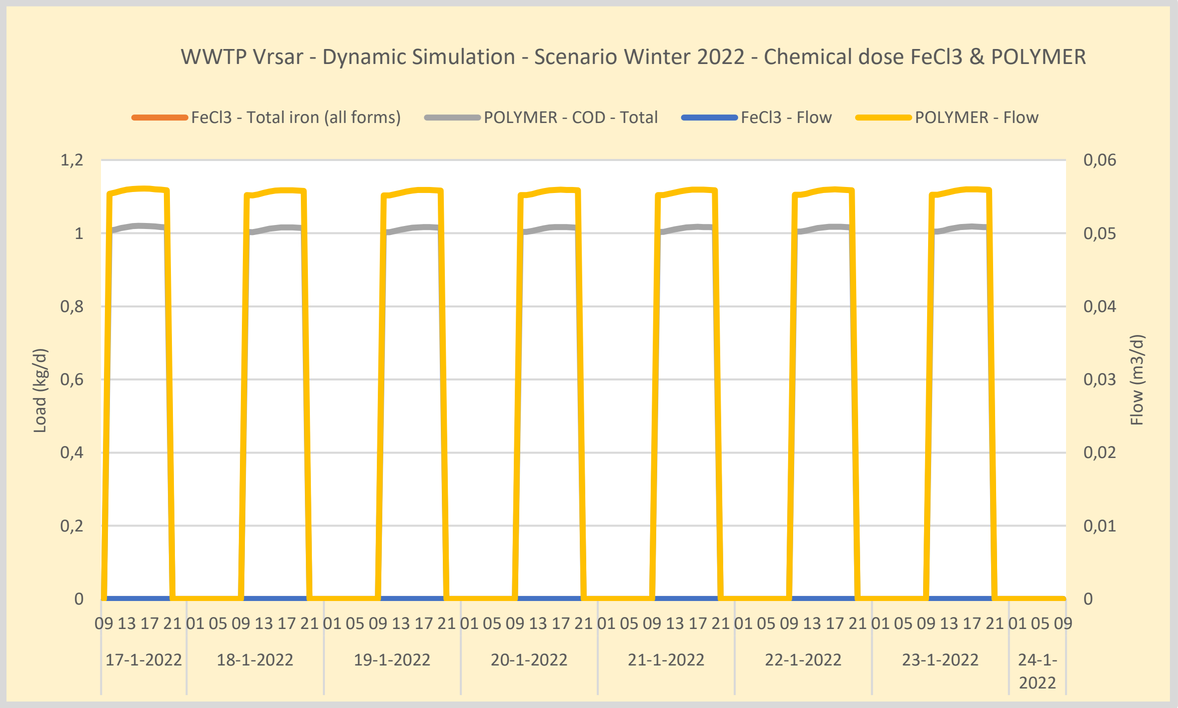


Figure 51. Winter 2022 - WWTP Vrsar load and flow of Iron and PE. No Iron dosage is used for P-removal. PE is assumed particulate biodegradable COD with a COD/VSS ratio of 1,42 gCOD/gTSS and dosed proportional to the WAS load based on 8 kg PE (dry weight) dosed per 1000 kg WAS (dry weight) flowing in the dewatering.

Sludge line operation modelling results

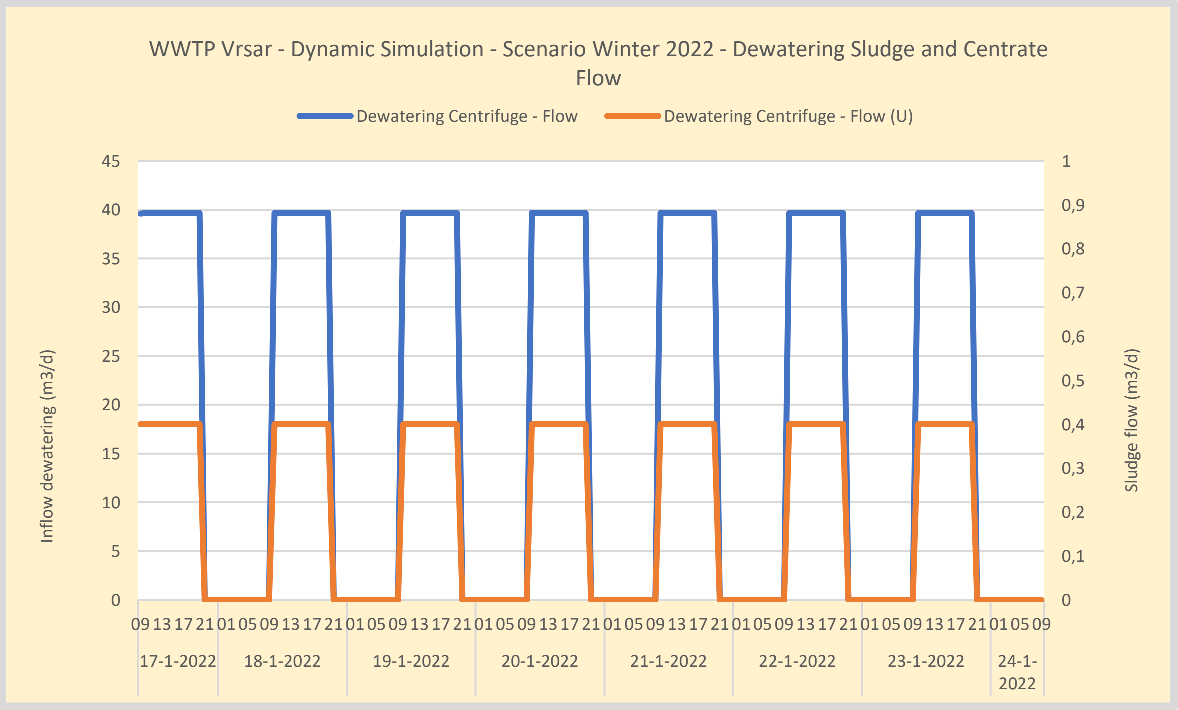


Figure 52. Winter 2022 - WWTP Vrsar dewatered sludge and centrate flow.

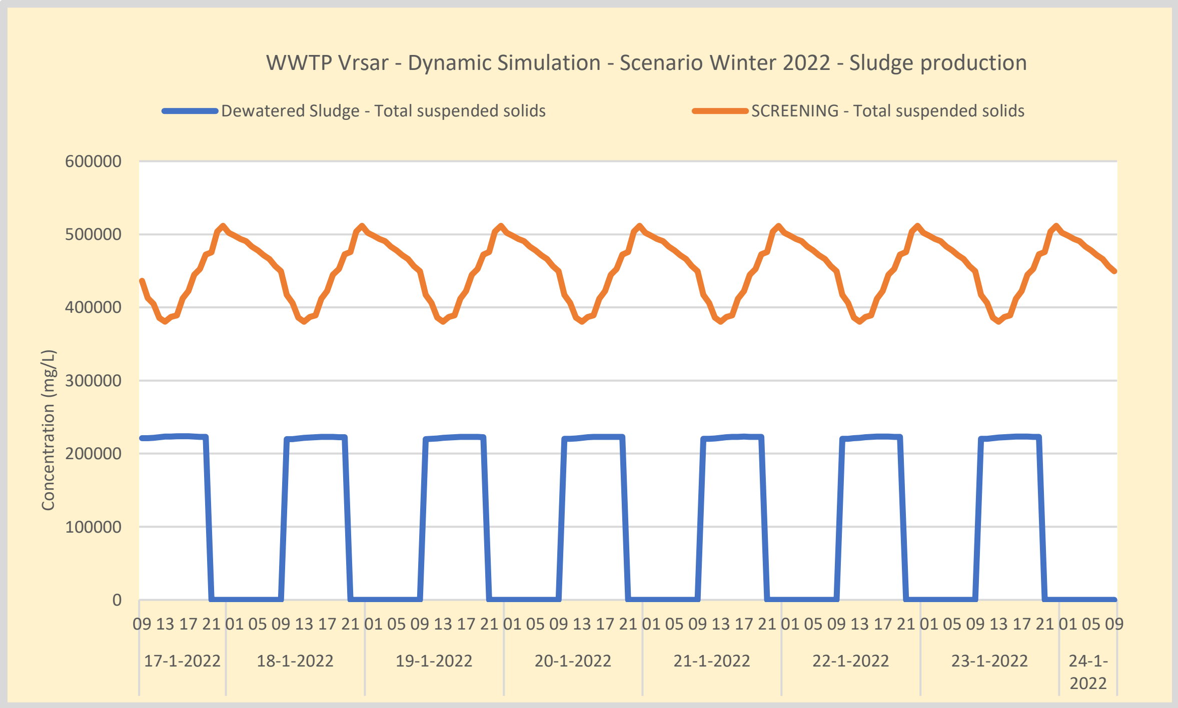


Figure 53. Winter 2022 - WWTP Vrsar dewatered sludge and screening sludge concentration. The design assumes dewatered sludge at 23% dry matter. Screening is an estimated concentration as the result of the press operation.

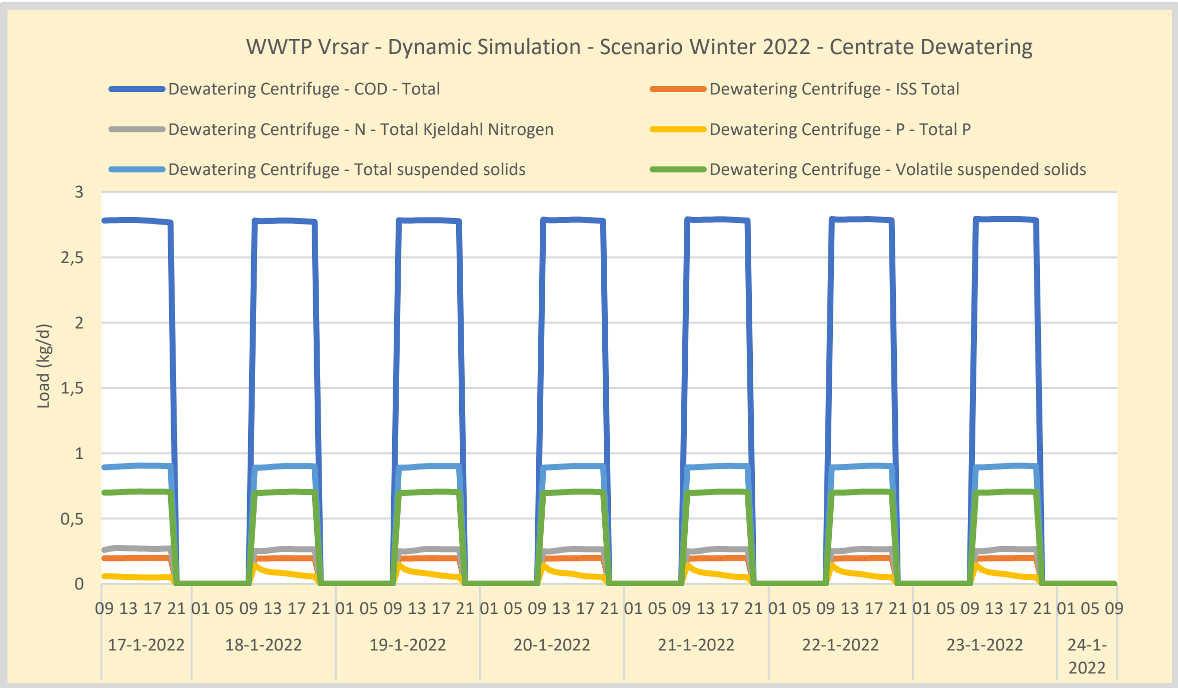


Figure 54. Winter 2022 - WWTP Vrsar Centrate load dewatering.

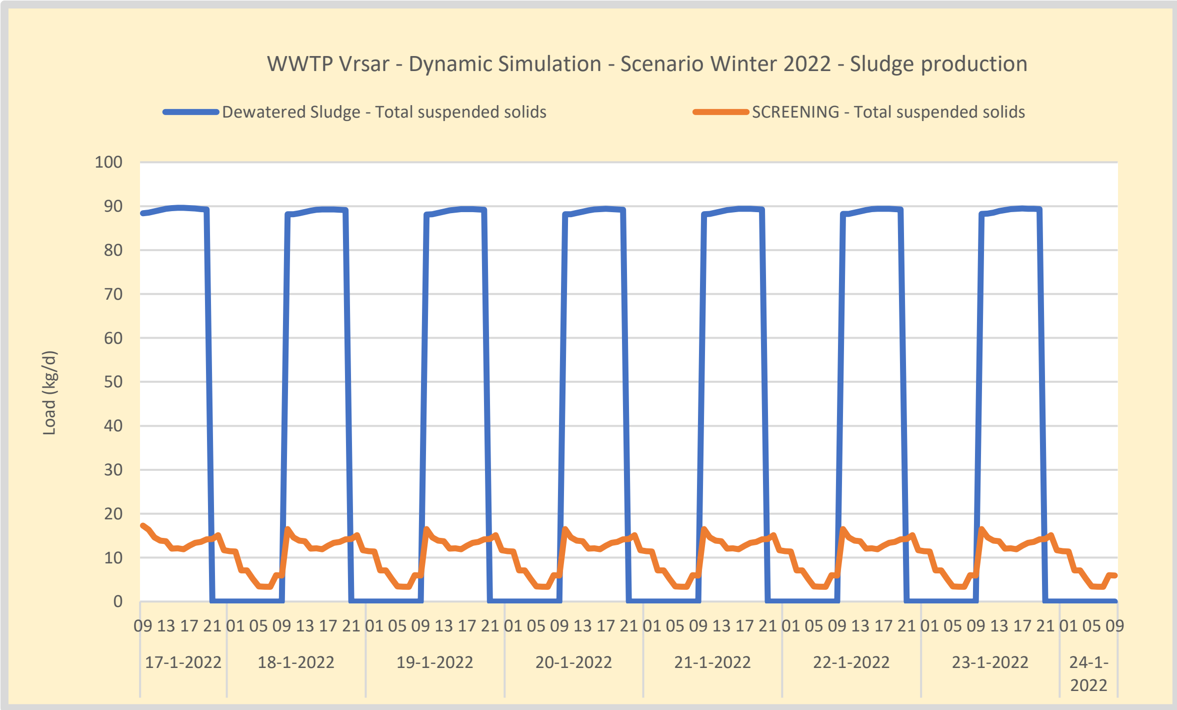


Figure 55. Winter 2022 - WWTP Vrsar dewatered sludge load and compacted screening load. Dewatered sludge is operated 10 hours a day at 23% dry solids. Screening is produces continuously as a factor of the influent.

Effluent modelling results

In the figures below the dynamic effluent quality of the plant is presented under winter conditions. The last day included a major rain event. The measurement is coming from the effluent buffer and has a reduced dynamic profile.

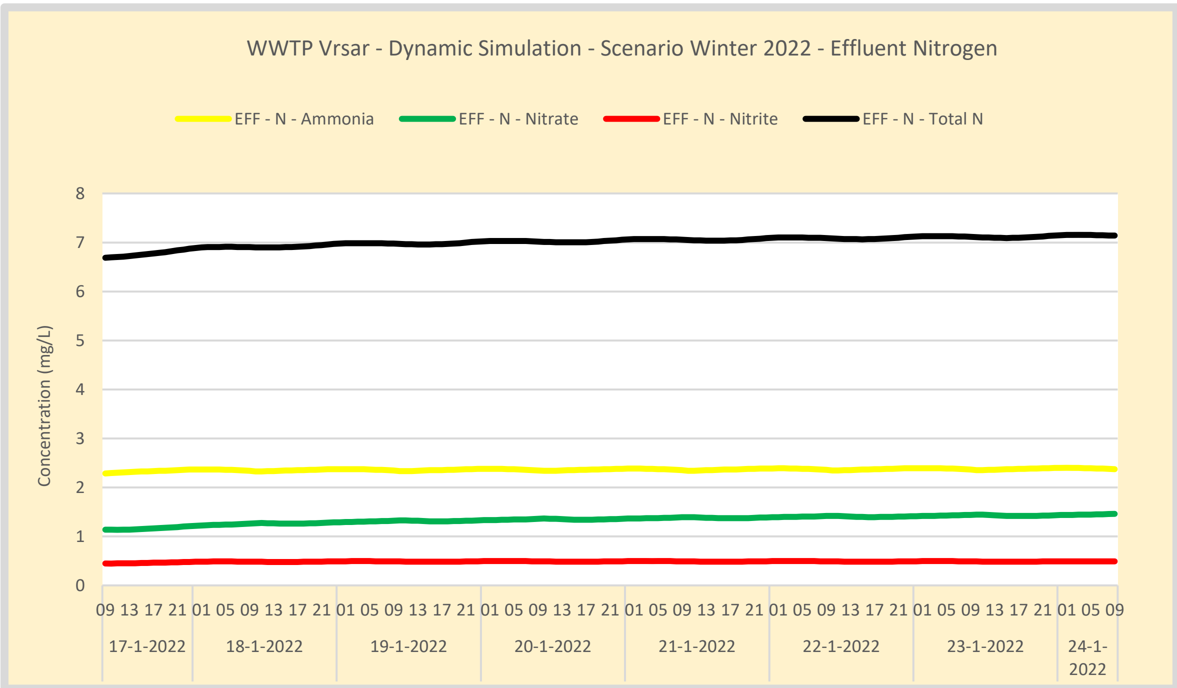


Figure 56. Winter 2022 - WWTP Vrsar Effluent nitrogen concentration. Effluent is measured in the outflow of the large effluent buffer.

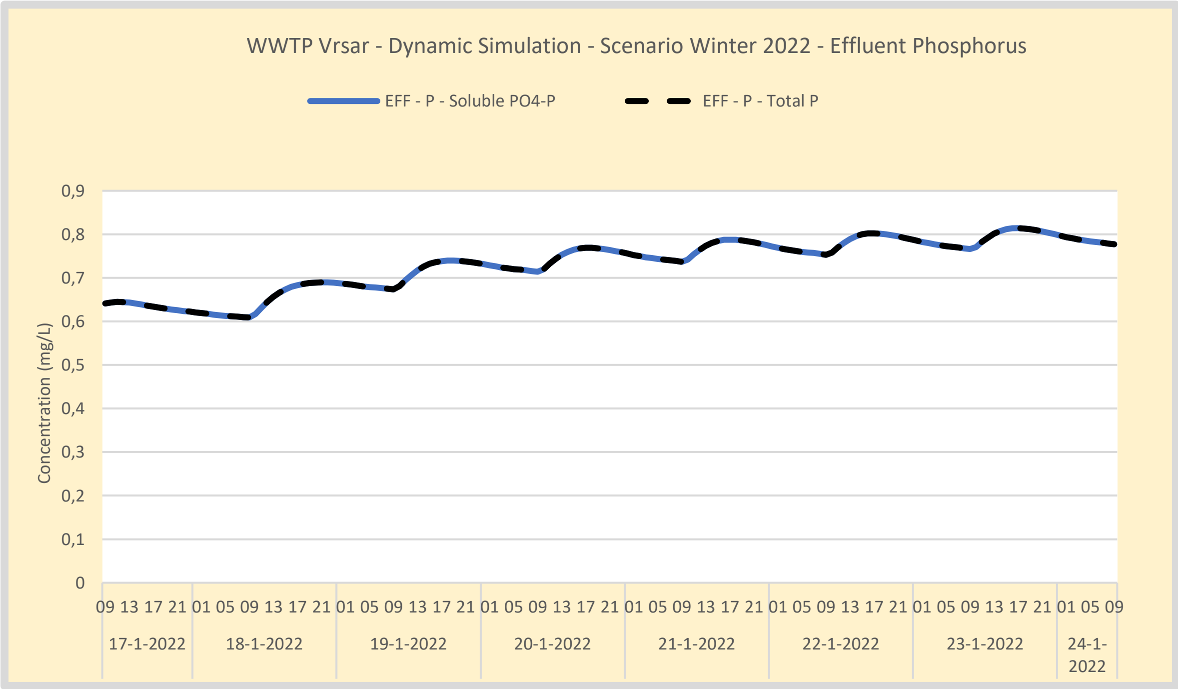


Figure 57. Winter 2022 - WWTP Vrsar Effluent phosphorus concentration. Effluent is measured in the outflow of the large effluent buffer.

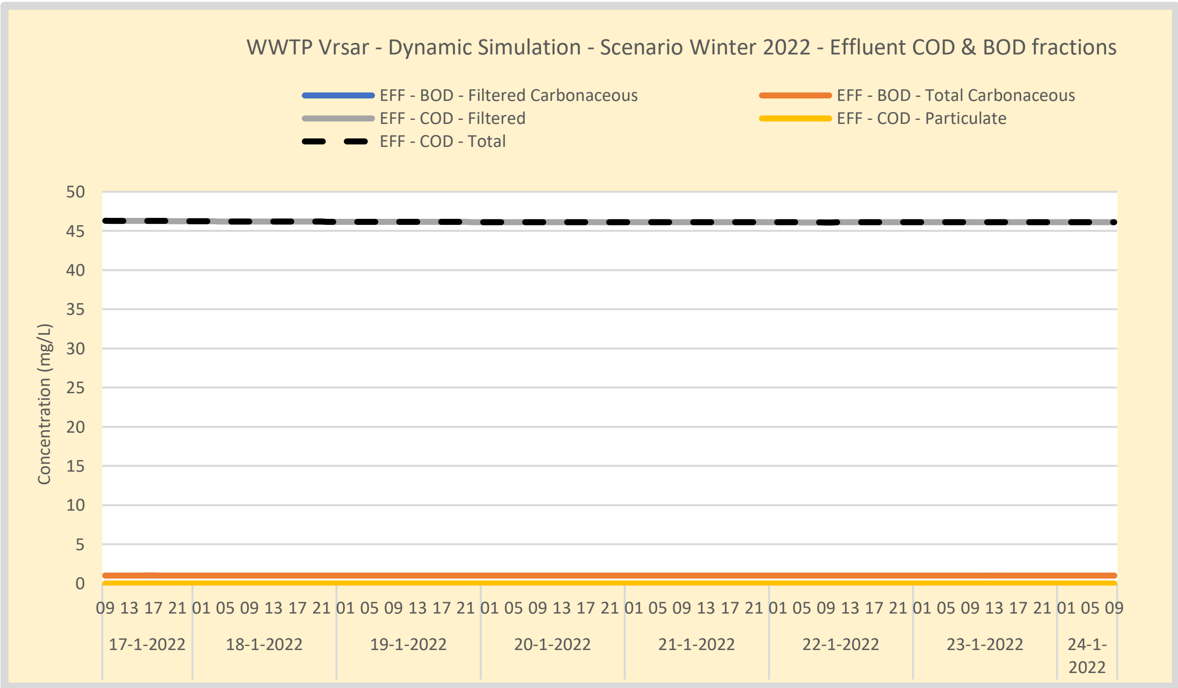


Figure 58. Winter 2022 - WWTP Vrsar Effluent COD and BOD concentration. Effluent is measured in the outflow of the large effluent buffer.

Appendix 5: BioWin configuration data calibration 2022

BioWin user and configuration data

Project details

Project name: Calibration Data Influent Winter 2022 Dynamic   Project ref.: Calibration Winter 2022 Dynamic Influent

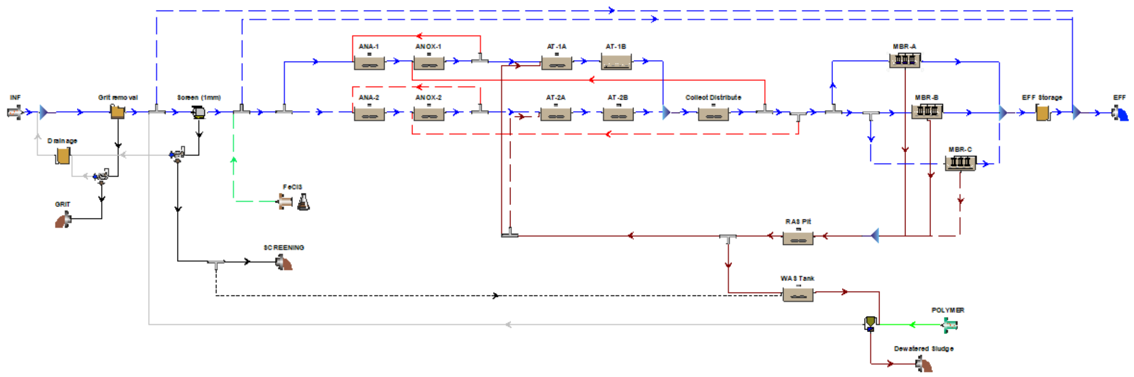
Plant name: WWTP Vrsar (VRS)   User name: ASM Design B.V.

Created: 15-2-2022   Saved: 2-3-2022

SRT: ** days**

Temperature: 10,0°C

Flowsheet



Configuration information for all Bioreactor units

Physical data

Element name	Volume [m3]	Area [m2]	Depth [m]	# of diffusers
ANA-1	200,0000	38,0952	5,250	Un-aerated
ANOX-1	175,0000	33,3333	5,250	Un-aerated
AT-1A	180,0000	34,2857	5,250	Un-aerated
ANA-2	200,0000	38,0952	5,250	Un-aerated
ANOX-2	175,0000	33,3333	5,250	Un-aerated
AT-2A	180,0000	34,2857	5,250	Un-aerated
Collect Distribute	94,5000	18,0000	5,250	Un-aerated
RAS Pit	40,0000	20,0000	2,000	Un-aerated
WAS Tank	2,0000	0,3810	5,250	Un-aerated
AT-1B	180,0000	34,2857	5,250	163
AT-2B	180,0000	34,2857	5,250	Un-aerated

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
ANA-1	0
ANOX-1	0
AT-1A	0
ANA-2	0
ANOX-2	0
AT-2A	0
Collect Distribute	0
RAS Pit	0
WAS Tank	0
AT-1B	0,5
AT-2B	0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	Diffuser mounting height	Min. air flow rate per diffuser m3/hr (20C, 1 atm)	Max. air flow rate per diffuser m3/hr (20C, 1 atm)	'A' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2	'B' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2	'C' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2
ANA-1	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
ANOX-1	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
AT-1A	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
ANA-2	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
ANOX-2	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
AT-2A	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
Collect Distribute	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
RAS Pit	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
WAS Tank	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
AT-1B	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0
AT-2B	1,2400	0,8960	0,8880	0,0380	0,2500	0,5000	10,0000	3,0000	0	0

Configuration information for all Bioreactor - MBR units

Physical data

Element name	Volume [m3]	Area [m2]	Depth [m]	# of diffusers	# of cassettes	Displaced volume / cassette [m3/cassette]	Membrane area / cassette [m2/cassette]	Total displaced volume [m3]	Membrane surface area [m2]

MBR-A	40,0000	7,6190	5,250	40	1,00	1,690	1306,10	1,69	1306,10
MBR-C	40,0000	7,6190	5,250	Un-aerated	1,00	1,690	1306,10	1,69	1306,10
MBR-B	40,0000	7,6190	5,250	40	1,00	1,690	1306,10	1,69	1306,10

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
MBR-A	3,0
MBR-C	0
MBR-B	3,0

Element name	Split method	Average Split specification
MBR-A	Flow paced	800,00 %
MBR-C	Ratio	1,00
MBR-B	Flow paced	800,00 %

Aeration equipment parameters

Element name	k1 in C = k1(PC)^0.25 + k2	k2 in C = k1(PC)^0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	Diffuser mounting height	Min. air flow rate per diffuser m3/hr (20C, 1 atm)	Max. air flow rate per diffuser m3/hr (20C, 1 atm)	'A' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2	'B' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2	'C' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2
MBR-A	0,0500	0,3800	1,0000	0,0500	0,2500	2,0000	50,0000	1,0000	0	0
MBR-C	0,0500	0,3800	1,0000	0,0500	0,2500	2,0000	50,0000	1,0000	0	0
MBR-B	0,0500	0,3800	1,0000	0,0500	0,2500	2,0000	50,0000	1,0000	0	0

Element name	Surface pressure [kPa]	Fractional effective saturation depth (Fed) [-]
MBR-A	101,3250	0,3000
MBR-C	101,3250	0,3000
MBR-B	101,3250	0,3000

Element name	Supply gas CO2 content [vol. %]	Supply gas O2 [vol. %]	Off-gas CO2 [vol. %]	Off-gas O2 [vol. %]	Off-gas H2 [vol. %]	Off-gas NH3 [vol. %]	Off-gas CH4 [vol. %]	Off-gas N2O [vol. %]	Surface turbulence factor [-]
MBR-A	0,0400	20,9500	1,2000	19,9000	0	0	0	0	2,0000
MBR-C	0,0400	20,9500	1,2000	19,9000	0	0	0	0	2,0000
MBR-B	0,0400	20,9500	1,2000	19,9000	0	0	0	0	2,0000

Configuration information for all Separator - Grit tank units

Physical data

Element name	Volume [m3]	Area [m2]	Depth [m]
Grit removal	12,8000	4,9231	2,600

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Grit removal	Flow paced	0,05 %

Element name	Percent removal	Blanket fraction
Grit removal	5,00	0,10

Configuration information for all Influent - COD units

Operating data Average (flow/time weighted as required)

Element name	INF
Flow	244,8
COD - Total mgCOD/L	640,98
N - Total Kjeldahl Nitrogen mgN/L	83,55
P - Total P mgP/L	9,93
S - Total S mgS/L	10,00
N - Nitrate mgN/L	0,40
pH	8,09
Alkalinity mmol/L	7,46
ISS Total mgISS/L	16,29
Metal soluble - Calcium mg/L	80,00
Metal soluble - Magnesium mg/L	15,00
Gas - Dissolved oxygen mg/L	0,10

Element name	INF
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0,2807
Fac - Acetate [gCOD/g of readily biodegradable COD]	0,2400
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0,8235
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0,0561
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0,1650
Fcel - Cellulose fraction of unbiodegradable particulate [gCOD/gCOD]	0,5000
Fna - Ammonia [gNH3-N/gTKN]	0,7844

Fnox - Particulate organic nitrogen [gN/g Organic N]	0,5000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0,0220
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0,0700
Fpo4 - Phosphate [gPO4-P/gTP]	0,5657
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0,0220
Fsr - Reduced sulfur [H2S] [gS/gS]	0,1500
FZbh - Ordinary heterotrophic COD fraction [gCOD/g of total COD]	0,0200
FZbm - Methylotrophic COD fraction [gCOD/g of total COD]	1,000E-4
FZao - Ammonia oxidizing COD fraction [gCOD/g of total COD]	1,000E-4
FZno - Nitrite oxidizing COD fraction [gCOD/g of total COD]	1,000E-4
FZaao - Anaerobic ammonia oxidizing COD fraction [gCOD/g of total COD]	1,000E-4
FZppa - Phosphorus accumulating COD fraction [gCOD/g of total COD]	1,000E-4
FZpa - Propionic acetogenic COD fraction [gCOD/g of total COD]	1,000E-4
FZam - Acetoclastic methanogenic COD fraction [gCOD/g of total COD]	1,000E-4
FZhm - Hydrogenotrophic methanogenic COD fraction [gCOD/g of total COD]	1,000E-4
FZso - Sulfur oxidizing COD fraction [gCOD/g of total COD]	1,000E-4
FZsrpa - Sulfur reducing propionic acetogenic COD fraction [gCOD/g of total COD]	1,000E-4
FZsra - Sulfur reducing acetotrophic COD fraction [gCOD/g of total COD]	1,000E-4
FZsrh - Sulfur reducing hydrogenotrophic COD fraction [gCOD/g of total COD]	1,000E-4
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0

Configuration information for all Input - Iron (as ferric chloride) units

Operating data Average (flow/time weighted as required)

Element name	FeCl3
Biomass - Ordinary heterotrophic [mgCOD/L]	0
Biomass - Methylotrophic [mgCOD/L]	0
Biomass - Ammonia oxidizing [mgCOD/L]	0

Biomass - Nitrite oxidizing [mgCOD/L]	0
Biomass - Anaerobic ammonia oxidizing [mgCOD/L]	0
Biomass - Phosphorus accumulating [mgCOD/L]	0
Biomass - Propionic acetogenic [mgCOD/L]	0
Biomass - Acetoclastic methanogenic [mgCOD/L]	0
Biomass - Hydrogenotrophic methanogenic [mgCOD/L]	0
Biomass - Endogenous products [mgCOD/L]	0
CODp - Slowly degradable particulate [mgCOD/L]	0
CODp - Slowly degradable colloidal [mgCOD/L]	0
CODp - Degradable external organics [mgCOD/L]	0
CODp - Undegradable non-cellulose [mgCOD/L]	0
CODp - Undegradable cellulose [mgCOD/L]	0
N - Particulate degradable organic [mgN/L]	0
P - Particulate degradable organic [mgP/L]	0
N - Particulate degradable external organics [mgN/L]	0
P - Particulate degradable external organics [mgP/L]	0
N - Particulate undegradable [mgN/L]	0
P - Particulate undegradable [mgP/L]	0
CODp - Stored PHA [mgCOD/L]	0
P - Releasable stored polyP [mgP/L]	0
P - Unreleasable stored polyP [mgP/L]	0
CODs - Complex readily degradable [mgCOD/L]	0
CODs - Acetate [mgCOD/L]	0
CODs - Propionate [mgCOD/L]	0
CODs - Methanol [mgCOD/L]	0
Gas - Dissolved hydrogen [mgCOD/L]	0
Gas - Dissolved methane [mg/L]	0
N - Ammonia [mgN/L]	0
N - Soluble degradable organic [mgN/L]	0
Gas - Dissolved nitrous oxide [mgN/L]	0
N - Nitrite [mgN/L]	0

N - Nitrate [mgN/L]	0
Gas - Dissolved nitrogen [mgN/L]	0
P - Soluble phosphate [mgP/L]	0
CODs - Undegradable [mgCOD/L]	0
N - Soluble undegradable organic [mgN/L]	0
Influent inorganic suspended solids [mgISS/L]	0
Precipitate - Struvite [mgISS/L]	0
Precipitate - Brushite [mgISS/L]	0
Precipitate - Hydroxy - apatite [mgISS/L]	0
Precipitate - Vivianite [mgISS/L]	0
HFO - High surface [mg/L]	0
HFO - Low surface [mg/L]	0
HFO - High with H2PO4- adsorbed [mg/L]	0
HFO - Low with H2PO4- adsorbed [mg/L]	0
HFO - Aged [mg/L]	0
HFO - Low with H+ adsorbed [mg/L]	0
HFO - High with H+ adsorbed [mg/L]	0
HAO - High surface [mg/L]	0
HAO - Low surface [mg/L]	0
HAO - High with H2PO4- adsorbed [mg/L]	0
HAO - Low with H2PO4- adsorbed [mg/L]	0
HAO - Aged [mg/L]	0
P - Bound on aged HMO [mgP/L]	0
Metal soluble - Magnesium [mg/L]	0
Metal soluble - Calcium [mg/L]	0
Metal soluble - Ferric [mg/L]	150000,00
Metal soluble - Ferrous [mg/L]	0
Metal soluble - Aluminum [mg/L]	0
Other Cations (strong bases) [meq/L]	5,00
Other Anions (strong acids) [meq/L]	8062,73
Gas - Dissolved total CO2 [mmol/L]	7,00

User defined - UD1 [mg/L]	0
User defined - UD2 [mg/L]	0
User defined - UD3 [mgVSS/L]	0
User defined - UD4 [mgISS/L]	0
Biomass - Sulfur oxidizing [mgCOD/L]	0
Biomass - Sulfur reducing propionic acetogenic [mgCOD/L]	0
Biomass - Sulfur reducing acetotrophic [mgCOD/L]	0
Biomass - Sulfur reducing hydrogenotrophic [mgCOD/L]	0
Gas - Dissolved total sulfides [mgS/L]	0
S - Soluble sulfate [mgS/L]	0
S - Particulate elemental sulfur [mgS/L]	0
Precipitate - Ferrous sulfide [mgISS/L]	0
CODp - Adsorbed hydrocarbon [mgCOD/L]	0
CODs - Degradable volatile ind. #1 [mgCOD/L]	0
CODs - Degradable volatile ind. #2 [mgCOD/L]	0
CODs - Degradable volatile ind. #3 [mgCOD/L]	0
CODs - Soluble hydrocarbon [mgCOD/L]	0
Gas - Dissolved oxygen [mg/L]	0
Flow	0

Configuration information for all Separator - Dewatering unit units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Compacter1	Flow paced	0,01 %
Compacter2	Flow paced	0,01 %

Element name	Percent removal
Compacter1	100,00
Compacter2	100,00

Configuration information for all Separator - Microscreen units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Screen (1mm)	Flow paced	0,02 %

Element name	Percent removal
Screen (1mm)	5,00

Configuration information for all Separator - Cyclone (dewatering) units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Dewatering Centrifuge	Fraction	0,01

Element name	Percent removal
Dewatering Centrifuge	99,00

Configuration information for all Splitter units

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
ANA-R1	Flowrate [Side]	1250
ANA-R2	Flowrate [Side]	0
MBR Distributer1	Ratio	1,00
AS Emergency Bypass	Bypass	4800
INF Distributer	Flowrate [Main]	0
Screen Emergency Bypass	Bypass	6000
ANOX-R2	Flowrate [Side]	0
ANOX-R1	Flow paced	800,00 %
RAS Splitter	Flowrate [Side]	0
WAS Splitter	Flowrate [Side]	18,333332
MBR Distributer2	Flowrate [Side]	0
SCREENING Splitter	Flowrate [Side]	0

Configuration information for all Influent - State variable units

Operating data Average (flow/time weighted as required)

Element name	POLYMER
Biomass - Ordinary heterotrophic [mgCOD/L]	0
Biomass - Methylotrophic [mgCOD/L]	0
Biomass - Ammonia oxidizing [mgCOD/L]	0
Biomass - Nitrite oxidizing [mgCOD/L]	0
Biomass - Anaerobic ammonia oxidizing [mgCOD/L]	0
Biomass - Phosphorus accumulating [mgCOD/L]	0

Biomass - Propionic acetogenic [mgCOD/L]	0
Biomass - Acetoclastic methanogenic [mgCOD/L]	0
Biomass - Hydrogenotrophic methanogenic [mgCOD/L]	0
Biomass - Endogenous products [mgCOD/L]	0
CODp - Slowly degradable particulate [mgCOD/L]	18180,00
CODp - Slowly degradable colloidal [mgCOD/L]	0
CODp - Degradable external organics [mgCOD/L]	0
CODp - Undegradable non-cellulose [mgCOD/L]	0
CODp - Undegradable cellulose [mgCOD/L]	0
N - Particulate degradable organic [mgN/L]	0
P - Particulate degradable organic [mgP/L]	0
N - Particulate degradable external organics [mgN/L]	0
P - Particulate degradable external organics [mgP/L]	0
N - Particulate undegradable [mgN/L]	0
P - Particulate undegradable [mgP/L]	0
CODp - Stored PHA [mgCOD/L]	0
P - Releasable stored polyP [mgP/L]	0
P - Unreleasable stored polyP [mgP/L]	0
CODs - Complex readily degradable [mgCOD/L]	0
CODs - Acetate [mgCOD/L]	0
CODs - Propionate [mgCOD/L]	0
CODs - Methanol [mgCOD/L]	0
Gas - Dissolved hydrogen [mgCOD/L]	0
Gas - Dissolved methane [mg/L]	0
N - Ammonia [mgN/L]	0
N - Soluble degradable organic [mgN/L]	0
Gas - Dissolved nitrous oxide [mgN/L]	0
N - Nitrite [mgN/L]	0
N - Nitrate [mgN/L]	0
Gas - Dissolved nitrogen [mgN/L]	0
P - Soluble phosphate [mgP/L]	0

CODs - Undegradable [mgCOD/L]	0
N - Soluble undegradable organic [mgN/L]	0
Influent inorganic suspended solids [mgISS/L]	0
Precipitate - Struvite [mgISS/L]	0
Precipitate - Brushite [mgISS/L]	0
Precipitate - Hydroxy - apatite [mgISS/L]	0
Precipitate - Vivianite [mgISS/L]	0
HFO - High surface [mg/L]	0
HFO - Low surface [mg/L]	0
HFO - High with H2PO4- adsorbed [mg/L]	0
HFO - Low with H2PO4- adsorbed [mg/L]	0
HFO - Aged [mg/L]	0
HFO - Low with H+ adsorbed [mg/L]	0
HFO - High with H+ adsorbed [mg/L]	0
HAO - High surface [mg/L]	0
HAO - Low surface [mg/L]	0
HAO - High with H2PO4- adsorbed [mg/L]	0
HAO - Low with H2PO4- adsorbed [mg/L]	0
HAO - Aged [mg/L]	0
P - Bound on aged HMO [mgP/L]	0
Metal soluble - Magnesium [mg/L]	0
Metal soluble - Calcium [mg/L]	0
Metal soluble - Ferric [mg/L]	0
Metal soluble - Ferrous [mg/L]	0
Metal soluble - Aluminum [mg/L]	0
Other Cations (strong bases) [meq/L]	0
Other Anions (strong acids) [meq/L]	0
Gas - Dissolved total CO2 [mmol/L]	0
User defined - UD1 [mg/L]	0
User defined - UD2 [mg/L]	0
User defined - UD3 [mgVSS/L]	0

User defined - UD4 [mgISS/L]	0
Biomass - Sulfur oxidizing [mgCOD/L]	0
Biomass - Sulfur reducing propionic acetogenic [mgCOD/L]	0
Biomass - Sulfur reducing acetotrophic [mgCOD/L]	0
Biomass - Sulfur reducing hydrogenotrophic [mgCOD/L]	0
Gas - Dissolved total sulfides [mgS/L]	0
S - Soluble sulfate [mgS/L]	0
S - Particulate elemental sulfur [mgS/L]	0
Precipitate - Ferrous sulfide [mgISS/L]	0
CODp - Adsorbed hydrocarbon [mgCOD/L]	0
CODs - Degradable volatile ind. #1 [mgCOD/L]	0
CODs - Degradable volatile ind. #2 [mgCOD/L]	0
CODs - Degradable volatile ind. #3 [mgCOD/L]	0
CODs - Soluble hydrocarbon [mgCOD/L]	0
Gas - Dissolved oxygen [mg/L]	0
Flow	0,04294583021

Configuration information for all Equalization Tank units

Physical data

Element name	Volume[m3]	Area[m2]	Depth[m]
EFF Storage	1400,0000	266,6667	5,250
Drainage	27,0000	9,0000	3,000

BioWin Album

Album page - Loads Overview

Elements	Flow [m3/d]	Total suspended solids [kg /d]	Volatile suspended solids [kg /d]	ISS Total [kg /d]	BOD - Total Carbonaceous [kg /d]	COD - Total [kg /d]	N - Total N [kg N/d]	P - Total P [kg P/d]
INF	396,00	95,83	90,28	5,54	104,76	232,45	32,79	3,52
Drainage	0,07	0	0	0	0,01	0,02	0,00	0,00
GRIT	0,04	0,11	0,02	0,09	0,01	0,04	0,00	0,00
SCREENING	0,04	5,94	5,87	0,07	0,91	8,28	0,27	0,09
Dewatering Centrifuge	0,09	0	0	0	0	0	0	0
Screen (1mm)	132,01	29,22	27,96	1,27	38,34	78,83	9,94	1,14
ANA-1	1381,97	2299,07	1861,29	437,79	584,63	2693,69	174,62	115,95
ANOX-1	2437,97	4460,54	3552,41	908,13	1082,65	5118,96	320,01	224,30
AT-1A	3299,97	6846,12	5367,29	1478,83	1590,23	7703,48	464,07	343,43
AT-1B	3299,97	6858,97	5356,42	1502,56	1581,03	7688,25	463,32	343,65
Collect Distribute	3299,97	6867,47	5356,43	1511,04	1576,95	7685,30	461,56	343,90
MBR-A	0,00	0	0	0	0,00	0,00	0,00	0,00
EFF Storage	131,97	0,00	0,00	0,00	0,13	6,08	0,94	0,10
EFF	131,97	0,00	0,00	0,00	0,13	6,08	0,94	0,10
RAS Pit	2112,00	4676,07	3641,14	1034,93	1066,55	5217,19	312,48	234,31
WAS Tank	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
FeCl3	0	0	0	0	0	0	0	0
POLYMER	0,09	1,11	1,10	0,01	0,85	1,70	0	0

Album page - Loads

Elements	INF	GRIT	SCREENING	EFF	Dewatered Sludge	FeCl3	POLYMER
Flow [m3/d]	396,00	0,04	0,04	131,97	0,00	0	0,09
Total suspended solids [kg /d]	95,83	0,11	5,94	0,00	0	0	1,11
Volatile suspended solids [kg /d]	90,28	0,02	5,87	0,00	0	0	1,10

ISS Total [kg /d]	5,54	0,09	0,07	0,00	0	0	0,01
BOD - Total Carbonaceous [kg /d]	104,76	0,01	0,91	0,13	0	0	0,85
COD - Total [kg /d]	232,45	0,04	8,28	6,08	0	0	1,70
N - Total N [kg N/d]	32,79	0,00	0,27	0,94	0	0	0
P - Total P [kg P/d]	3,52	0,00	0,09	0,10	0	0	0
Total iron (all forms) [kg Me/d]	0	0,00	0,00	0,00	0	0	0

Album page - Concentration Overview

Elements	Flow [m3/d]	Total suspended solids [mg/L]	Volatile suspended solids [mg/L]	ISS Total [mg/L]	BOD - Total Carbonaceous [mg/L]	COD - Total [mg/L]	N - Total N [mgN/L]	P - Total P [mgP/L]
INF	396,00	241,99	227,99	14,00	264,53	587,00	82,80	8,90
Drainage	0,07	0	0	0	153,27	266,86	72,70	5,55
GRIT	0,04	2766,86	414,57	2352,29	377,64	887,79	90,89	12,79
SCREENING	0,04	149907,52	148224,63	1682,89	23054,38	208980,51	6784,17	2274,41
Dewatering Centrifuge	0,09	0	0	0	0	0	0	0
Screen (1mm)	132,01	221,37	211,77	9,60	290,45	597,12	75,31	8,63
ANA-1	1381,97	1663,62	1346,83	316,78	423,04	1949,16	126,36	83,90
ANOX-1	2437,97	1829,61	1457,12	372,49	444,08	2099,68	131,26	92,00
AT-1A	3299,97	2074,60	1626,46	448,13	481,89	2334,41	140,63	104,07
AT-1B	3299,97	2078,49	1623,17	455,32	479,10	2329,79	140,40	104,14
Collect Distribute	3299,97	2081,07	1623,17	457,89	477,87	2328,90	139,87	104,21
MBR-A	0,00	0	0	0	0,80	46,21	6,06	0,41
EFF Storage	131,97	0,00	0,00	0,00	1,00	46,11	7,14	0,78
EFF	131,97	0,00	0,00	0,00	1,00	46,11	7,14	0,78
RAS Pit	2112,00	2214,05	1724,02	490,02	505,00	2470,26	147,96	110,94
WAS Tank	0,00	2216,27	1738,00	478,28	504,78	2491,88	148,95	111,80

FeCl3	0	0	0	0	0	0	0	0
POLYMER	0,09	11806,88	11729,03	77,85	9092,92	18180,00	0	0

Album page - Concentrations

Elements	INF	ANA-1	ANOX-1	AT-1B	Collect Distribute	EFF	RAS Pit
Flow [m3/d]	396,00	1381,97	2437,97	3299,97	3299,97	131,97	2112,00
Total suspended solids [mg/L]	241,99	1663,62	1829,61	2078,49	2081,07	0,00	2214,05
Volatile suspended solids [mg/L]	227,99	1346,83	1457,12	1623,17	1623,17	0,00	1724,02
ISS Total [mg/L]	14,00	316,78	372,49	455,32	457,89	0,00	490,02
BOD - Total Carbonaceous [mg/L]	264,53	423,04	444,08	479,10	477,87	1,00	505,00
BOD - Filtered Carbonaceous [mg/L]	142,25	1,38	0,28	0,97	0,49	1,00	0,62
COD - Total [mg/L]	587,00	1949,16	2099,68	2329,79	2328,90	46,11	2470,26
COD - Particulate [mg/L]	339,88	1903,30	2055,02	2283,47	2283,20	0,00	2424,27
COD - Filtered [mg/L]	247,12	45,86	44,66	46,32	45,70	46,11	45,99
N - Total N [mgN/L]	82,80	126,36	131,26	140,40	139,87	7,14	147,96
N - Total Kjeldahl Nitrogen [mgN/L]	82,40	126,36	131,24	138,25	138,04	5,19	145,37
N - Particulate TKN [mgN/L]	10,11	106,94	117,61	133,50	133,63	0,00	142,19
N - Ammonia [mgN/L]	64,63	16,97	11,16	1,95	1,67	2,37	0,37
N - Nitrate [mgN/L]	0,40	0,00	0,02	1,77	1,60	1,46	2,50
N - Nitrite [mgN/L]	0	0,00	0,00	0,39	0,23	0,49	0,09
P - Total P [mgP/L]	8,90	83,90	92,00	104,14	104,21	0,78	110,94
P - Soluble PO4-P [mgP/L]	5,03	18,31	11,60	1,76	0,99	0,78	0,25

Album page - Conversions

Elements	Nit - Ammonia removal rate [kg/d]	Denit - Nitrate removal rate [kg/d]	OTR [kg/d]	OUR - Carbonaceous [kg/d]	OUR - Nitrification [kg/d]	OUR - Sulfur [kg/d]	OUR - Total [kg/d]	SOTR [kg/d]

ANA-1	0,00	0,07	0	0,00	0,00	0,01	0,01	0
ANA-2	0	0	0	0	0	0	0	0
ANOX-1	0,00	1,66	0	0,02	0,00	0,14	0,16	0
ANOX-2	0	0	0	0	0	0	0	0
AT-1A	0,02	4,85	0	0,14	0,08	1,30	1,52	0
AT-1B	8,08	1,88	61,54	20,20	33,05	6,64	59,90	156,59
AT-2A	0	0	0	0	0	0	0	0
AT-2B	0	0	0	0	0	0	0	0
Collect Distribute	0,92	2,30	0	2,28	4,31	1,54	8,13	0
MBR-A	1,18	0,35	9,31	3,75	5,07	0,31	9,12	35,93
MBR-B	1,18	0,35	9,31	3,75	5,07	0,31	9,12	35,93
MBR-C	0,00	0,00	0	0,00	0,00	0,00	0,00	0
RAS Pit	0,58	0,77	0	2,07	2,64	0,19	4,89	0
WAS Tank	0	0	0	0	0	0	0	0

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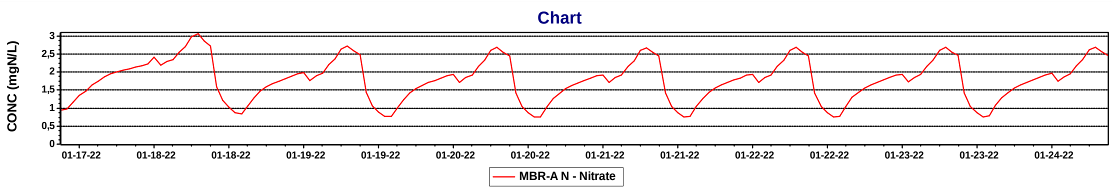

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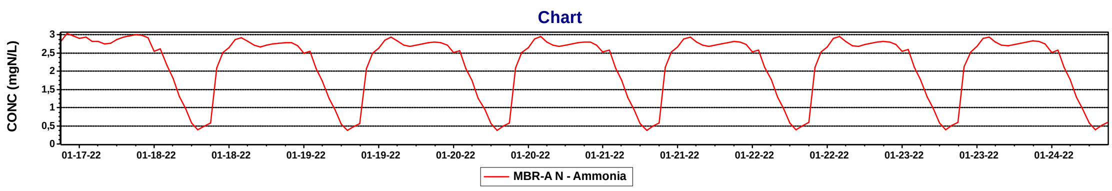

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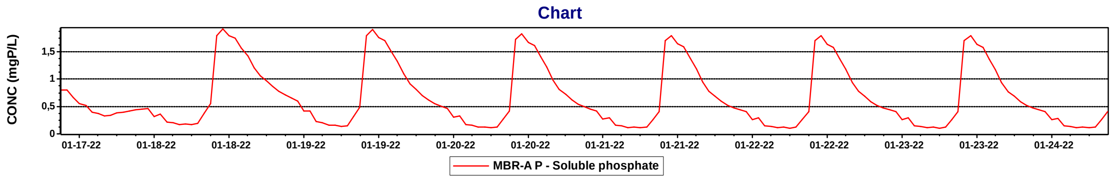

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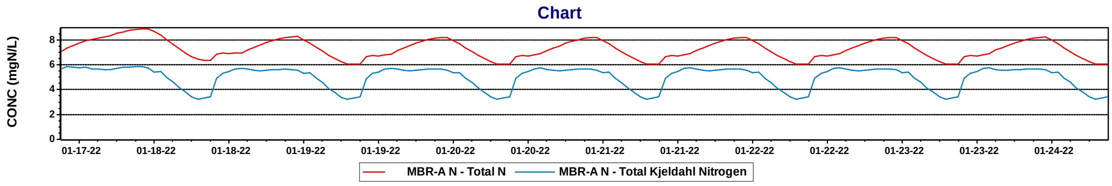

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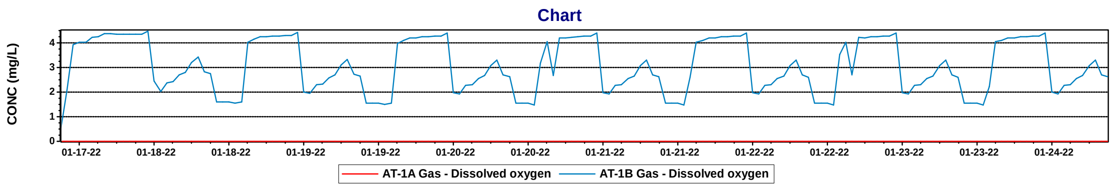

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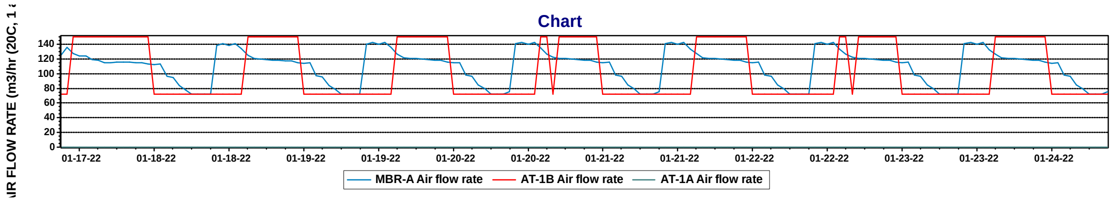

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Global Parameters

Common

Name	Default	Value	
Hydrolysis rate [1/d]	2,1000	2,1000	1,0290
Hydrolysis half sat. [-]	0,0600	0,0600	1,0000
External organics hydrolysis rate [1/d]	2,1000	2,1000	1,0290
External organics hydrolysis half sat. [-]	0,0600	0,0600	1,0000
Anoxic hydrolysis factor [-]	0,2800	0,2800	1,0000
Anaerobic hydrolysis factor (AS) [-]	0,0400	0,0400	1,0000
Anaerobic hydrolysis factor (AD) [-]	0,5000	0,5000	1,0000
Adsorption rate of colloids [L/(mgCOD d)]	0,1500	0,1500	1,0290
Ammonification rate [L/(mgCOD d)]	0,0800	0,0800	1,0290
Assimilative nitrate/nitrite reduction rate [1/d]	0,5000	0,5000	1,0000
Endogenous products decay rate [1/d]	0	0	1,0000

Ammonia oxidizing

Name	Default	Value	
Max. spec. growth rate [1/d]	0,9000	0,9000	1,0720
Substrate (NH4) half sat. [mgN/L]	0,7000	0,7000	1,0000
Byproduct NH4 logistic slope [-]	50,0000	50,0000	1,0000
Byproduct NH4 inflection point [mgN/L]	1,4000	1,4000	1,0000
Denite DO half sat. [mg/L]	0,1000	0,1000	1,0000
Denite HNO2 half sat. [mgN/L]	5,000E-6	5,000E-6	1,0000
Aerobic decay rate [1/d]	0,1700	0,1700	1,0290
Anoxic/anaerobic decay rate [1/d]	0,0800	0,0800	1,0290
KiHNO2 [mmol/L]	5,000E-3	5,000E-3	1,0000

Nitrite oxidizing

Name	Default	Value	
Max. spec. growth rate [1/d]	0,7000	0,7000	1,0600
Substrate (NO2) half sat. [mgN/L]	0,1000	0,1000	1,0000
Aerobic decay rate [1/d]	0,1700	0,1700	1,0290
Anoxic/anaerobic decay rate [1/d]	0,0800	0,0800	1,0290
KiNH3 [mmol/L]	0,0750	0,0750	1,0000

Anaerobic ammonia oxidizing

Name	Default	Value	
Max. spec. growth rate [1/d]	0,2000	0,2000	1,1000
Substrate (NH4) half sat. [mgN/L]	2,0000	2,0000	1,0000
Substrate (NO2) half sat. [mgN/L]	1,0000	1,0000	1,0000
Aerobic decay rate [1/d]	0,0190	0,0190	1,0290
Anoxic/anaerobic decay rate [1/d]	9,500E-3	9,500E-3	1,0290
Ki Nitrite [mgN/L]	1000,0000	1000,0000	1,0000
Nitrite sensitivity constant [L / (d mgN)]	0,0160	0,0160	1,0000

Ordinary heterotrophic

Name	Default	Value	
Max. spec. growth rate [1/d]	3,2000	3,2000	1,0290
Substrate half sat. [mgCOD/L]	5,0000	5,0000	1,0000
Anoxic growth factor [-]	0,5000	0,8000	1,0000
Denite N2 producers (NO3 or NO2) [-]	0,5000	0,5000	1,0000
Aerobic decay rate [1/d]	0,6200	0,6200	1,0290
Anoxic decay rate [1/d]	0,2330	0,2330	1,0290

Anaerobic decay rate [1/d]	0,1310	0,1310	1,0290
Fermentation rate [1/d]	1,6000	1,6000	1,0290
Fermentation half sat. [mgCOD/L]	5,0000	5,0000	1,0000
Fermentation growth factor (AS) [-]	0,2500	0,2500	1,0000
Free nitrous acid inhibition [mol/L]	1,000E-7	1,000E-7	1,0000

Heterotrophic on industrial COD

Name	Default	Value	
Maximum specific growth rate on Ind #1 COD [1/d]	4,3000	4,3000	1,0290
Substrate (Ind #1) half sat. [mgCOD/L]	1,0000	1,0000	1,0000
Inhibition coefficient for Ind #1 [mgCOD/L]	60,0000	60,0000	1,0000
Anaerobic growth factor for Ind #1 [mgCOD/L]	0,0500	0,0500	1,0000
Maximum specific growth rate on Ind #2 COD [1/d]	1,5000	1,5000	1,0290
Substrate (Ind #2) half sat. [mgCOD/L]	30,0000	30,0000	1,0000
Inhibition coefficient for Ind #2 [mgCOD/L]	3000,0000	3000,0000	1,0000
Anaerobic growth factor for Ind #2 [mgCOD/L]	0,0500	0,0500	1,0000
Maximum specific growth rate on Ind #3 COD [1/d]	4,3000	4,3000	1,0290
Substrate (Ind #3) half sat. [mgCOD/L]	1,0000	1,0000	1,0000
Inhibition coefficient for Ind #3 COD [mgCOD/L]	60,0000	60,0000	1,0000
Anaerobic growth factor for Ind #3 [mgCOD/L]	0,0500	0,0500	1,0000
Maximum specific growth rate on adsorbed hydrocarbon COD [1/d]	2,0000	2,0000	1,0290
Substrate (adsorbed hydrocarbon) half sat. [-]	0,1500	0,1500	1,0000
Anaerobic growth factor for adsorbed hydrocarbons [mgCOD/L]	0,0100	0,0100	1,0000
Adsorption rate of soluble hydrocarbons [l/(mgCOD d)]	0,2000	0,2000	1,0000

Methylotrophic

Name	Default	Value

Max. spec. growth rate [1/d]	1,3000	1,3000	1,0720
Methanol half sat. [mgCOD/L]	0,5000	0,5000	1,0000
Denite N2 producers (NO3 or NO2) [-]	0,5000	0,5000	1,0000
Aerobic decay rate [1/d]	0,0400	0,0400	1,0290
Anoxic/anaerobic decay rate [1/d]	0,0300	0,0300	1,0290
Free nitrous acid inhibition [mmol/L]	1,000E-7	1,000E-7	1,0000

Phosphorus accumulating

Name	Default	Value	
Max. spec. growth rate [1/d]	0,9500	0,9500	1,0000
Max. spec. growth rate, P-limited [1/d]	0,4200	0,4200	1,0000
Substrate half sat. [mgCOD(PHB)/mgCOD(Zbp)]	0,1000	0,1000	1,0000
Substrate half sat., P-limited [mgCOD(PHB)/mgCOD(Zbp)]	0,0500	0,0500	1,0000
Magnesium half sat. [mgMg/L]	0,1000	0,1000	1,0000
Cation half sat. [mmol/L]	0,1000	0,1000	1,0000
Calcium half sat. [mgCa/L]	0,1000	0,1000	1,0000
Aerobic/anoxic decay rate [1/d]	0,1000	0,1000	1,0000
Aerobic/anoxic maintenance rate [1/d]	0	0	1,0000
Anaerobic decay rate [1/d]	0,0400	0,0400	1,0000
Anaerobic maintenance rate [1/d]	0	0	1,0000
Sequestration rate [1/d]	4,5000	4,5000	1,0000
Anoxic growth factor [-]	0,3300	0,3300	1,0000

Propionic acetogenic

Name	Default	Value	
Max. spec. growth rate [1/d]	0,2500	0,2500	1,0290
Substrate half sat. [mgCOD/L]	10,0000	10,0000	1,0000

Acetate inhibition [mgCOD/L]	10000,0000	10000,0000	1,0000
Anaerobic decay rate [1/d]	0,0500	0,0500	1,0290
Aerobic/anoxic decay rate [1/d]	0,5200	0,5200	1,0290

Methanogenic

Name	Default	Value	
Acetoclastic max. spec. growth rate [1/d]	0,3000	0,3000	1,0290
H2-utilizing max. spec. growth rate [1/d]	1,4000	1,4000	1,0290
Acetoclastic substrate half sat. [mgCOD/L]	100,0000	100,0000	1,0000
Acetoclastic methanol half sat. [mgCOD/L]	0,5000	0,5000	1,0000
H2-utilizing CO2 half sat. [mmol/L]	0,1000	0,1000	1,0000
H2-utilizing substrate half sat. [mgCOD/L]	1,0000	1,0000	1,0000
H2-utilizing methanol half sat. [mgCOD/L]	0,5000	0,5000	1,0000
Acetoclastic propionic inhibition [mgCOD/L]	10000,0000	10000,0000	1,0000
Acetoclastic anaerobic decay rate [1/d]	0,1300	0,1300	1,0290
Acetoclastic aerobic/anoxic decay rate [1/d]	0,6000	0,6000	1,0290
H2-utilizing anaerobic decay rate [1/d]	0,1300	0,1300	1,0290
H2-utilizing aerobic/anoxic decay rate [1/d]	2,8000	2,8000	1,0290

Sulfur oxidizing

Name	Default	Value	
Maximum specific growth rate (sulfide) [1/d]	0,7500	0,7500	1,0290
Maximum specific growth rate (sulfur) [1/d]	0,1000	0,1000	1,0290
Substrate (H2S) half sat. [mgS/L]	1,0000	1,0000	1,0000
Substrate (sulfur) half sat. [mgS/L]	1,0000	1,0000	1,0000
Anoxic growth factor [-]	0,5000	0,5000	1,0000
Decay rate [1/d]	0,0400	0,0400	1,0290

Sulfur reducing

Name	Default	Value	
Propionic max. spec. growth rate [1/d]	0,5830	0,5830	1,0350
Propionic acid half sat. [mgCOD/L]	295,0000	295,0000	1,0000
Hydrogen sulfide inhibition coefficient [mgS/L]	185,0000	185,0000	1,0000
Sulfate (SO4=) half sat. [mgS/L]	2,4700	2,4700	1,0000
Decay rate [1/d]	0,0185	0,0185	1,0350
Acetotrophic max. spec. growth rate [1/d]	0,6120	0,6120	1,0350
Acetic acid half sat. [mgCOD/L]	24,0000	24,0000	1,0000
Hydrogen sulfide inhibition coefficient [mgS/L]	164,0000	164,0000	1,0000
Sulfate (SO4=) half sat. [mgS/L]	6,4100	6,4100	1,0000
Decay rate [1/d]	0,0275	0,0275	1,0350
Hydrogenotrophic max. spec. growth rate with SO4= [1/d]	2,8000	2,8000	1,0350
Hydrogenotrophic max. spec. growth rate with S [1/d]	0,1000	0,1000	1,0350
Hydrogen half sat. [mgCOD/L]	0,0700	0,0700	1,0000
Hydrogen sulfide inhibition coefficient [mgS/L]	550,0000	550,0000	1,0000
Sulfate (SO4=) half sat. [mgS/L]	6,4100	6,4100	1,0000
Sulfur (S) half sat. [mgS/L]	50,0000	50,0000	1,0000
Decay rate [1/d]	0,0600	0,0600	1,0350

pH

Name	Default	Value
Ordinary heterotrophic low pH limit [-]	4,0000	4,0000
Ordinary heterotrophic high pH limit [-]	10,0000	10,0000
Methylotrophic low pH limit [-]	4,0000	4,0000
Methylotrophic high pH limit [-]	10,0000	10,0000

Autotrophic low pH limit [-]	5,5000	5,5000
Autotrophic high pH limit [-]	9,5000	9,5000
Phosphorus accumulating low pH limit [-]	4,0000	4,0000
Phosphorus accumulating high pH limit [-]	10,0000	10,0000
Ordinary heterotrophic low pH limit (anaerobic) [-]	5,5000	5,5000
Ordinary heterotrophic high pH limit (anaerobic) [-]	8,5000	8,5000
Propionic acetogenic low pH limit [-]	4,0000	4,0000
Propionic acetogenic high pH limit [-]	10,0000	10,0000
Acetoclastic methanogenic low pH limit [-]	5,0000	5,0000
Acetoclastic methanogenic high pH limit [-]	9,0000	9,0000
H2-utilizing methanogenic low pH limit [-]	5,0000	5,0000
H2-utilizing methanogenic high pH limit [-]	9,0000	9,0000

Switches

Name	Default	Value
Ordinary heterotrophic DO half sat. [mgO2/L]	0,1500	0,7000
Phosphorus accumulating DO half sat. [mgO2/L]	0,0500	0,0500
Anoxic/anaerobic NOx half sat. [mgN/L]	0,1500	0,1500
Ammonia oxidizing DO half sat. [mgO2/L]	0,2500	0,7000
Nitrite oxidizing DO half sat. [mgO2/L]	0,5000	0,2500
Anaerobic ammonia oxidizing DO half sat. [mgO2/L]	0,0100	0,0100
Sulfur oxidizing sulfate pathway DO half sat. [mgO2/L]	0,2500	0,2500
Sulfur oxidizing sulfur pathway DO half sat. [mgO2/L]	0,0500	0,0500
Anoxic NO3(->NO2) half sat. [mgN/L]	0,1000	0,1000
Anoxic NO3(->N2) half sat. [mgN/L]	0,0500	0,0500
Anoxic NO2(->N2) half sat. (mgN/L)	0,0100	0,0100
NH3 nutrient half sat. [mgN/L]	5,000E-3	5,000E-3
PolyP half sat. [mgP/mgCOD]	0,0100	0,0100
VFA sequestration half sat. [mgCOD/L]	5,0000	5,0000

P uptake half sat. [mgP/L]	0,1500	0,1500
P nutrient half sat. [mgP/L]	1,000E-3	1,000E-3
Autotrophic CO2 half sat. [mmol/L]	0,1000	0,1000
H2 low/high half sat. [mgCOD/L]	1,0000	1,0000
Propionic acetogenic H2 inhibition [mgCOD/L]	5,0000	5,0000
Synthesis anion/cation half sat. [meq/L]	0,0100	0,0100

Common

Name	Default	Value
Biomass/Endog Ca content (gCa/gCOD)	3,912E-3	3,912E-3
Biomass/Endog Mg content (gMg/gCOD)	3,912E-3	3,912E-3
Biomass/Endog other cations content (mol/gCOD)	5,115E-4	5,115E-4
Biomass/Endog other Anions content (mol/gCOD)	1,410E-4	1,410E-4
N in endogenous residue [mgN/mgCOD]	0,0700	0,0700
P in endogenous residue [mgP/mgCOD]	0,0220	0,0220
Ca content of slowly biodegradabe (gCa/gCOD)	3,912E-3	3,912E-3
Mg content of slowly biodegradabe (gMg/gCOD)	3,700E-4	3,700E-4
Endogenous residue COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200
Particulate substrate COD:VSS ratio [mgCOD/mgVSS]	1,6327	1,5500
Particulate inert COD:VSS ratio [mgCOD/mgVSS]	1,6000	1,3500
Cellulose COD:VSS ratio [mgCOD/mgVSS]	1,4000	1,4000
External organic COD:VSS ratio [mgCOD/mgVSS]	1,6000	1,6000
Molecular weight of other anions [mg/mmol]	35,5000	35,5000
Molecular weight of other cations [mg/mmol]	39,0983	39,0983

Ammonia oxidizing

Name	Default	Value

Yield [mgCOD/mgN]	0,1500	0,1500
Denite NO2 fraction as TEA [-]	0,5000	0,5000
Byproduct NH4 fraction to N2O [-]	2,500E-3	2,500E-3
N in biomass [mgN/mgCOD]	0,0700	0,0700
P in biomass [mgP/mgCOD]	0,0220	0,0220
Fraction to endogenous residue [-]	0,0800	0,0800
COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200

Nitrite oxidizing

Name	Default	Value
Yield [mgCOD/mgN]	0,0900	0,0900
N in biomass [mgN/mgCOD]	0,0700	0,0700
P in biomass [mgP/mgCOD]	0,0220	0,0220
Fraction to endogenous residue [-]	0,0800	0,0800
COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200

Anaerobic ammonia oxidizing

Name	Default	Value
Yield [mgCOD/mgN]	0,1140	0,1140
Nitrate production [mgN/mgBiomassCOD]	2,2800	2,2800
N in biomass [mgN/mgCOD]	0,0700	0,0700
P in biomass [mgP/mgCOD]	0,0220	0,0220
Fraction to endogenous residue [-]	0,0800	0,0800
COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200

Ordinary heterotrophic

Name	Default	Value
Yield (aerobic) [-]	0,6660	0,6660
Yield (fermentation, low H2) [-]	0,1000	0,1000
Yield (fermentation, high H2) [-]	0,1000	0,1000
H2 yield (fermentation low H2) [-]	0,3500	0,3500
H2 yield (fermentation high H2) [-]	0	0
Propionate yield (fermentation, low H2) [-]	0	0
Propionate yield (fermentation, high H2) [-]	0,7000	0,7000
CO2 yield (fermentation, low H2) [-]	0,7000	0,7000
CO2 yield (fermentation, high H2) [-]	0	0
N in biomass [mgN/mgCOD]	0,0700	0,0700
P in biomass [mgP/mgCOD]	0,0220	0,0220
Endogenous fraction - aerobic [-]	0,0800	0,0800
Endogenous fraction - anoxic [-]	0,1030	0,1030
Endogenous fraction - anaerobic [-]	0,1840	0,1840
COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200
Yield (anoxic) [-]	0,5400	0,5400
Yield propionic (aerobic) [-]	0,6400	0,6400
Yield propionic (anoxic) [-]	0,4600	0,4600
Yield acetic (aerobic) [-]	0,6000	0,6000
Yield acetic (anoxic) [-]	0,4300	0,4300
Yield methanol (aerobic) [-]	0,5000	0,5000
Adsorp. max. [-]	1,0000	1,0000
Max fraction to N2O at high FNA over nitrate [-]	0,0500	0,0500
Max fraction to N2O at high FNA over nitrite [-]	0,1000	0,1000

Ordinary heterotrophic on industrial COD

Name	Default	Value

Yield Ind #1 COD (Aerobic) [-]	0,5000	0,5000
Yield Ind #1 COD (Anoxic) [-]	0,4000	0,4000
Yield Ind #1 COD (Anaerobic) [-]	0,0400	0,0400
COD:Mole ratio - Ind #1 COD [gCOD/Mol]	224,0000	224,0000
Yield Ind #2 COD (Aerobic) [-]	0,5000	0,5000
Yield Ind #2 COD (Anoxic) [-]	0,4000	0,4000
Yield Ind #2 COD (Anaerobic) [-]	0,0500	0,0500
COD:Mole ratio - Ind #2 COD [gCOD/Mol]	240,0000	240,0000
Yield on Ind #3 COD (Aerobic) [-]	0,5000	0,5000
Yield on Ind #3 COD (Anoxic) [-]	0,4000	0,4000
Yield on Ind #3 COD (Anaerobic) [-]	0,0400	0,0400
COD:Mole ratio - Ind #3 COD [gCOD/Mol]	288,0000	288,0000
Yield enmeshed hydrocarbons (Aerobic) [-]	0,5000	0,5000
Yield enmeshed hydrocarbons (Anoxic) [-]	0,4000	0,4000
Yield enmeshed hydrocarbons (Anaerobic) [-]	0,0400	0,0400
COD:Mole ratio - Hydrocarbon COD [gCOD/Mol]	336,0000	336,0000
Hydrocarbon COD:VSS ratio [mgCOD/mgVSS]	3,2000	3,2000
Max. hydrocarbon adsorp. ratio [-]	1,0000	1,0000
Yield of Ind #1 on Ind #3 COD (Aerobic) [-]	0	0
Yield of Ind #1 on Ind #3 COD (Anoxic) [-]	0	0
Hydrocarbon Yield on Ind #3 COD (Aerobic) [-]	0	0
Hydrocarbon Yield on Ind #3 COD (Anoxic) [-]	0	0

Methylotrophic

Name	Default	Value
Yield (anoxic) [-]	0,4000	0,4000
N in biomass [mgN/mgCOD]	0,0700	0,0700
P in biomass [mgP/mgCOD]	0,0220	0,0220
Fraction to endogenous residue [-]	0,0800	0,0800

COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200
Max fraction to N2O at high FNA over nitrate [-]	0,1000	0,1000
Max fraction to N2O at high FNA over nitrite [-]	0,1500	0,1500

Phosphorus accumulating

Name	Default	Value
Yield (aerobic) [-]	0,6390	0,6390
Yield (anoxic) [-]	0,5200	0,5200
Aerobic P/PHA uptake [mgP/mgCOD]	0,9300	0,9300
Anoxic P/PHA uptake [mgP/mgCOD]	0,3500	0,6350
Yield of PHA on Ac sequestration [-]	0,8890	0,8890
N in biomass [mgN/mgCOD]	0,0700	0,0700
N in sol. inert [mgN/mgCOD]	0,0700	0,0700
P in biomass [mgP/mgCOD]	0,0220	0,0220
Fraction to endogenous part. [-]	0,2500	0,2500
Inert fraction of endogenous sol. [-]	0,2000	0,2000
P/Ac release ratio [mgP/mgCOD]	0,5100	0,5300
COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200
Yield of low PP [-]	0,9400	0,9400
Mg to P mole ratio in polyphosphate [mmolMg/mmolP]	0,3000	0,3000
Cation to P mole ratio in polyphosphate [meq/mmolP]	0,1500	0,1500
Ca to P mole ratio in polyphosphate [mmolCa/mmolP]	0,0500	0,0500

Propionic acetogenic

Name	Default	Value
Yield [-]	0,1000	0,1000
H2 yield [-]	0,4000	0,4000

CO2 yield [-]	1,0000	1,0000
N in biomass [mgN/mgCOD]	0,0700	0,0700
P in biomass [mgP/mgCOD]	0,0220	0,0220
Fraction to endogenous residue [-]	0,0800	0,0800
COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200

Methanogenic

Name	Default	Value
Acetoclastic yield [-]	0,1000	0,1000
Acetoclastic yield on methanol[-]	0,1000	0,1000
H2-utilizing yield [-]	0,1000	0,1000
H2-utilizing yield on methanol [-]	0,1000	0,1000
N in acetoclastic biomass [mgN/mgCOD]	0,0700	0,0700
N in H2-utilizing biomass [mgN/mgCOD]	0,0700	0,0700
P in acetoclastic biomass [mgP/mgCOD]	0,0220	0,0220
P in H2-utilizing biomass [mgP/mgCOD]	0,0220	0,0220
Acetoclastic fraction to endog. residue [-]	0,0800	0,0800
H2-utilizing fraction to endog. residue [-]	0,0800	0,0800
Acetoclastic COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200
H2-utilizing COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200

Sulfur oxidizing

Name	Default	Value
Yield (aerobic) [mgCOD/mgS]	0,5000	0,5000
Yield (Anoxic) [mgCOD/mgS]	0,3500	0,3500
N in biomass [mgN/mgCOD]	0,0700	0,0700
P in biomass [mgP/mgCOD]	0,0220	0,0220

Fraction to endogenous residue [-]	0,0800	0,0800
COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200

Sulfur reducing

Name	Default	Value
Yield [mgCOD/mg H2 COD]	0,0712	0,0712
Yield [mgCOD/mg Ac COD]	0,0470	0,0470
Yield [mgCOD/mg Pr COD]	0,0384	0,0384
N in biomass [mgN/mgCOD]	0,0700	0,0700
P in biomass [mgP/mgCOD]	0,0220	0,0220
Fraction to endogenous residue [-]	0,0800	0,0800
COD:VSS ratio [mgCOD/mgVSS]	1,4200	1,4200

General

Name	Default	Value
Tank head loss per metre of length (from flow) [m/m]	2,500E-3	2,500E-3
BOD calculation rate constant for Xsc degradation [/d]	0,5000	0,3500
BOD calculation rate constant for Xsp (and hydrocarbon) degradation [/d]	0,5000	0,3500
BOD calculation rate constant for Xeo degradation [/d]	0,5000	0,5000

Heating fuel/Chemical Costs

Name	Default	Value
Methanol [€/L]	0,3884	0,3884
Ferric chloride [€/kg Fe]	1,0327	1,0327
Ferric sulfate [€/kg Fe]	0,6973	0,6973

Ferrous chloride [€/kg Fe]	0,5384	0,5384
Ferrous sulfate [€/kg Fe]	2,0919	2,0919
Aluminum sulfate [€/kg Al]	1,4917	1,4917
Aluminum chloride [€/kg Al]	1,7477	1,7477
Poly Aluminum Chloride (PAC) [€/kg Al]	1,0327	1,0327
Natural gas [€/GJ]	2,6480	2,6480
Heating oil [€/L]	0,4413	0,4413
Diesel [€/L]	0,6179	0,6179
Custom fuel [€/L]	0,8827	0,8827
Biogas sale price [€/GJ]	1,7653	1,7653

Anaerobic digester

Name	Default	Value
Bubble rise velocity (anaerobic digester) [cm/s]	23,9000	23,9000
Bubble Sauter mean diameter (anaerobic digester) [cm]	0,3500	0,3500
Anaerobic digester gas hold-up factor []	1,0000	1,0000

Combined Heat and Power (CHP) engine

Name	Default	Value
Methane heat of combustion [kJ/mole]	800,0000	800,0000
Hydrogen heat of combustion [kJ/mole]	240,0000	240,0000
CHP engine heat price [€/kWh]	0	0
CHP engine power price [€/kWh]	0,1324	0,1324

Calorific values of heating fuels

Name	Default	Value
Calorific value of natural gas [kJ/kg]	48000	48000
Calorific value of heating fuel oil [kJ/kg]	42000	42000
Calorific value of diesel [kJ/kg]	46000	46000
Calorific value of custom fuel [kJ/kg]	32000	32000

Density of liquid heating fuels

Name	Default	Value
Density of heating fuel oil [kg/m3]	900	900
Density of diesel [kg/m3]	875	875
Density of custom fuel [kg/m3]	790	790

Mass transfer

Name	Default	Value	
Kl for H2 [m/d]	17,0000	17,0000	1,0240
Kl for CO2 [m/d]	10,0000	10,0000	1,0240
Kl for NH3 [m/d]	1,0000	1,0000	1,0240
Kl for CH4 [m/d]	8,0000	8,0000	1,0240
Kl for N2 [m/d]	15,0000	15,0000	1,0240
Kl for N2O [m/d]	8,0000	8,0000	1,0240
Kl for H2S [m/d]	1,0000	1,0000	1,0240
Kl for Ind #1 COD [m/d]	0	0	1,0240
Kl for Ind #2 COD [m/d]	0,5000	0,5000	1,0240
Kl for Ind #3 COD [m/d]	0	0	1,0240
Kl for O2 [m/d]	13,0000	13,0000	1,0240

Henry's law constants

Name	Default	Value	
CO2 [M/atm]	3,4000E-2	3,4000E-2	2400,0000
O2 [M/atm]	1,3000E-3	1,3000E-3	1500,0000
N2 [M/atm]	6,5000E-4	6,5000E-4	1300,0000
N2O [M/atm]	2,5000E-2	2,5000E-2	2600,0000
NH3 [M/atm]	5,8000E+1	5,8000E+1	4100,0000
CH4 [M/atm]	1,4000E-3	1,4000E-3	1600,0000
H2 [M/atm]	7,8000E-4	7,8000E-4	500,0000
H2S [M/Atm]	1,0000E-1	1,0000E-1	2200,0000
Ind 1 [M/Atm]	1,9000E+3	1,9000E+3	7300,0000
Ind 2 [M/Atm]	1,8000E-1	1,8000E-1	2200,0000
Ind 3 [M/Atm]	1,5000E-1	1,5000E-1	1900,0000

Properties constants

Name	Default	Value
K in Viscosity = K e ^(Ea/RT) [Pa s]	6,849E-7	6,849E-7
Ea in Viscosity = K e ^(Ea/RT) [j/mol]	1,780E+4	1,780E+4
Y in ML Viscosity = H2O viscosity * (1+A*MLSS^Y) [-]	1,0000	1,0000
A in ML Viscosity = H2O viscosity * (1+A*MLSS^Y) [m3/g]	1,000E-7	1,000E-7
A in ML Density = H2O density + A*MLSS [(kg/m3)/(g/m3)]	3,248E-4	3,248E-4
A in Antoine equn. [T in K, P in Bar {NIST}]	5,2000	5,2000
B in Antoine equn. [T in K, P in Bar {NIST}]	1734,0000	1734,0000
C in Antoine equn. [T in K, P in Bar {NIST}]	-39,5000	-39,5000

Metal salt solution densities

Mineral precipitation rates

Name	Default	Value	
Vivianite precipitation rate [L/(mol d)]	1,000E+5	1,000E+5	1,0240
Vivianite redissolution rate [L/(mol d)]	1,000E+5	1,000E+5	1,0240
Vivianite half sat. [mgTSS/L]	0,0100	0,0100	1,0000
FeS precipitation rate [L/(mol d)]	1000,0000	1000,0000	1,0240
FeS redissolution rate [L/(mol d)]	10,0000	10,0000	1,0240
FeS half sat. [mgTSS/L]	0,1000	0,1000	1,0000
Struvite precipitation rate [L^2/(mol^2 d)]	3,000E+10	3,000E+10	1,0240
Struvite redissolution rate [L^2/(mol^2 d)]	3,000E+11	3,000E+11	1,0240
Struvite half sat. [mgTSS/L]	1,0000	1,0000	1,0000
Brushite precipitation rate [L/(mol d)]	1,000E+6	1,000E+6	1,0000
Brushite redissolution rate [L/(mol d)]	10000,0000	10000,0000	1,0000
Brushite half sat. [mgTSS/L]	1,0000	1,0000	1,0000
HAP precipitation rate [g/d]	5,000E-4	5,000E-4	1,0000

Mineral precipitation constants

Name	Default	Value
Vivianite solubility product [mol/L]^5	1,710E-36	1,710E-36
FeS solubility product [mol/L]^2	4,258E-4	4,258E-4
Struvite solubility product [mol/L]^3	6,918E-14	6,918E-14
Brushite solubility product [mol/L]^2	2,490E-7	2,490E-7

Fe rates

Name	Default	Value	
A in aging rate = A * exp(-G/B) [1/d)]	16,1550	16,1550	1,0000
B in aging rate = A * exp(-G/B) [1/s)]	57,3000	57,3000	1,0000
HFO(L) aging rate factor	2,500E-4	2,500E-4	1,0000
HFO(H) with H2PO4- bound aging factor []	1,000E-5	1,000E-5	1,0000
HFO(L) with H2PO4- bound aging factor []	0,4000	0,4000	1,0000
H2PO4- coprecipitation rate [mol/(L d)]	1,500E-9	1,500E-9	1,0000
H2PO4- Adsorption rate [mol /(L d)]	2,000E-11	2,000E-11	1,0000
H+ competition for HFO(H) protonation sites [L/(mmol . d)]	1000,0000	1000,0000	1,0000
H+ competition for HFO(L) protonation sites [L/(mmol . d)]	100,0000	100,0000	1,0000

Fe constants

Name	Default	Value
Ferric active site factor(high) [{mol Sites}/{mol HFO(H)}]	4,0000	4,0000
Ferric active site factor(low) [{mol Sites}/{mol HFO(L)}]	2,4000	2,4000
H+ competition level for Fe(OH)3 [mol/L]	7,000E-7	7,000E-7
Equilibrium constant for FeOH3-H2PO4- [{mf HFO(H).H2PO4}/({mol H2PO4-}{mf HFO(H)}^2)]	2,000E-9	2,000E-9
Colloidal COD removed with Ferric [gCOD/Fe active site]	80,0000	80,0000
Minimum residual P level with iron addition [mgP/L]	0,0150	0,0150
HFO(H) with H2PO4- P release factor	10000,0000	10000,0000
HFO(L) with H2PO4- P release factor	10000,0000	10000,0000

Fe RedOx rates

Name	Default	Value	
Iron reduction using acetic acid	1,000E-7	1,000E-7	1,0000
Half Sat. acetic acid	0,5000	0,5000	1,0000
Iron reduction using propionic acid	1,000E-7	1,000E-7	1,0000

Half Sat. propionic acid	0,5000	0,5000	1,0000
Iron reduction using dissolved hydrogen gas	1,000E-7	1,000E-7	1,0000
Half Sat. dissolved hydrogen gas	0,5000	0,5000	1,0000
Iron reduction using hydrogen sulfide	5,000E-5	5,000E-5	1,0000
Half Sat. hydrogen sulfide	0,5000	0,5000	1,0000
Iron oxidation rate (aerobic)	1,000E-3	1,000E-3	1,0000
Abiotic iron reduction using acetic acid	2,000E-5	2,000E-5	1,0000
Abiotic iron reduction using propionic acid	2,000E-5	2,000E-5	1,0000
Abiotic iron reduction using dissolved hydrogen gas	2,000E-5	2,000E-5	1,0000
Abiotic iron reduction using hydrogen sulfide	2,000E-5	2,000E-5	1,0000
Abiotic iron oxidation rate (aerobic)	1,0000	1,0000	1,0000

CEPT rates

Name	Default	Value	
HFO colloidal adsorption rate	1,0000	1,0000	1,0000
Residual Xsc for adsorption to HFO	5,0000	5,0000	1,0000
Slope for Xsc residual	1,0000	1,0000	1,0000
HAO colloidal adsorption rate	1,0000	1,0000	1,0000
Residual Xsc for adsorption to HAO	5,0000	5,0000	1,0000
Slope for Xsc residual	1,0000	1,0000	1,0000

Al rates

Name	Default	Value	
A in aging rate = A * exp(-G/B) [1/d)]	16,1550	16,1550	1,0000
B in aging rate = A * exp(-G/B) [1/s)]	57,3000	57,3000	1,0000
HAO(L) aging rate factor	2,500E-4	2,500E-4	1,0000
HAO(H) with H2PO4- bound aging factor []	1,000E-5	1,000E-5	1,0000

HAO(L) with H2PO4- bound aging factor []	0,4000	0,4000	1,0000
H2PO4- coprecipitation rate [mol/(L d)]	1,500E-9	1,500E-9	1,0000
H2PO4- Adsorption rate [mol /(L d)]	1,000E-9	1,000E-9	1,0000

Al constants

Name	Default	Value
Al active site factor(high) [{mol Sites}/{mol HAO(H)}]	3,0000	3,0000
Al active site factor(low) [{mol Sites}/{mol HAO(L)}]	1,5000	1,5000
Equilibrium constant for AlOH3-H2PO4- [{mf HAO(H).H2PO4}/({mol H2PO4-}{mf HAO(H)}^2)]	8,000E-10	8,000E-10
Colloidal COD removed with Al [gCOD/Al active site]	30,0000	30,0000
Minimum residual P level with Al addition [mgP/L]	0,0150	0,0150
HAO(H) with H2PO4- P release factor	10000,0000	10000,0000
HAO(L) with H2PO4- P release factor	10000,0000	10000,0000

Pipe and pump parameters

Name	Default	Value
Static head [m]	0,2500	0,2500
Pipe length (headloss calc.s) [m]	50,0000	50,0000
Pipe inside diameter [mm]	500,000	500,000
K(fittings) - Total minor losses K	5,0000	5,0000
Pipe roughness [mm]	0,200	0,200
'A' in overall pump efficiency = A + B*Q + C*(Q^2)[-]	0,8500	0,8500
'B' in overall pump efficiency = A + B*Q + C*(Q^2)[[-]/(m3/d)]	0	0
'C' in overall pump efficiency = A + B*Q + C*(Q^2)[[-]/(m3/d)^2]	0	0

Fittings and loss coefficients ('K' values)

Name	Default	Value
Pipe entrance (bellmouth)	0,0500	1,0000
90° bend	0,7500	5,0000
45° bend	0,3000	2,0000
Butterfly value (open)	0,3000	1,0000
Non-return value	1,0000	0
Outlet (bellmouth)	0,2000	1,0000

Aeration

Name	Default	Value
Surface pressure [kPa]	101,3250	101,3250
Fractional effective saturation depth (Fed) [-]	0,3250	0,3250
Supply gas CO2 content [vol. %]	0,0400	0,0400
Supply gas O2 [vol. %]	20,9500	20,9500
Off-gas CO2 [vol. %]	2,0000	2,0000
Off-gas O2 [vol. %]	18,8000	18,8000
Off-gas H2 [vol. %]	0	0
Off-gas NH3 [vol. %]	0	0
Off-gas CH4 [vol. %]	0	0
Off-gas N2O [vol. %]	0	0
Surface turbulence factor [-]	2,0000	2,0000
Set point controller gain []	1,0000	1,0000

MABR Membrane effective diffusivities

Name	Default	Value	
O2 [m2/s]	2,500E-9	2,500E-9	1,0000

N2 [m2/s]	1,900E-9	1,900E-9	1,0000
CO2 [m2/s]	1,960E-9	1,960E-9	1,0000
H2 [m2/s]	5,850E-9	5,850E-9	1,0000
CH4 [m2/s]	1,963E-9	1,963E-9	1,0000
NH3 [m2/s]	2,000E-9	2,000E-9	1,0000
N2O [m2/s]	1,607E-9	1,607E-9	1,0000
H2S [m2/s]	1,530E-9	1,530E-9	1,0000
Ind 1 [m2/s]	7,240E-10	7,240E-10	1,0000
Ind 2 [m2/s]	8,900E-10	8,900E-10	1,0000
Ind 3 [m2/s]	7,960E-10	7,960E-10	1,0000

MABR Membrane transfer factors

Name	Default	Value	
O2 []	1,0000	1,0000	1,0000
N2 []	1,0000	1,0000	1,0000
CO2 []	1,0000	1,0000	1,0000
H2 []	1,0000	1,0000	1,0000
CH4 []	1,0000	1,0000	1,0000
NH3 []	1,0000	1,0000	1,0000
N2O []	1,0000	1,0000	1,0000
H2S []	1,0000	1,0000	1,0000
Ind 1 []	1,0000	1,0000	1,0000
Ind 2 []	1,0000	1,0000	1,0000
Ind 3 []	1,0000	1,0000	1,0000

Blower

Name	Default	Value

Intake filter pressure drop [kPa]	3,5000	3,5000
Pressure drop through distribution system (piping/valves) [kPa]	3,0000	3,0000
Adiabatic/polytropic compression exponent (1.4 for adiabatic)	1,4000	1,4000
'A' in blower efficiency = A + B*Qa + C*(Qa^2)[-]	0,7500	0,7500
'B' in blower efficiency = A + B*Qa + C*(Qa^2)[[-]/(m3/hr (20C, 1 atm))]	0	0
'C' in blower efficiency = A + B*Qa + C*(Qa^2)[[-]/(m3/hr (20C, 1 atm))^2]	0	0

Diffuser

Name	Default	Value
k1 in C = k1(PC)^0.25 + k2	1,2400	1,2400
k2 in C = k1(PC)^0.25 + k2	0,8960	0,8960
Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	0,8880	0,8880
Area of one diffuser [m2]	0,0410	0,0380
Diffuser mounting height [m]	0,2500	0,2500
Min. air flow rate per diffuser m3/hr (20C, 1 atm)	0,5000	0,5000
Max. air flow rate per diffuser m3/hr (20C, 1 atm)	10,0000	10,0000
'A' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2 [kPa]	3,0000	3,0000
'B' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2[kPa/(m3/hr (20C, 1 atm))]	0	0
'C' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2[kPa/(m3/hr (20C, 1 atm))^2]	0	0

Surface aerators

Name	Default	Value
Surface aerator Std. oxygen transfer rate [kg O /(kW hr)]	1,50000	1,50000

Modified Vesilind

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [m/d]	170,000	170,000
Vesilind hindered zone settling parameter (K) [L/g]	0,370	0,370
Clarification switching function [mg/L]	100,000	100,000
Specified TSS conc.for height calc. [mg/L]	2500,000	2500,000
Maximum compactability constant [mg/L]	15000,000	15000,000
Maximum compactability slope [L/mg]	0,010	0,010

Double exponential

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [m/d]	410,000	410,000
Maximum (practical) settling velocity (Vo') [m/d]	270,000	270,000
Hindered zone settling parameter (Kh) [L/g]	0,400	0,400
Flocculent zone settling parameter (Kf) [L/g]	2,500	2,500
Maximum non-settleable TSS [mg/L]	20,0000	20,0000
Non-settleable fraction [-]	1,000E-3	1,000E-3
Specified TSS conc. for height calc. [mg/L]	2500,0000	2500,0000

Emission factors

Name	Default	Value
Carbon dioxide equivalence of nitrous oxide	296,0000	296,0000
Carbon dioxide equivalence of methane	23,0000	23,0000

Biofilm general

Name	Default	Value

Attachment rate [g / (m2 d)]	8,0000	8,0000	1,0000
Attachment TSS half sat. [mg/L]	100,0000	100,0000	1,0000
Detachment rate [g/(m3 d)]	8000,0000	8000,0000	1,0000
Solids movement factor []	10,0000	10,0000	1,0000
Diffusion neta []	0,8000	0,8000	1,0000
Thin film limit [mm]	0,5000	0,5000	1,0000
Thick film limit [mm]	3,0000	3,0000	1,0000
Assumed Film thickness for tank volume correction (temp independent) [mm]	1,2500	1,2500	1,0000
Film surface area to media area ratio - Max.[ ]	1,0000	1,0000	1,0000
Minimum biofilm conc. for streamer formation [gTSS/m2]	4,0000	4,0000	1,0000

Maximum biofilm concentrations [mg/L]

Name	Default	Value	
Biomass - Ordinary heterotrophic	5,000E+4	5,000E+4	1,0000
Biomass - Methylotrophic	5,000E+4	5,000E+4	1,0000
Biomass - Ammonia oxidizing	1,000E+5	1,000E+5	1,0000
Biomass - Nitrite oxidizing	1,000E+5	1,000E+5	1,0000
Biomass - Anaerobic ammonia oxidizing	5,000E+4	5,000E+4	1,0000
Biomass - Phosphorus accumulating	5,000E+4	5,000E+4	1,0000
Biomass - Propionic acetogenic	5,000E+4	5,000E+4	1,0000
Biomass - Acetoclastic methanogenic	5,000E+4	5,000E+4	1,0000
Biomass - Hydrogenotrophic methanogenic	5,000E+4	5,000E+4	1,0000
Biomass - Endogenous products	3,000E+4	3,000E+4	1,0000
CODp - Slowly degradable particulate	5000,0000	5000,0000	1,0000
CODp - Slowly degradable colloidal	4000,0000	4000,0000	1,0000
CODp - Degradable external organics	5000,0000	5000,0000	1,0000
CODp - Undegradable non-cellulose	5000,0000	5000,0000	1,0000
CODp - Undegradable cellulose	5000,0000	5000,0000	1,0000
N - Particulate degradable organic	0	0	1,0000

P - Particulate degradable organic	0	0	1,0000
N - Particulate degradable external organics	0	0	1,0000
P - Particulate degradable external organics	0	0	1,0000
N - Particulate undegradable	0	0	1,0000
P - Particulate undegradable	0	0	1,0000
CODp - Stored PHA	5000,0000	5000,0000	1,0000
P - Releasable stored polyP	1,150E+6	1,150E+6	1,0000
P - Unreleasable stored polyP	1,150E+6	1,150E+6	1,0000
CODs - Complex readily degradable	0	0	1,0000
CODs - Acetate	0	0	1,0000
CODs - Propionate	0	0	1,0000
CODs - Methanol	0	0	1,0000
Gas - Dissolved hydrogen	0	0	1,0000
Gas - Dissolved methane	0	0	1,0000
N - Ammonia	0	0	1,0000
N - Soluble degradable organic	0	0	1,0000
Gas - Dissolved nitrous oxide	0	0	1,0000
N - Nitrite	0	0	1,0000
N - Nitrate	0	0	1,0000
Gas - Dissolved nitrogen	0	0	1,0000
P - Soluble phosphate	0	0	1,0000
CODs - Undegradable	0	0	1,0000
N - Soluble undegradable organic	0	0	1,0000
Influent inorganic suspended solids	1,300E+6	1,300E+6	1,0000
Precipitate - Struvite	8,500E+5	8,500E+5	1,0000
Precipitate - Brushite	1,165E+6	1,165E+6	1,0000
Precipitate - Hydroxy - apatite	1,600E+6	1,600E+6	1,0000
Precipitate - Vivianite	1,340E+6	1,340E+6	1,0000
HFO - High surface	5,000E+4	5,000E+4	1,0000
HFO - Low surface	5,000E+4	5,000E+4	1,0000
HFO - High with H2PO4- adsorbed	5,000E+4	5,000E+4	1,0000

HFO - Low with H2PO4- adsorbed	5,000E+4	5,000E+4	1,0000
HFO - Aged	5,000E+4	5,000E+4	1,0000
HFO - Low with H+ adsorbed	5,000E+4	5,000E+4	1,0000
HFO - High with H+ adsorbed	5,000E+4	5,000E+4	1,0000
HAO - High surface	5,000E+4	5,000E+4	1,0000
HAO - Low surface	5,000E+4	5,000E+4	1,0000
HAO - High with H2PO4- adsorbed	5,000E+4	5,000E+4	1,0000
HAO - Low with H2PO4- adsorbed	5,000E+4	5,000E+4	1,0000
HAO - Aged	5,000E+4	5,000E+4	1,0000
P - Bound on aged HMO	5,000E+4	5,000E+4	1,0000
Metal soluble - Magnesium	0	0	1,0000
Metal soluble - Calcium	0	0	1,0000
Metal soluble - Ferric	0	0	1,0000
Metal soluble - Ferrous	0	0	1,0000
Metal soluble - Aluminum	0	0	1,0000
Other Cations (strong bases)	0	0	1,0000
Other Anions (strong acids)	0	0	1,0000
Gas - Dissolved total CO2	0	0	1,0000
User defined - UD1	0	0	1,0000
User defined - UD2	0	0	1,0000
User defined - UD3	5,000E+4	5,000E+4	1,0000
User defined - UD4	5,000E+4	5,000E+4	1,0000
Biomass - Sulfur oxidizing	1,000E+5	1,000E+5	1,0000
Biomass - Sulfur reducing propionic acetogenic	5,000E+4	5,000E+4	1,0000
Biomass - Sulfur reducing acetotrophic	5,000E+4	5,000E+4	1,0000
Biomass - Sulfur reducing hydrogenotrophic	1,000E+5	1,000E+5	1,0000
Gas - Dissolved total sulfides	0	0	1,0000
S - Soluble sulfate	0	0	1,0000
S - Particulate elemental sulfur	5,000E+4	5,000E+4	1,0000
Precipitate - Ferrous sulfide	5,000E+4	5,000E+4	1,0000
CODp - Adsorbed hydrocarbon	5,000E+4	5,000E+4	1,0000

CODs - Degradable volatile ind. #1	0	0	1,0000
CODs - Degradable volatile ind. #2	0	0	1,0000
CODs - Degradable volatile ind. #3	0	0	1,0000
CODs - Soluble hydrocarbon	0	0	1,0000
Gas - Dissolved oxygen	0	0	1,0000

Effective diffusivities [m2/s]

Name	Default	Value	
Biomass - Ordinary heterotrophic	5,000E-14	5,000E-14	1,0290
Biomass - Methylotrophic	5,000E-14	5,000E-14	1,0290
Biomass - Ammonia oxidizing	5,000E-14	5,000E-14	1,0290
Biomass - Nitrite oxidizing	5,000E-14	5,000E-14	1,0290
Biomass - Anaerobic ammonia oxidizing	5,000E-14	5,000E-14	1,0290
Biomass - Phosphorus accumulating	5,000E-14	5,000E-14	1,0290
Biomass - Propionic acetogenic	5,000E-14	5,000E-14	1,0290
Biomass - Acetoclastic methanogenic	5,000E-14	5,000E-14	1,0290
Biomass - Hydrogenotrophic methanogenic	5,000E-14	5,000E-14	1,0290
Biomass - Endogenous products	5,000E-14	5,000E-14	1,0290
CODp - Slowly degradable particulate	5,000E-14	5,000E-14	1,0290
CODp - Slowly degradable colloidal	5,000E-10	5,000E-10	1,0290
CODp - Degradable external organics	5,000E-14	5,000E-14	1,0290
CODp - Undegradable non-cellulose	5,000E-14	5,000E-14	1,0290
CODp - Undegradable cellulose	5,000E-14	5,000E-14	1,0290
N - Particulate degradable organic	5,000E-14	5,000E-14	1,0290
P - Particulate degradable organic	5,000E-14	5,000E-14	1,0290
N - Particulate degradable external organics	5,000E-14	5,000E-14	1,0290
P - Particulate degradable external organics	5,000E-14	5,000E-14	1,0290
N - Particulate undegradable	5,000E-14	5,000E-14	1,0290
P - Particulate undegradable	5,000E-14	5,000E-14	1,0290

CODp - Stored PHA	5,000E-14	5,000E-14	1,0290
P - Releasable stored polyP	5,000E-14	5,000E-14	1,0290
P - Unreleasable stored polyP	5,000E-14	5,000E-14	1,0290
CODs - Complex readily degradable	6,900E-10	6,900E-10	1,0290
CODs - Acetate	1,240E-9	1,240E-9	1,0290
CODs - Propionate	8,300E-10	8,300E-10	1,0290
CODs - Methanol	1,600E-9	1,600E-9	1,0290
Gas - Dissolved hydrogen	5,850E-9	5,850E-9	1,0290
Gas - Dissolved methane	1,963E-9	1,963E-9	1,0290
N - Ammonia	2,000E-9	2,000E-9	1,0290
N - Soluble degradable organic	1,370E-9	1,370E-9	1,0290
Gas - Dissolved nitrous oxide	1,607E-9	1,607E-9	1,0290
N - Nitrite	2,980E-9	2,980E-9	1,0290
N - Nitrate	2,980E-9	2,980E-9	1,0290
Gas - Dissolved nitrogen	1,900E-9	1,900E-9	1,0290
P - Soluble phosphate	2,000E-9	2,000E-9	1,0290
CODs - Undegradable	6,900E-10	6,900E-10	1,0290
N - Soluble undegradable organic	6,850E-10	6,850E-10	1,0290
Influent inorganic suspended solids	5,000E-14	5,000E-14	1,0290
Precipitate - Struvite	5,000E-14	5,000E-14	1,0290
Precipitate - Brushite	5,000E-14	5,000E-14	1,0290
Precipitate - Hydroxy - apatite	5,000E-14	5,000E-14	1,0290
Precipitate - Vivianite	5,000E-14	5,000E-14	1,0290
HFO - High surface	5,000E-14	5,000E-14	1,0290
HFO - Low surface	5,000E-14	5,000E-14	1,0290
HFO - High with H2PO4- adsorbed	5,000E-14	5,000E-14	1,0290
HFO - Low with H2PO4- adsorbed	5,000E-14	5,000E-14	1,0290
HFO - Aged	5,000E-14	5,000E-14	1,0290
HFO - Low with H+ adsorbed	5,000E-14	5,000E-14	1,0290
HFO - High with H+ adsorbed	5,000E-14	5,000E-14	1,0290
HAO - High surface	5,000E-14	5,000E-14	1,0290

HAO - Low surface	5,000E-14	5,000E-14	1,0290
HAO - High with H2PO4- adsorbed	5,000E-14	5,000E-14	1,0290
HAO - Low with H2PO4- adsorbed	5,000E-14	5,000E-14	1,0290
HAO - Aged	5,000E-14	5,000E-14	1,0290
P - Bound on aged HMO	5,000E-14	5,000E-14	1,0290
Metal soluble - Magnesium	7,200E-10	7,200E-10	1,0290
Metal soluble - Calcium	7,200E-10	7,200E-10	1,0290
Metal soluble - Ferric	4,800E-10	4,800E-10	1,0290
Metal soluble - Ferrous	4,800E-10	4,800E-10	1,0290
Metal soluble - Aluminum	4,800E-10	4,800E-10	1,0290
Other Cations (strong bases)	1,440E-9	1,440E-9	1,0290
Other Anions (strong acids)	1,440E-9	1,440E-9	1,0290
Gas - Dissolved total CO2	1,960E-9	1,960E-9	1,0290
User defined - UD1	6,900E-10	6,900E-10	1,0290
User defined - UD2	6,900E-10	6,900E-10	1,0290
User defined - UD3	5,000E-14	5,000E-14	1,0290
User defined - UD4	5,000E-14	5,000E-14	1,0290
Biomass - Sulfur oxidizing	5,000E-14	5,000E-14	1,0290
Biomass - Sulfur reducing propionic acetogenic	5,000E-14	5,000E-14	1,0290
Biomass - Sulfur reducing acetotrophic	5,000E-14	5,000E-14	1,0290
Biomass - Sulfur reducing hydrogenotrophic	5,000E-14	5,000E-14	1,0290
Gas - Dissolved total sulfides	1,530E-9	1,530E-9	1,0290
S - Soluble sulfate	2,130E-10	2,130E-10	1,0290
S - Particulate elemental sulfur	5,000E-14	5,000E-14	1,0290
Precipitate - Ferrous sulfide	5,000E-14	5,000E-14	1,0290
CODp - Adsorbed hydrocarbon	5,000E-14	5,000E-14	1,0290
CODs - Degradable volatile ind. #1	7,240E-10	7,240E-10	1,0290
CODs - Degradable volatile ind. #2	8,900E-10	8,900E-10	1,0290
CODs - Degradable volatile ind. #3	7,960E-10	7,960E-10	1,0290
CODs - Soluble hydrocarbon	7,120E-10	7,120E-10	1,0290
Gas - Dissolved oxygen	2,500E-9	2,500E-9	1,0290

EPS Strength coefficients [ ]

Name	Default	Value	
Biomass - Ordinary heterotrophic	1,0000	1,0000	1,0000
Biomass - Methylotrophic	1,0000	1,0000	1,0000
Biomass - Ammonia oxidizing	5,0000	5,0000	1,0000
Biomass - Nitrite oxidizing	25,0000	25,0000	1,0000
Biomass - Anaerobic ammonia oxidizing	10,0000	10,0000	1,0000
Biomass - Phosphorus accumulating	1,0000	1,0000	1,0000
Biomass - Propionic acetogenic	1,0000	1,0000	1,0000
Biomass - Acetoclastic methanogenic	1,0000	1,0000	1,0000
Biomass - Hydrogenotrophic methanogenic	1,0000	1,0000	1,0000
Biomass - Endogenous products	1,0000	1,0000	1,0000
CODp - Slowly degradable particulate	1,0000	1,0000	1,0000
CODp - Slowly degradable colloidal	1,0000	1,0000	1,0000
CODp - Degradable external organics	1,0000	1,0000	1,0000
CODp - Undegradable non-cellulose	1,0000	1,0000	1,0000
CODp - Undegradable cellulose	1,0000	1,0000	1,0000
N - Particulate degradable organic	1,0000	1,0000	1,0000
P - Particulate degradable organic	1,0000	1,0000	1,0000
N - Particulate degradable external organics	1,0000	1,0000	1,0000
P - Particulate degradable external organics	1,0000	1,0000	1,0000
N - Particulate undegradable	1,0000	1,0000	1,0000
P - Particulate undegradable	1,0000	1,0000	1,0000
CODp - Stored PHA	1,0000	1,0000	1,0000
P - Releasable stored polyP	1,0000	1,0000	1,0000
P - Unreleasable stored polyP	1,0000	1,0000	1,0000
CODs - Complex readily degradable	0	0	1,0000
CODs - Acetate	0	0	1,0000

CODs - Propionate	0	0	1,0000
CODs - Methanol	0	0	1,0000
Gas - Dissolved hydrogen	0	0	1,0000
Gas - Dissolved methane	0	0	1,0000
N - Ammonia	0	0	1,0000
N - Soluble degradable organic	0	0	1,0000
Gas - Dissolved nitrous oxide	0	0	1,0000
N - Nitrite	0	0	1,0000
N - Nitrate	0	0	1,0000
Gas - Dissolved nitrogen	0	0	1,0000
P - Soluble phosphate	0	0	1,0000
CODs - Undegradable	0	0	1,0000
N - Soluble undegradable organic	0	0	1,0000
Influent inorganic suspended solids	0,3300	0,3300	1,0000
Precipitate - Struvite	1,0000	1,0000	1,0000
Precipitate - Brushite	1,0000	1,0000	1,0000
Precipitate - Hydroxy - apatite	1,0000	1,0000	1,0000
Precipitate - Vivianite	1,0000	1,0000	1,0000
HFO - High surface	1,0000	1,0000	1,0000
HFO - Low surface	1,0000	1,0000	1,0000
HFO - High with H2PO4- adsorbed	1,0000	1,0000	1,0000
HFO - Low with H2PO4- adsorbed	1,0000	1,0000	1,0000
HFO - Aged	1,0000	1,0000	1,0000
HFO - Low with H+ adsorbed	1,0000	1,0000	1,0000
HFO - High with H+ adsorbed	1,0000	1,0000	1,0000
HAO - High surface	1,0000	1,0000	1,0000
HAO - Low surface	1,0000	1,0000	1,0000
HAO - High with H2PO4- adsorbed	1,0000	1,0000	1,0000
HAO - Low with H2PO4- adsorbed	1,0000	1,0000	1,0000
HAO - Aged	1,0000	1,0000	1,0000
P - Bound on aged HMO	1,0000	1,0000	1,0000

Metal soluble - Magnesium	0	0	1,0000
Metal soluble - Calcium	0	0	1,0000
Metal soluble - Ferric	0	0	1,0000
Metal soluble - Ferrous	0	0	1,0000
Metal soluble - Aluminum	0	0	1,0000
Other Cations (strong bases)	0	0	1,0000
Other Anions (strong acids)	0	0	1,0000
Gas - Dissolved total CO2	0	0	1,0000
User defined - UD1	0	0	1,0000
User defined - UD2	0	0	1,0000
User defined - UD3	1,0000	1,0000	1,0000
User defined - UD4	1,0000	1,0000	1,0000
Biomass - Sulfur oxidizing	1,0000	1,0000	1,0000
Biomass - Sulfur reducing propionic acetogenic	1,0000	1,0000	1,0000
Biomass - Sulfur reducing acetotrophic	1,0000	1,0000	1,0000
Biomass - Sulfur reducing hydrogenotrophic	1,0000	1,0000	1,0000
Gas - Dissolved total sulfides	0	0	1,0000
S - Soluble sulfate	0	0	1,0000
S - Particulate elemental sulfur	1,0000	1,0000	1,0000
Precipitate - Ferrous sulfide	1,0000	1,0000	1,0000
CODp - Adsorbed hydrocarbon	1,0000	1,0000	1,0000
CODs - Degradable volatile ind. #1	0	0	1,0000
CODs - Degradable volatile ind. #2	0	0	1,0000
CODs - Degradable volatile ind. #3	0	0	1,0000
CODs - Soluble hydrocarbon	0	0	1,0000
Gas - Dissolved oxygen	0	0	1,0000