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PROJECT DESCRIPTION:

Design, Build and operate of a Mechanical and Biological Waste Treatment Plant North of Malta

CLIENT:

CONSORTIUM:

BTA International

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DOCUMENT TITLE

process description WWTP (detail design)

Process Description:

Waste Water Treatment

Northern Malta

General Index

1. Introduction

The MBT Plant generates wastewater which has to be treated in a wastewater treatment plant to meet the effluent quality criteria given by the local regulation. The amount of water which has to be purified in the wastewater treatment plant (WWTP) as well as its composition depends on the amount and composition of the different types of wastes treated in the MBT Plant.

The wastewater treatment plant of the MBT Plant Northern Malta is designed to purify the wastewater coming from the anaerobic digestion section (AD Plant) and its operational time is 24 hours per day and 7 days per week.

The POW regarding the WWTP, that includes the plant constructions, cold and warm commissioning, remains unchanged compared to the conventional SBR reactor.

2. Design Basis

The amount of Waste treated in the AD Plant is:

- Organic fraction of MSW from dry pre-treatment: 41,122 t/a
- Cattle manure: 35,000 t/a
- Poultry mix: 4,000 t/a

The data needed to design the water treatment are the input flow and the wastewater composition.

The design flow is calculated from the WWTP-input indicated in the detailed mass balance for the nominal capacity (file: *Malta Mass Balance rev2 12032014*) plus 15% of the WWTP-input from the scenario treating only MSW (file: *Malta Mass Balance without Manure rev2 12032014*). The following table shows the determination of the daily design flow rate.

	m³/a	m³/d
Nominal capacity	60,396	165.5
Only MSW (without manure)	*17,420*	*47.7*
Plus 15% MSW	2,613	7.2
Design flow		172.7

The design flow to the wastewater treatment plant is 172.7 m³/day or 7.2 m³/hour. That means 63,036 m³/year.

The quality of the input flow of the wastewater treatment has to be determined based on experienced values acquired with other wastes digestion plants of the same process type and similar wastes composition as well as on the base of mass balances based on published data of wastes composition.

The following table shows the most important parameters which characterize the water fed to the biological step and the discharge limits into a sewer system:

Parameter	Unit	WWTP-Input	Effluent limit
Suspended solids	kg / m³	3.0	1.0
COD	kg / m³	3.5	1.65
COD easily biodegradable	kg / m³	0*)	——
BOD_5	kg / m³	1.5	0.78
TKN	kg / m³	4.3	0.182**)
NH_4-N	kg / m³	4.1	
P_{total}	kg / m³	0.5	0.008

*) after aerobic treatment of the digestate
**) Target value for total nitrogen

Based on the composition of the wastewater, the loads to WWTP as well as the removal rate can be identified (see table below).

Parameter	WWTP-load kg / d	Reduction kg / d	Removal rate %
Suspended solids	518	345	66.7
COD	604	319	52.9
BOD_5	259	124	48
TKN	742	711	95.8
P_{total}	86.3	84.9	98.4

3. WWTP – Process Description

The wastewater is treated biologically in an activated sludge process with intermitted feed and intermitted aeration as described in document 8.12 "Preliminary Details Relative to the Quantity and Composition of Surplus Water for the Relative Number of Waste Water Treatment Steps". Referred to this operation mode the system could be classified as modified sequencing batch reactors (SBR) as well.

The main target is to reduce the carbon and nitrogen content through a nitrification/denitrification process. The system is composed by two tanks which are parallel operated: the feed switches time controlled between the two tanks that form the WWTP. Therefore the plant wastewater is continuously fed to the WWTP. The system is working on a semi-batch based process: there are intermitted feeding of each nitrification/denitrification tank as well as intermitted aeration/anoxic phases (such as an SBR system) but feeding and discharging of each nitrification/denitrification tank occurs at the same time by overflow: therefore no sedimentation phase takes place inside the reaction tanks.

For the solid/liquid separation of the biomass and suspended solids, the effluent is discharged into one sedimentation tank. Part of the separated sludge is recycled into the nitrification/denitrification tanks and part of it (surplus sludge) is pumped into the suspension buffer.

The WWTP treats biologically the wastewater to reduce the effluent concentration resp. load of BOD_5 and total nitrogen. BOD_5-removal occurs during the aeration sequences of nitrification/denitrification tanks.

Sequences of aeration and anoxic periods reduce the total nitrogen by nitrification and denitrification to the form of de-nitrogen gas. As the wastewater has only a minor content of easily degradable BOD, the denitrification requires a dosage of a biologically easily-degradable carbon source (e.g. acetic acid).

Phosphorous is removed from the stream principally through two ways: a certain amount of phosphorous is incorporated into the biomass generated from COD/TKN removal because it is needed for bacterial growth; the remaining P_{tot}-load has to be removed by precipitation in the Nitrification/denitrification Tanks (simultaneous precipitation). For this purpose the dosing of a precipitation agent (e.g. $FeCl_3$) into the Nitrification/denitrification Tanks has to be foreseen. Both streams are then removed downstream in the Sedimentation Tank and discharged as excess sludge.

Suspended solids and COD are removed either by biological degradation or flocculation and separation by sedimentation.

The centrifuge producing the wastewater operates only from Monday morning to Saturday noon. Therefore, a buffer tank upstream to WWTP (Process Water 2 Buffer) guarantees a continuous feed during the whole week.

4. Operation Mode

4.1 WWTP Feeding

The WWTP is fed by two centrifugal pumps (Water Treatment Charge Pumps). Parallel connection of Pumps provides the possibility to feed each tank by each pump.

Feeding of each tank takes place intermittently and is time controlled. For example wastewater is pumped for one hour in nitrification/denitrification tank 1. That means that 7.2 m³ wastewater enter tank 1. Afterwards the wastewater feed is diverted for one hour to nitrification/denitrification tank 2 (7.2 m³ wastewater enter tank 2). Then wastewater fed switches again for one hour to nitrification/denitrification tank 1 and so on.

4.2 Nitrification/Denitrification

The biological activity in the nitrification/denitrification tanks removes nitrogen as well as biologically degradable organic compounds from the surplus water. Each of the two tanks is equipped with an air diffuser system, two mixers as well as an O_2-Sensor.

During feeding (e.g. for one hour) the tanks are mixed but not aerated. Mixing achieve a better accessibility of components for denitrification. Thus biologically degradable organics fed by the surplus water enhance the biological conversion of remaining nitrate (NO_3^-) and nitrite (NO_2^-) to gaseous nitrogen (N_2). In case of a lack of easily available biologically degradable organic matter addition of acetic acid improves this denitrification step. It can be said that the C-source consumption predicted in our proposal is equal to a conventional SBR reactor, because the biological process operating in both process is the same (based on a sequence of nitrification and denitrification steps).

After the feed stops, the aeration of the tank starts. The oxygen content in the tank increases up to 2 mg O_2/l within minutes by running two of the three installed blowers (Air Compressors Waste Water). Then the oxygen level in the tank is kept at 2 mg O_2/l by variation of the speed of the two blowers resp. stop of one blower.

After complete oxidation of ammonium (NH_4^+) or after stop of the feeding sequence of the second tank (e.g. one hour) the aeration is shut down and the mixers as well as acetic acid dosing are started.

The following table shows over a time period of four hours (e.g. from 8 am to 12 am) the status of the main units for the different sequences:

Time Period		*8 - 9*	*9 - 10*	*10 - 11*	*11 - 12*	→
Nitrification / Denitrifikation Tank 1	*Sequence*	*Denitri*	*Nitri*	*Denitri*	*Nitri*	→
	Feed Surplus Water	On	Off	On	Off	→
	Feed Acetic Acid	On	Off	On	Off	→
	No-Aeration only mixing	Yes	No	Yes	No	→
	Aeration	Off	On	Off	On	→
Nitrification / Denitrifikation Tank 2	*Sequence*	*Nitri*	*Denitri*	*Nitri*	*Denitri*	→
	Feed Surplus Water	Off	On	Off	On	→
	Feed Acetic Acid	Off	On	Off	On	→
	No-Aeration only mixing	No	Yes	No	Yes	→
	Aeration	On	Off	On	Off	→
Sedimentation Tank	Feed $FeCl_3$	Yes	Yes	Yes	Yes	→
	Effluent from N/D-Tank 1	Yes	No	Yes	No	→
	Effluent from N/D-Tank 2	No	Yes	No	Yes	→

In each of the parallel operated aeration tanks, sludge is recycled from the sedimentation tank to the nitrification/denitrification tanks to provide sufficient biomass content in these tanks. A back-charge rate from 100 up to 200 % of the volume of fed waste water is sufficient to achieve a SS-content of about 5 to 6 kgSS/m³ in each tank.

The effluent from each nitrification/denitrification flows by gravity to the sedimentation tank.

The above described operation mode of the nitrification/denitrification tanks ensures to meet the required effluent water values.

The intermittent process operation mode is more flexible because the aeration time and the proportion of denitrification phase to nitrification phase can be adjusted to the current requirements. By intermittent aeration and feeding of acetic acid during anoxic sequence, the conditions for reaction of biodegradable carbon with nitrate or nitrite are met optimally.

A manually controlled dosing system for antifoam agent is implemented for reduction of foam production if foam is generated excessively. The Antifoam Agent Tank is equipped with a stirrer, a level sensor and two pumps for separate agent dosing in each nitrification/denitrification tank.

4.3 P-Removal and Sedimentation Tank

The Iron Chloride Pumps feed the iron chloride solution from the buffer tank into the effluent of the nitrification/denitrification tanks during the feeding step of these tanks. These pumps are equipped with VFD for optimal agent dosing.

In a conventional SBR system, the precipitation agent is dosed directly inside the tank and it will be mixed in the entire volume: phosphorus precipitation and uptake for growth takes place in the same moment. In the proposed setup, there is time/space separation for those reactions, with the possibility to optimize the phosphorus removal. In the actual proposal the agent will be dosed shortly before the reactor discharge by