State of Palestine
Nablus Municipality

دولــة فلسطين
بلدية نابلس

Wastewater Treatment Plant

Nablus West

Annual Report for Operations and Reuse

2018

January 2019

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1. ABBREVIATIONS

µs/cm: Micro Siemens per centimeter

Al: Aluminum element

AT: Aeration tank

B: Boron element

BOD: Biological oxygen demand

Ca: Calcium element

Cd: Cadmium element

cfu: colony fecal unit

CH_4: Methane

Cl: Chloride

Cn: Cyanide element

C^o: Carbon monoxide

C^o: Celsius degree

CO_2: Carbon Dioxide

COD: Chemical oxygen demand

Cr: Chrome element

Cu: Cupper element

DO: Dissolved oxygen

FC: Fecal coliform

Fe: Ferric element

GIZ: Gesellschaft für International Zusammenarbeit

Hg: Mercury element

JV: Joint venture

KfW : Kreditanstalt für Wiederaufbau

kg/d: Kilogram per day

Km: Kilometer

KPR: Kinetics- Passavant Reodiger

kWh: Kilowatt hour

Li/HEC: Consultant Lahmeyer and Hijjawi Engineering Center

m^3: Cubic meter

MBAS: Methylene blue active substance

MCC: Motorized control centre

Mg: Magnesium element

MLSS: Mixed liquor concentration

Mn: Manganese element

MoA: Ministry of Agriculture

Na: Sodium element

NH_4-N: Ammonium as nitrogen

NM Nablus Municipality

NO_3-N: Nitrate as nitrogen

Pb: Lead element

PE: Population equivalent

PLC: Programmable Logic Controller

PO_4-P: Phosphate as phosphorous

SAR: Sodium adsorption ration

SCADA: Supervisory Control and Data Acquisition

Se: Selenium element

SO_4: Sulphate compound

TDS: Total dissolved solids

TN: Total nitrogen

TSS: Total suspended solids

UV: Ultra violet

WSSD: Water supply and sanitation department

WWTP: Wastewater treatment plant

WUA: Water user association

Zn: Zink element

Ni: Nickel element

2. INTRODUCTION

Water supply and sanitation department (WSSD) is considered one of the important departments of Nablus Municipality (NM) that provides safe drinking water and sanitation services to Nablus citizens and several surrounding villages in addition to four refugee camps, namely, Balata, Ein Beit Elma, New and Old Askar Camps. It is estimated that 230,000 inhabitants receive drinking water services. Water and sanitation department has a staff of 300 employees including engineers, technicians, skilled and unskilled laborers.

In 1998 the financial agreement for the implementation of Sewage Project Nablus West was signed between the German Government through KfW and Nablus Municipality. So far the allocated fund reached up to 39 million Euros. The Project consisted of construction trunk and interceptor of 12 km and wastewater treatment plant (WWTP) of 150,000 PE. The WWTP was designed to treat 14,000 m^3/day and 8.0 tons of BOD_5 per day. The plant is located near Beit Leed village junction. The wastewater is collected from Zawata, Beit Eba, Beit Wazan, Deir Sharaf and Qusin in the future by gravity after the implementation of relevant sewerage networks.

Nablus West catchment area presently has a population of about 120,000. Presently about 95% of the population of Nablus west is connected to the sewerage network. The main objective of the sewerage project Nablus West is:

- Improve the environmental and health conditions in upper Wadi Zumer
- Protect the surface and groundwater from pollution
- Reuse of treated wastewater for irrigation purposes

The construction works of the project have been completed in July 2013; however it was put into operation in November 2013. The consultant Lahmeyer and Hijjawi Engineering Center (Li/HEC) who provided the consultancy services for Nablus west sewerage project had issued the performance certificate to the contractor the JV of Kinetics- Passavant Reodiger (KPR) on September 23th 2015.

Operation assistance (OA) for two years at the cost of 1.10 million Euros has been allocated through KfW to provide operational assistance to operate, guide and train NM WWTP staff. The OA was provided by the KPR which was concluded in November 2015.

A second phase of OA financed through KfW is provided now by Consul Aqua to guide the WWTP staff on part time basis.

3. BACKGROUND

3.1 Location of the WWTP Nablus West

The WWTP Nablus West is located approx. 12 km West of Nablus City and lies on a much lower orthographical level than Nablus City. Ideally, wastewater is flowing into the treatment plant through gravity sewer system.

Figure (1): Section of a topographic map in the project area

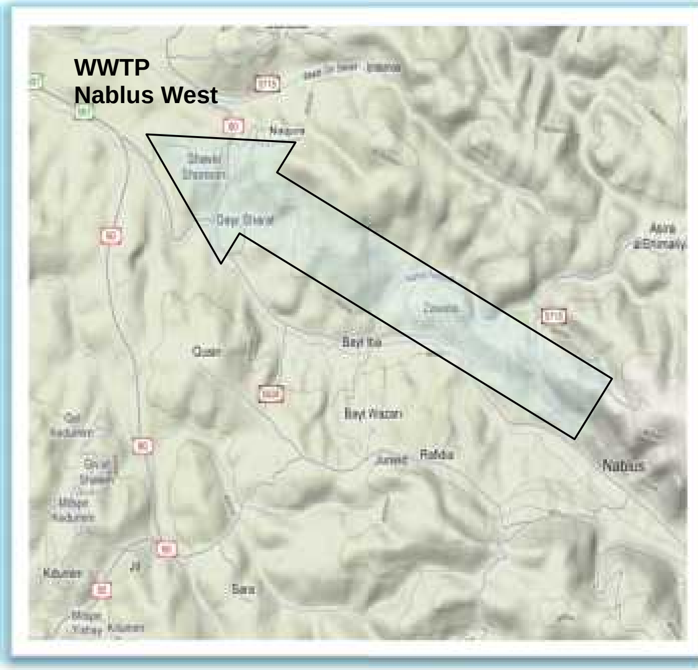


Figure (2): Direction of slope

Figure (3): Overview of WWTP Nablus West

3.2 WWTP Nablus West

The WWTP Nablus West is operated as an activated sludge process with a mechanical treatment, a biological treatment and a sludge treatment steps with gas utilization. In Figure (3) shows an overview of the WWTP Nablus West. Three construction stages have been planned for the WWTP Nablus West: stage 1 with a design horizon in 2020, stage 2 with design horizon in 2025 and a final stage 3 with design horizon in 2035. During the first construction stage only the colored parts in green of the WWTP (Figure 4) were implemented.

Figure (4): WWTP Nablus West

4. GENERAL PERFORMANCE

Around four millions six hundred and forty seven thousands (4,647,000 m^3) cubic meters of wastewater were treated in the year 2018, with an electrical consumption of three millions one hundred and forty eight thousands (3,148,000 kWh). During last year, in general the average lab results were in line with the Palestinian standards. The average effluent concentration of BOD_5 was 7.8 mg/l and TSS was 10 mg/l. By these results, the treatment efficiency in terms of BOD_5 and TSS were 98 % and 98% respectively.

5. OPERATION OF WASTEWATER TREATMENT PLANT FACILITIES

5.1 Screens and grit/grease removal

The wastewater treatment in Nablus west began with a screening unit. The screening unit consisted of two types of screens. The first is coarse screen (bar space of 5 cm), and the second was fine screen (bar space of 5 mm). The main objective of this unit was to protect the facilities from plastics, woods, rubbish and etc. The screened solid material removed by the screen conveyors for disposal.

Grit/grease removal unit was designed to remove sand and grits/grease from wastewater. The grease was sent to the anaerobic digester however, grits/sands were washed out by treated wastewater in the grit classifier to sanitary disposal.

5.2 Two Primary sedimentation tanks with total volume (1,728 m^3)

In this unit, around 60% of organic suspended solids were settled down in two rectangular tanks forming primary sludge. The primary sludge was thickened in a gravity primary thickener to increase its concentration from 1% to 4% to be digested in the anaerobic digester in a later stage.

5.3 Two Aeration tanks with total volume (18,000 m^3)

The biological wastewater treatment in the aeration tanks was the core of the WWTP. High concentration of special aerobic bacteria and other microorganisms were activated in the aeration tanks at existence of high concentration of oxygen called activated sludge. The soluble and other suspended organic material was digested by bacteria .This unit has to be controlled in terms of the concentration of activated sludge and dissolved oxygen content.

Almost 90% of the power consumption of the WWTP is required to operate theses two tanks.

5.3.1 Nitrification and de- nitrification

The plant was designed for COD removal. Nitrification and de-nitrification also phosphate elimination was not foreseen in the first stage. However, on the 17th of March, 2015 the plant started to perform nitrification, and de- nitrification process in the aeration tanks in addition to carbon removal process.

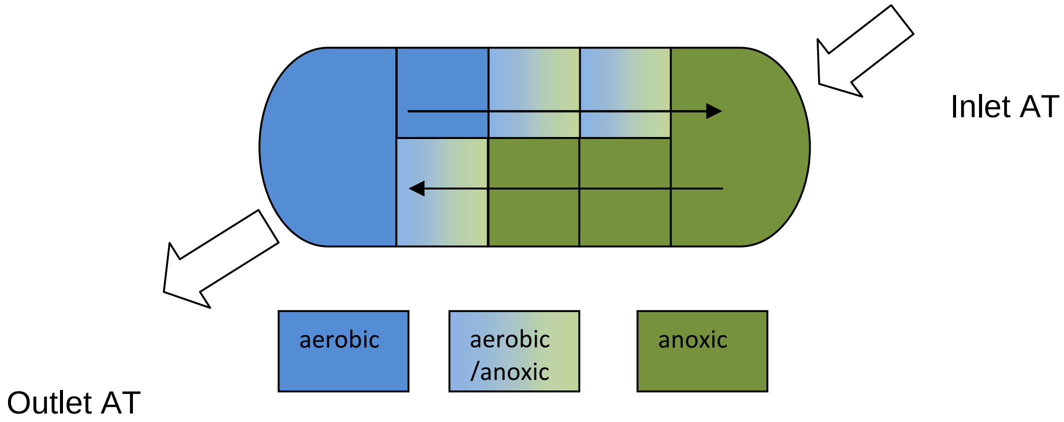


Figure (5): Aeration tank with implemented de-nitrification zone

In areas where oxygen was reduced, there were bacteria starting a de-nitrification process. In de- nitrification, elemental gaseous nitrogen is produced from nitrate and nitrite and released to the atmosphere.

5.4 Two Final sedimentation tanks with total volume ($7,718\ m^3$)

The activated sludge was settled down in the two circular final sedimentation tanks. The settled bacteria was withdrawn from the bottom of the tanks and returned back to the aeration tanks as returned sludge. This recycling of activated sludge was necessary to maintain certain concentration of activated sludge (around 2-3% SS) with optimal sludge age, however the excess sludge was pumped to the mechanical thickeners for further treatment in the anaerobic digester.

6. OPERATION OF SLUDGE FACILITIES

6.1 Two Belt thickeners

The excess sludge was withdrawn via pumps to the belt thickeners where polymer was added. This machine thickened the excess sludge up to 1% to 6% SS concentration. After thickening it was mixed with the primary thickened sludge to be pumped later on to the digester.

6.2 Primary thickener tank (548 m^3)

The settled primary sludge in the primary sedimentation tanks was sent to the primary gravity thickener circular tank. In this unit, the sludge was thickened to reach 6% which was treated in the anaerobic digester.

6.3 Anaerobic digester (3,650 m^3)

The thickened primary sludge and thickened excess sludge were treated in the anaerobic digester; the retention time is 21 days. Temperature and pH were carefully monitored to maintain optimum conditions for the anaerobic bacteria in the digester (pH= 6.8-7.5), the solid content was around 3-4%. The biogas produced from the digester normally contained 33% of CO_2 and 66% of methane gas. The sludge was heated up via boiler to maintain mesophilic conditions in the digester around 36 C^o.

Figure (6): Digester tank in Nablus West WWTP with the gas flare

6.4 Gas balloon holder (660 m^3)

Produced CH_4 gas from the digester was treated in stone filters to remove the humidity and then store it in the gas holder.

6.5 Gas flare

The excess gas was burned by the gas flare. It started flaring when the storage in the balloon reaches up to 90% and stop when it reached 80% of the volume of gas balloon.

6.6 Sludge drying beds

In emergency cases, the digested sludge was pumped to the drying beds for drying via natural evaporation. There were 11 beds with total area of 11.5 donum. After drying, the sludge was transported to the sludge storage yard for disposal into Zahret Al-Fenjan sanitary landfill site near Jenin.

6.7 Belt Filter Presses

Two belt filter presses were used to dewatering the digested sludge coming from the digester to have solids more than 25%. Special polymers were used to improve the efficiency of these machines as shown in Figure (7).

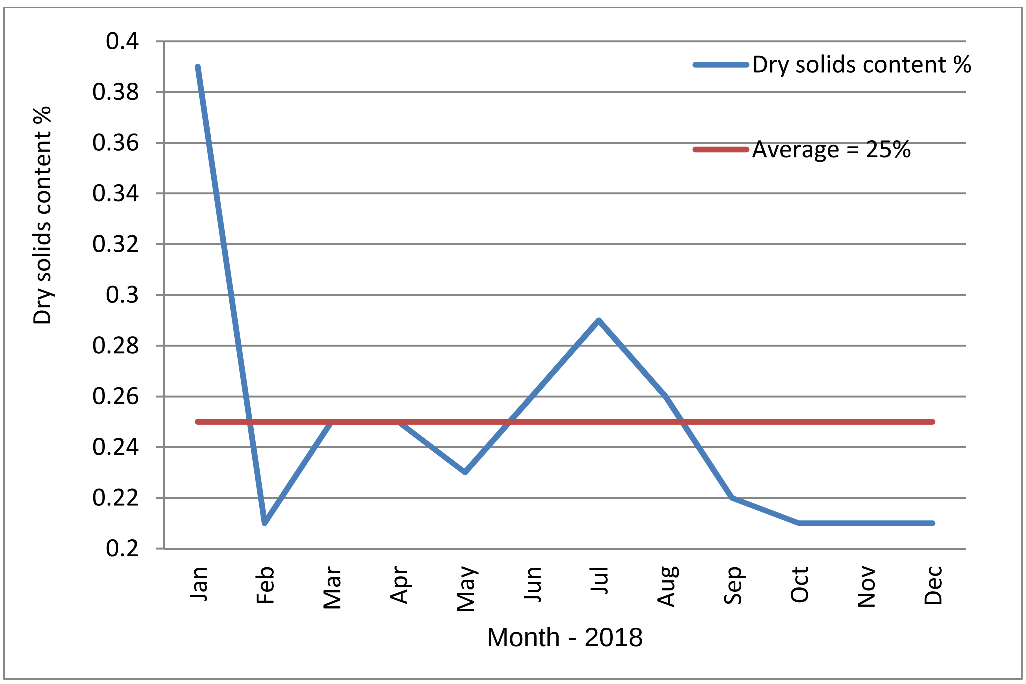


Figure (7): Dry solids content after mechanical dewatering.

6.8 Other facilities

Other equipment were available for the sustainability of the operation of the WWTP such as well-equipped lab, stand by generator, spare parts, administration building and workshop.

6.9 Additional improvement works

Nablus Municipality has always has a strategy to improve the performance. In 2018, kfW funded a project to implement additional improvements on the plant. Four main improvements have been implemented in the plant:

- Constructing a stone trap.
- Constructing a storage tank for olive mill wastewater.
- Covering and Odour control of primary thickener tank.
- Rehabilitation of the cladding of digester.

The following photo's are depicting the above implemented works.

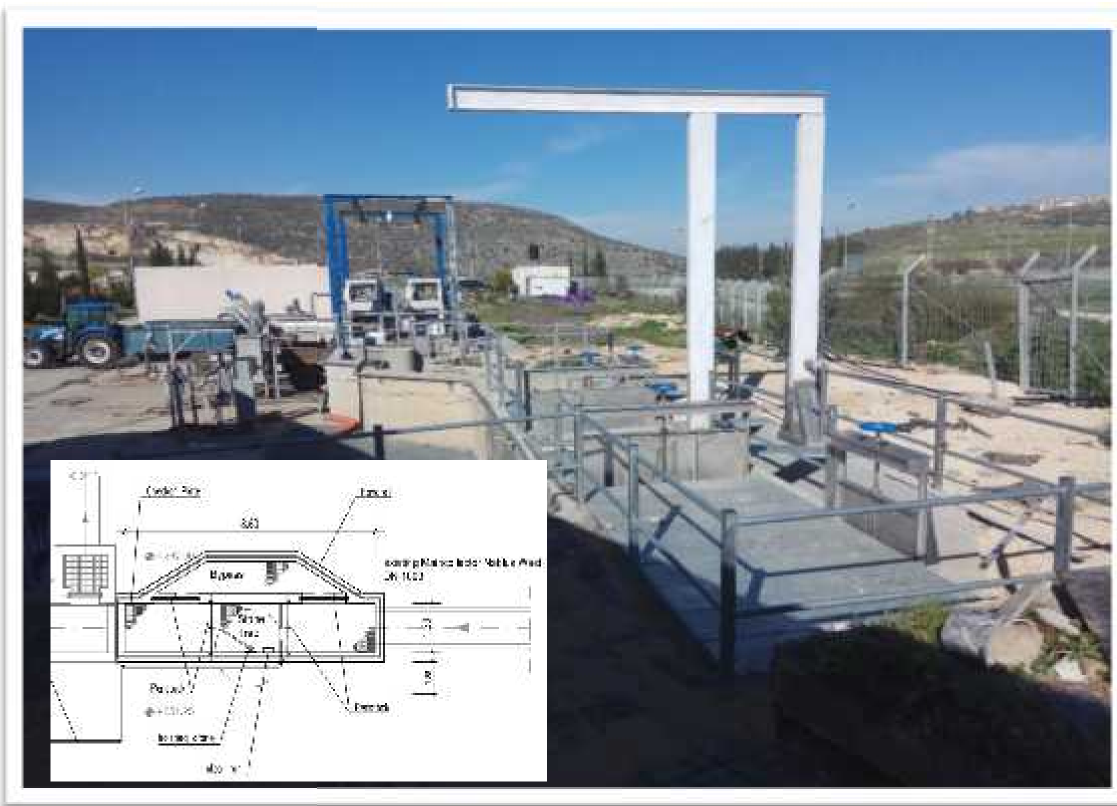


Figure (8): Stone trap at the inlet of WWTP

Figure (9): Storage tank of olive mill wastewater

Figure (10): Odor control (bio filter to treat the gases of the primary thickener and Zibar storage tanks)

Figure (11): Covering of the primary thickener tank

Figure (12): Cladding Rehabilitation of Anaerobic digester roof insulation.

6.10 Olive Mill wastewater treatment in Nablus WWTP

By Environmental control unit (ECU) coordination with Nablus WWTP, suction trucks which belongs to private sector have been hired to transport olive mills wastewater (OMW) produced from the following olive mills (Aladham from Nablus, Abu-Shadi, Abu-laila from Qusin village, olive mills from Beit Leed). About 390 m^3 have been transported and stored in the newly constructed storage tank that was pumped into the anaerobic digester for treatment. The feeding dose rate was gradually increased from 5 to 16 m^3/day. The gradual increase was aiming to alleviate the shocks load to the digester biomass. Performance efficiency of the digester was monitored and compared to the normal operation conditions. The results obtained indicated that, biogas production rate was increased in the time of OMW feeding. During a month of the experiment, which was started in 10/10/2018 and ends on 10/11/2018, the overall biogas production was increased by around 12,000 Nm^3/month. Due to this increase in biogas, the electrical production was increased by around 30,000 kWh, which is about 14,000 NIS. No inhibition was noticed by OMW and its phenolic compounds. The disposal strategy of OMWW is possible as it was treated in the digester without any negative impacts on the performance. In addition it was feasible in terms of gas production and electrical savings. This is in-line with the strategy of NM to protect the environment by avoiding dumping OMW in nearby Wadies.

6.10.1 Performance comparison

In this section, comparison figures were drawn to depict the difference of the digester performance in terms of different disturbances. Figure (13) shows total VS load that fed to the digester versus the biogas production. It shows a decrease in total VS load fed to the digester at the date of OMW experiment began, where at the same time the biogas production has increased before the experiment. This proves that a change in VS quality has occurred once OMW fed to the digester which increased the biogas production.

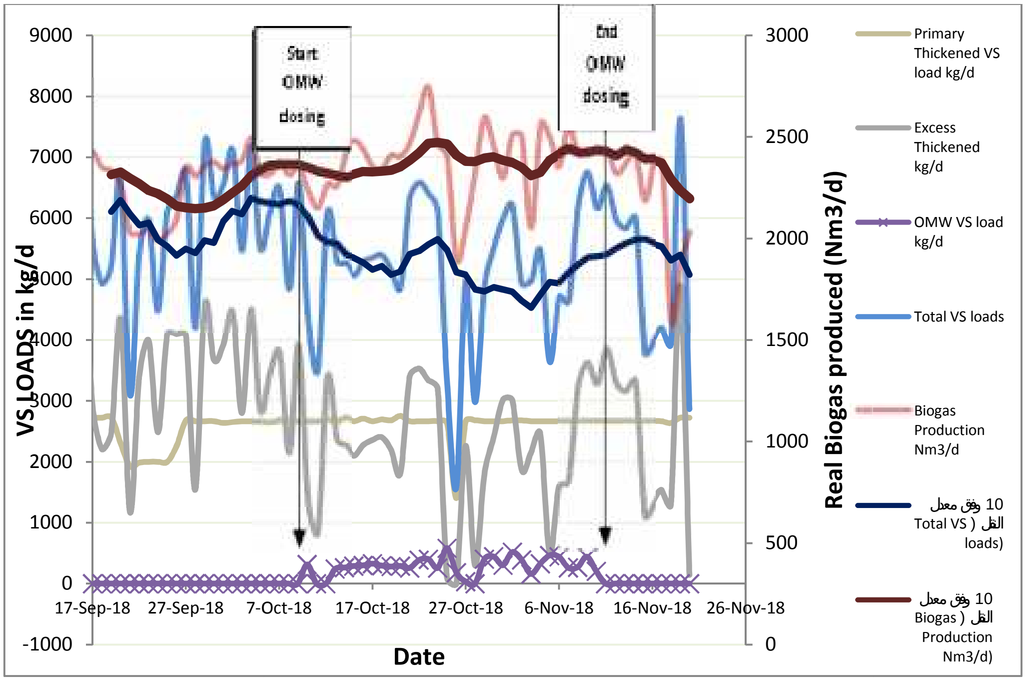


Figure (13): Total organic VS load relationship with real biogas production

6.10.2 Digester Performance evaluation

The digester reference point of operation data is compared with the case of OMW dosing. Alkalinity, and Organic Acid, are evaluated and figured. No tangible change in pH was happened. Figure (14) shows the relationships of Alkalinity and organic acid in the digester before, during and after experiment.

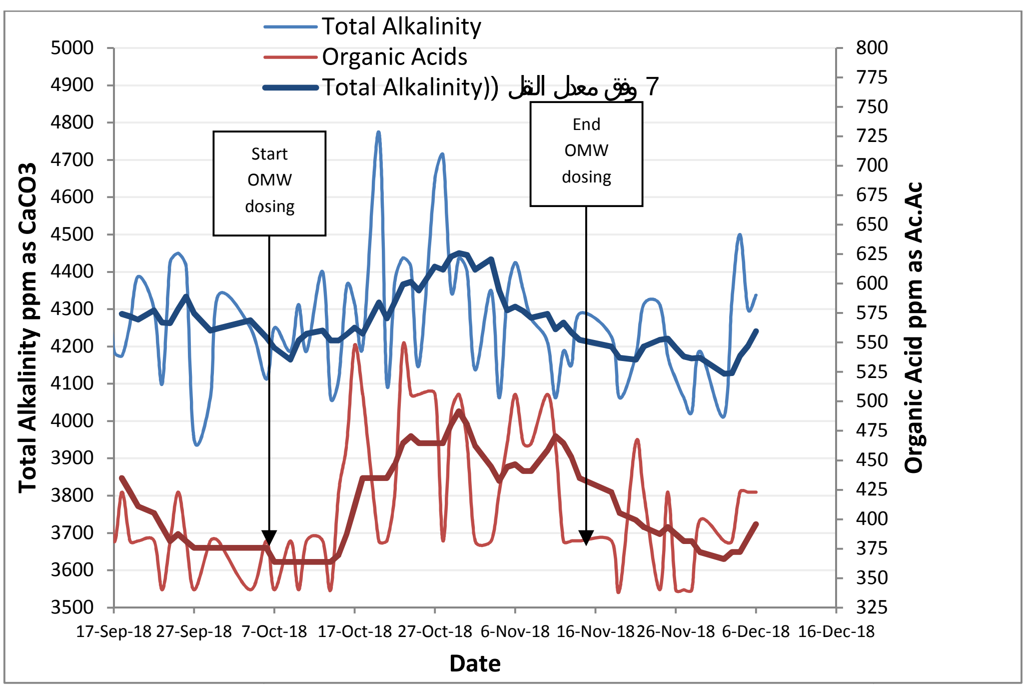


Figure (14): The behavior of qualitative parameters of Nablus plant digester

7. SCADA SYSTEM

The sewage treatment plant was controlled by using Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA). The PLC’s are located in several substations (electrical switch rooms) within the wastewater treatment plant.

The wastewater treatment plant was controlled by PLC’s. PLC’s and their support equipment were computer controlled system that was capable of remote managing of the plant’s operation. The control was executed from the analogous and digital in-puts / outputs received from instruments, drives and MCC and from signals received from the SCADA system.

Figure (15): Nablus WWTP SCADA system

8. PERFORMANCE OF WWTP

8.1 Influent flow

The performance of WWTP Nablus West during 2018 was analyzed on the basis of the plant loading which had been monitored regularly. Two aeration treatment tanks were mainly in operation, the hydraulic treatment capacity of the plant was sufficient and the amount of inflow in most cases under design capacity. Only extreme weather conditions (heavy rain) led to capacity problems. The hydraulic and pollutants loading and the actual performance of WWTP Nablus West from January 2018 to December 2018 were analyzed.

Figure (16) Shows the hydrographs of the daily wastewater flows which were treated in WWTP Nablus West. It became clear that no strong fluctuation of the daily wastewater flows occurred during summer time. However, in the winter time the fluctuation was sometimes very high due to heavy rain events. In such cases, the bypass to Wadi prior to the WWTP had to be used for the plant protection design capacity.

The average daily wastewater flow in the year 2018 was approximately 12,895 m³/day . The amount of incoming wastewater will increase gradually over the next years.

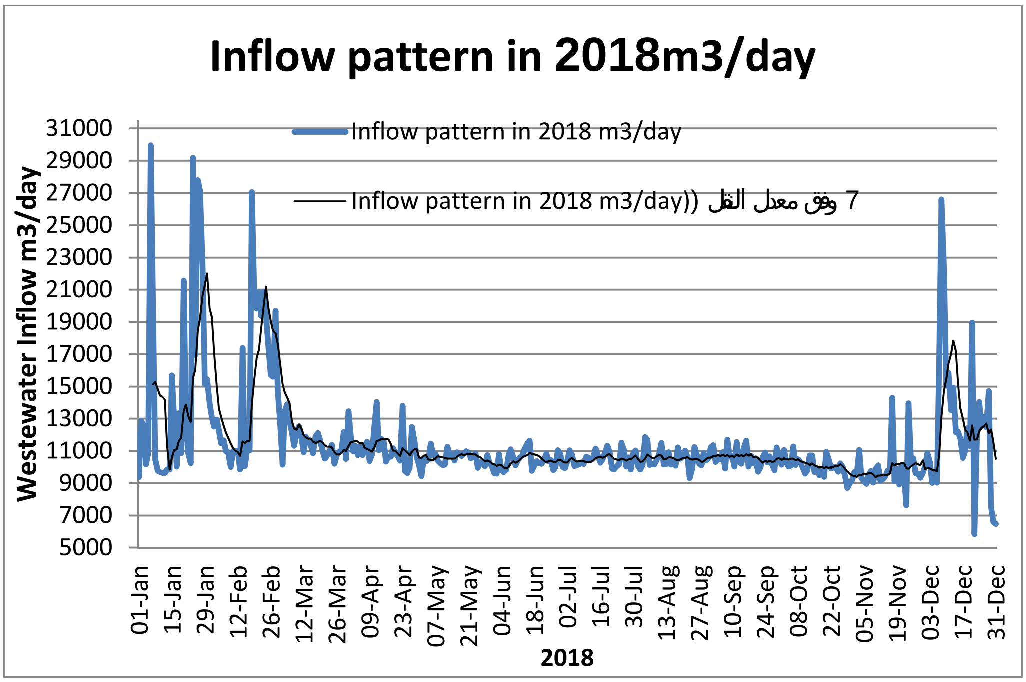


Figure (16): Hydrograph of the daily treated wastewater inflow

8.2 Cleaning performance

The current daily wastewater pollution load treated in WWTP Nablus West in terms of COD and SS were calculated. The average daily COD load was approximately 12,344 kg/d and the total COD load over the year of 2018 was 4,505,000 kg/year. The COD load at the effluent in the same period was 185,420 kg/year. The cleaning performance is approximately 96%.

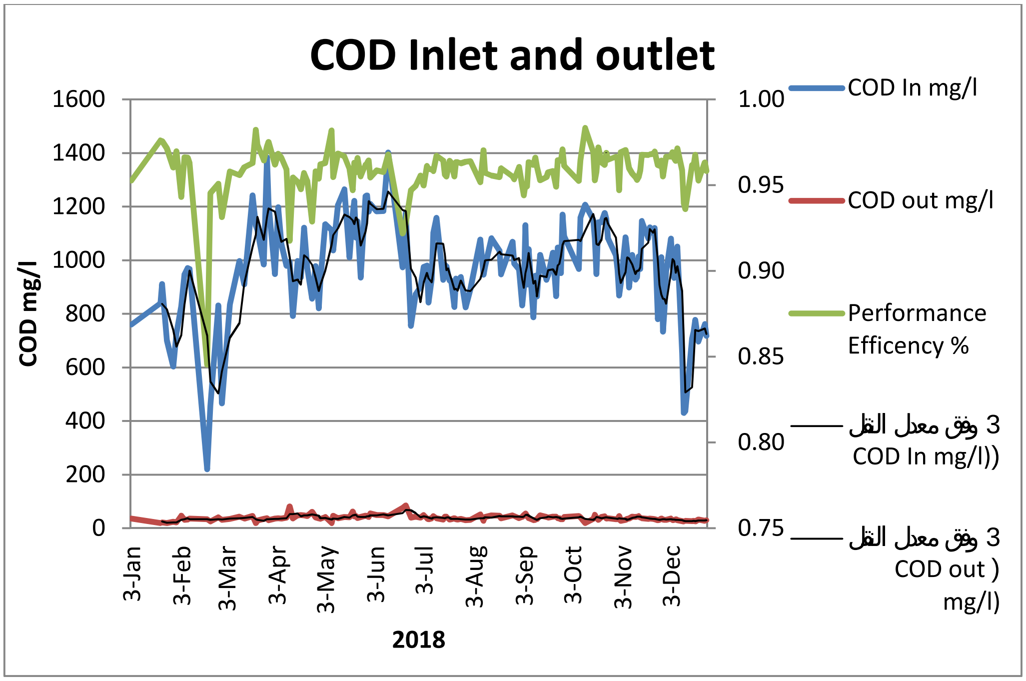


Figure (17): Influent and effluent concentration of COD

The hydraulic and pollutant load of WWTP Nablus West as well as site conditions had an effect on the performance of the WWTP. The average daily suspended solids inflow was approximately 5,654 kg/d. The reduction of suspended solids was in average approximately 97%.

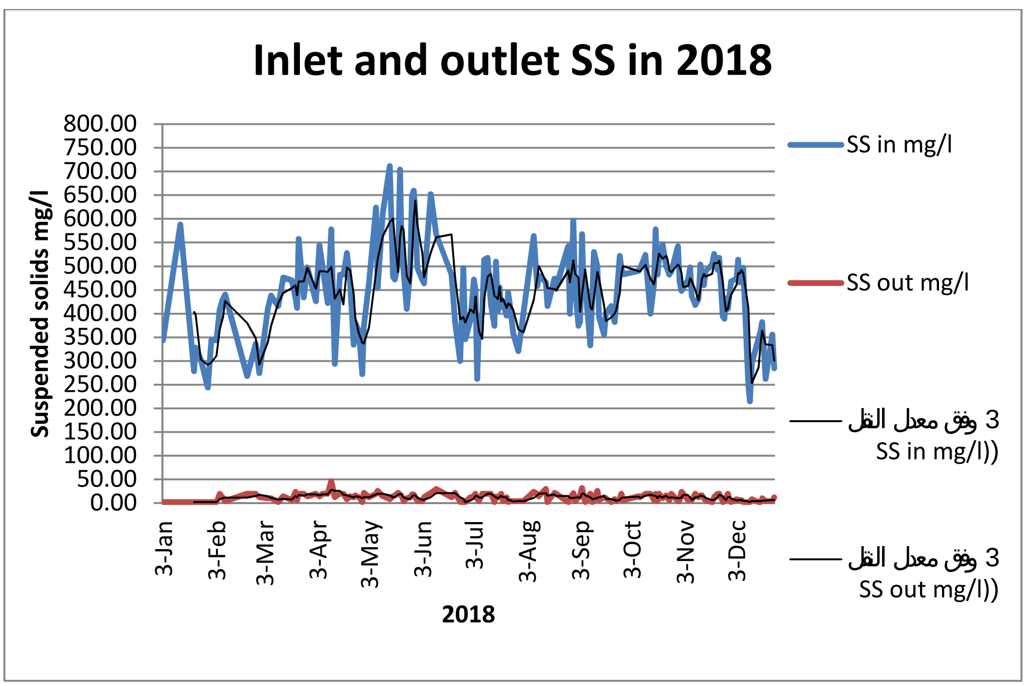


Figure (18): Suspended solids of the inlet and outlet of the treatment plant

8.3 Power consumption

Optimization of operation was one of the most important challenges in municipal WWTPs. The specific power consumption of similar WWTP is about below 0.85 kWh per m^3 of treated wastewater, and below 0.8 kWh of kg COD removed, however in Nablus WWTP is 0.69 kwh/m^3 and is 0.74 kg/COD removed respectively. Deviations from this value can be attributed to the circumstances of daily plant operation.

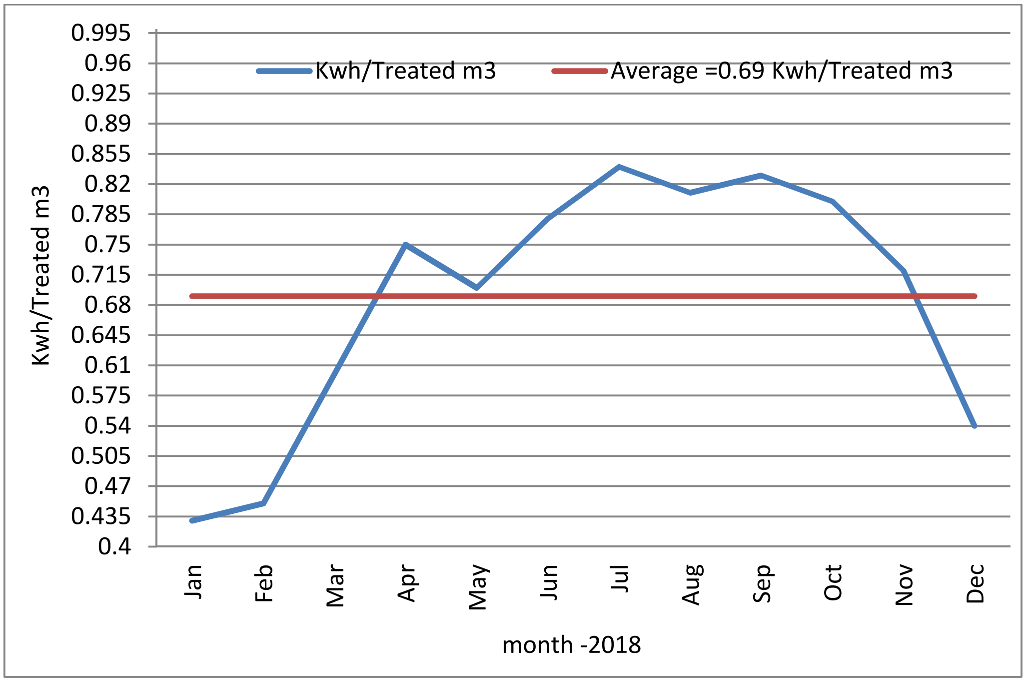


Figure (19): Monthly values of power consumption per treated m^3 of wastewater

8.4 Gas production

The average gas production in 2018 was 2,127 nm^3/d, and was fed to CHP to produce the electrical and thermal powers, part of the produced thermal power was used for heating up the digester.

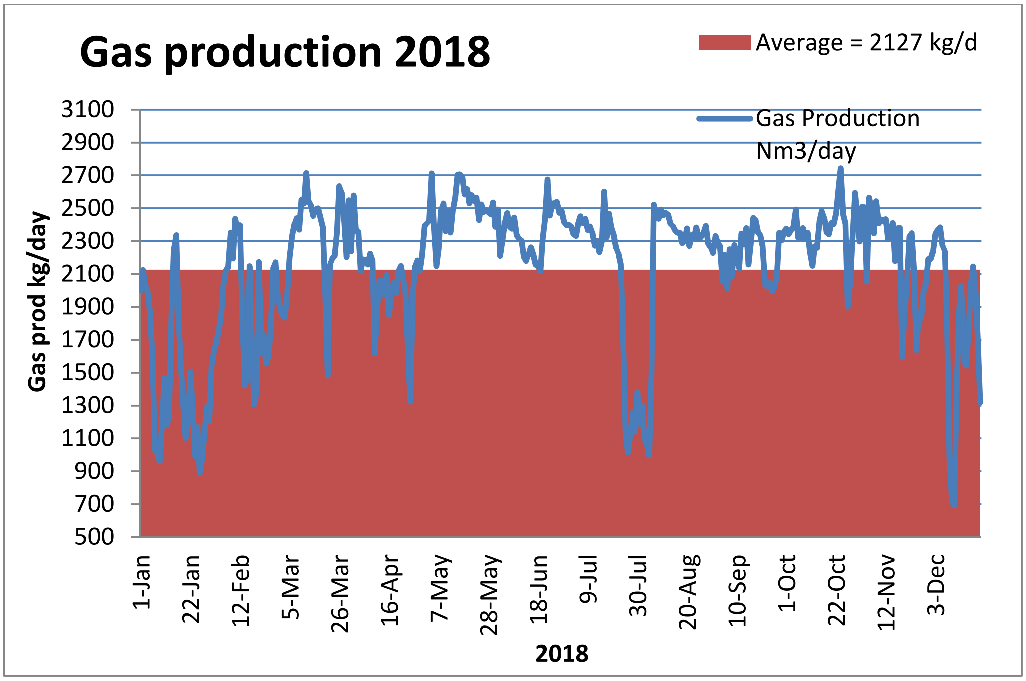


Figure (20): Gas production of the digester

In 2018 more regular operation of the digester was done and as a result a substantial increase in biogas occurred. Biogas flowmeters were optimized for reading the flow in normal cubic meters instead of kilogram. This optimization was done with reference of new installed sensor of biogas flowmeter in the combined heat and power plant (CHP).

8.5 Desulfurization Unit

The desulphurization unit of biogas is considered as one of the main components of CHP unit, which ensures the sustainability of operation of the CHP. It treats the produced biogas from anaerobic digester from H_2S gas and Siloxane. Such compounds are dangerous for the engine and could cause engine failure.

Figure (21): **Nablus West desulfurization unit**

8.6 CHP engine

One of the best energy efficiency practices in WWTP’s is utilizing the biogas through CHP engine. Nablus CHP engine has been put in operation in 18/6/2017. It is burning the treated biogas which treated in desulfurization unit and produce electrical and thermal power. It was covered around 60% of the total electrical consumption of Nablus plant. the future planning is to cover around 80% of total electrical demand is foreseen as more organic load reaches to the Treatment plant from the nearby villages of Nablus West.

Figure (22): Nablus West CHP engine.

8.7 Nablus CHP electrical figures

The electrical consumption of the plant and CHP production are monitored on daily.

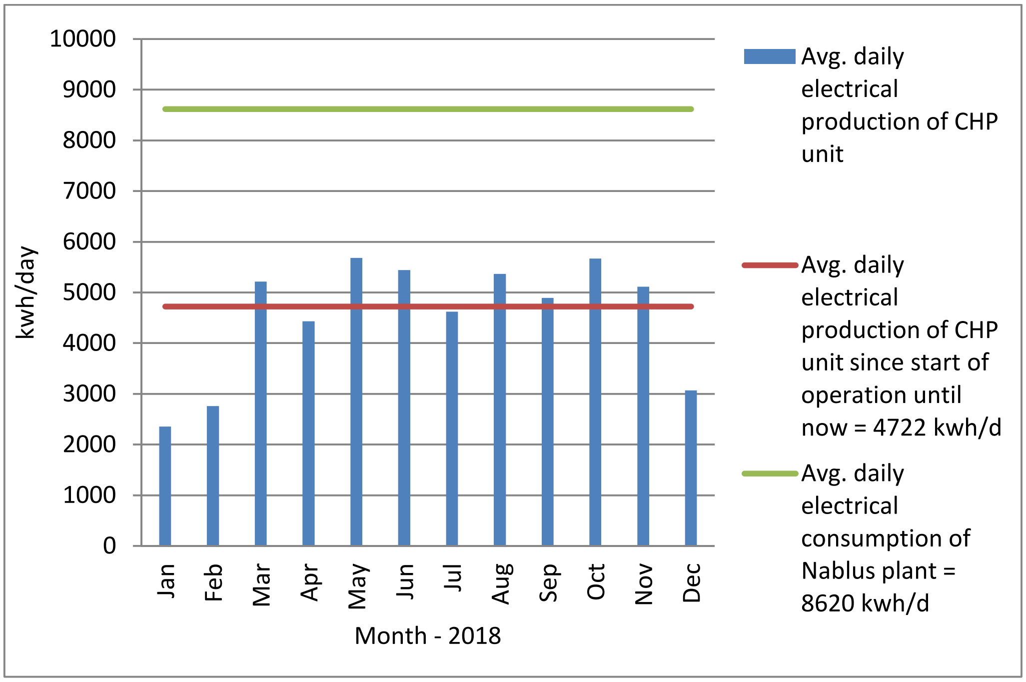


Figure (23): Electrical consumption of plant with comparison of CHP electrical production

8.8 Online measurement For Nitrogen and suspended solids in the aeration tanks:

In 2017 an online system for measuring Nitrogen with suspended solids have been installed in the aeration tanks, four sensors (NH_4, NO_3) and two (suspended solids) at specific locations in the aeration tanks which help controlling the nitrification/denitrification process efficiently.

By direct on line measurement of such parameters, an optimization of energy could be achieved in terms of oxygen supply via the surface aerators which are considered the prominent energy consumers among other units, as a result a significant reduction of wastewater energy demand.

A complete connection to SCADA will be optimized in terms of Oxygen supply from surface aerators.

9. PREVENTIVE MAINTENANCE

From the beginning of the plant operation maintenance works and plans had been conducted in accordance with the periodic and routine works of machines manuals. These works could be classified as preventive maintenance. Preventive maintenance was done by Nablus WWTP staff.

It is worthy to mention that 84 maintenance operations were done in 2018 for different units and equipments.

10. STAFF TRAINING AND ORGANIZATION STRUCTURE

Training was essential for the sustainability of the plant. The staff of Nablus plant had been trained through KfW in the fields of process operations such as:

- Practical training on routine and preventive maintenance of CHP and biogas bio filter for the electro mechanical staff by the Garman supplying co.
- Attending the iFAT exhibition held in Munich in May 2018.
- Training in Japan for operation and maintenance of sewerage systems.

11. REUSE PROJECTS

11.1 Introduction

Middle East developing countries are facing a scarcity in water resources. They depend on groundwater as the main source. The last three decades were witnessed an urban renaissance in these countries which includes sewer systems construction. Unfortunately, this progress was done without going for a proper treatment projects for the collected big quantities of urban sewers propagates a negative impact on the main source of water. Lack of financing to construct wastewater treatment projects was the main reason for this environmental ignorance. In Palestine, Nablus was funded by KfW to construct two wastewater treatment plants in east and west of the city. In 2015, Nablus West wastewater treatment plant was put into operation and created an alternative source of water. Nablus Municipality strategy was concentrated into insuring a sustainable operation before going ahead for tertiary treatment and starting reuse projects. After two years of sustainable operation for the plant, pilot reuse projects have been done to improve the quality of treated water using tertiary treatment to be fit for agricultural reuse. Lands inside and outside the plant were planted and irrigated by tertiary treated wastewater that meets 34 quality items required by the specification of Ministry of agriculture for restricted irrigation (law 34-2012). Alfalfa and various kinds of trees are planted and irrigated by the projects. The treated water is distributed to farmers by irrigation networks which have flowmeters for accounting the sold water under the local law conditions.

11.2 Nablus Tertiary treatment

Three different tertiary treatment systems have been installed in Nablus plant for supplying tertiary water for reuse pilot projects. The First system was funded by KfW which consists of sand filtration units and UV disinfection. This system has a capacity of 10 m^3/hr and serving 40 donums as educational pilot reuse project inside the plant. The second system was funded by USAID through compete project which consists of gravel filtration units and chlorination. This system has a capacity of 60 m^3/hr and Pumping the tertiary treated water to the reservoir with capacity 750 m^3 and then distribute the water by gravity to the farmer's land (140 donums) outside the plant south area of the treatment plant. The Third one funded by KfW which consists of Disc filter units and UV disinfection. This system has a capacity of 100 m^3/hr and serving 120 donums as another pilot reuse project outside the plant North area between the main street and the treatment plant.

11.3 Quality of tertiary treatment systems

Table (1): Quality of the treated water (NWWTP) with comparison of reuse standard (34/2014) 2017

Maximum limits for chemical and biological properties	**KfW** reuse project July 2017	**USAID** reuse project July 2017	**Quality of Tech. Spec 34-2014**				**Method of Testing**
			High Quality (A)	**Good Quality (B)**	**Medium Quality (C)**	**Low Quality (D)**	
(BOD_5) mg/l	14.8	5	20	20	20	60	Birzeit Lab, StMe
suspended solids	<2	6	30	30	30	90	Birzeit Lab, StMe
FC (Colony/100ml)	Nill	2	200	1000	1000	1000	Birzeit Lab, Iso method
(COD) mg/l	45.3	25	50	50	100	150	Birzeit Lab, StMe
Dissolved Solids	975	820	1200	1500	1500	1500	Birzeit Lab, StMe
pH	7.74	7.54	6--9	6--9	6—9	6--9	Birzeit Lab, StMe
Fat, Oil, & Grease	4	4	5	5	5	5	Birzeit Lab, StMe method
Phenol mg/l	-	BDL	0.002	0.002	0.002	0.002	
MBAS	-	<10	15	15	15	25	
NO3-N ppm	BDL	2.46	20	20	30	40	Birzeit Lab, StMe method
NH4-N mg/l	1.3	1.4	5	5	10	15	
Total nitrogen	6.6	11.06	40	40	40	40	
CL ppm	260.82	239.38	400	400	400	400	Birzeit Lab, CIA method
SO_4 ppm	88.73	97.40	300	300	300	300	Birzeit Lab, CIA method
Na ppm	177	197	200	200	200	200	Birzeit Lab, ICP instrument
Mg ppm	26.2	21.9	60	60	60	60	
Ca ppm	74.7	82.28	300	300	300	300	
SAR	5.37	5.33	5.85	5.85	5.85	5.85	Birzeit Lab, ICP
PO_4-P ppm	16.3	11.93	30	30	30	30	Birzeit Lab, ICP
Al ppm	0.10	0.05	5	5	5	5	0.001Birzeit Lab, ICP instrument
Cu ppm	0.035	0.013	0.2	0.2	0.2	0.2	
Fe ppm	0.113	0.07	5	5	5	5	
Mn ppm	BDL	0.04	0.2	0.2	0.2	0.2	
Ni ppm	0.054	BDL	0.2	0.2	0.2	0.2	
Pb ppm	0.03	0.03	0.2	0.2	0.2	0.2	
Se ppm	BDL	BDL	0.02	0.02	0.02	0.02	
Cd ppm	0.01	BDL	0.01	0.01	0.01	0.01	
Zn ppm	0.08	0.16	2	2	2	2	
Cn ppm	BDL	BDL	0.05	0.05	0.05	0.05	
Cr ppm	<0.04	BDL	0.1	0.1	0.1	0.1	
Hg ppm	<0.05 ppb	0.44 ppb	0.001	0.001	0.001	0.001	
Co ppm	BDL	BDL	0.05	0.05	0.05	0.05	
B ppm	0.15	0.065	0.7	0.7	0.7	0.7	
Ag ppm	BDL	1					Birzeit Lab, ICP
E. coli (Colony/100ml)	Absent	Absent	100	1000	1000	1000	Birzeit Lab, Iso method
Nematodes (eggs/L)	Absent	Absent	1>=	1>=	1>=	1>=	Birzeit Lab, StMe

BDL = below detection limit

Table (2): Quality of the treated water (NWWTP) with comparison of reuse standard (34/2014) 2018

Maximum limits for chemical and biological properties	**KfW** reuse Inside project sampled 8\12\2018 **Sand Filter and UV**	**USAID** reuse project sampled 8\12\2018 **Gravel Filter and Chlorination**	**Quality of Tech. Spec 34-2014**				**Method of Testing**
			High Quality (A)	Good Quality (B)	**Medium Quality (C)**	**Low Quality (D)**	
(BOD_5) mg/l	<5	<5	20	20	(BOD_5)	<5	<5
suspended solids	<2	<2	30	30	suspen	<2	<2
FC (Colony/100ml)	Nill	Nill	200	1000	FC	Nill	Nill
(COD) mg/l	14	16	50	50	(COD)	14	16
Dissolved Solids	725	811	1200	1500	Dissolv	725	811
pH	7.65	7.79	6--9	6--9	pH	7.65	7.79
Fat, Oil, & Grease	-	-	5	5	Fat, Oil,	-	-
Phenol mg/l	-	-	0.002	0.002	Phenol	-	-
MBAS	-	-	15	15	MBAS	-	
NO3-N ppm	10.16	8.83	20	20	NO3-N	10.16	8.83
NH4-N mg/l	-	-	5	5	NH4-N	-	
Total nitrogen	31.06	40.3	40	40	Total	31.06	40.3
CL ppm	156.16	159.15	400	400	CL	156.16	159.15
SO_4 ppm	56.94	51.32	300	300	SO_4	56.94	51.32
Na ppm	132.3	161	200	200	Na	132.3	161
Mg ppm	16.54	16.64	60	60	Mg	16.54	16.64
Ca ppm	90	88.6	300	300	Ca	90	
SAR	3.36	4.12	5.85	5.85	SAR	3.36	4.12
PO_4-P ppm	9.32	9.28	30	30	PO_4-P	9.32	9.28
Al ppm	0.051	0.052	5	5	Al ppm	0.051	0.052
Cu ppm	N.D	N.D	0.2	0.2	Cu	N.D	N.D
Fe ppm	N.D	N.D	5	5	Fe	N.D	
Mn ppm	0.012	0.09	0.2	0.2	Mn	0.012	N.D
Ni ppm	N.D	N.D	0.2	0.2	Ni	N.D	
Pb ppm	N.D	N.D	0.2	0.2	Pb	N.D	0.09
Se ppm	N.D	N.D	0.02	0.02	Se	N.D	N.D
Cd ppm	N.D	N.D	0.01	0.01	Cd	N.D	
Zn ppm	0.028	0.027	2	2	Zn	0.028	N.D
Cn ppm	-	-	0.05	0.05	Cn	-	N.D
Cr ppm	N.D	N.D	0.1	0.1	Cr	N.D	
Hg ppm	-	-	0.001	0.001	Hg	-	N.D
Co ppm	N.D	N.D	0.05	0.05	Co	N.D	
B ppm	N.D	0.052	0.7	0.7	B ppm	N.D	0.027
Ag ppm	-	-			Ag	-	-
E. coli (Colony/100ml)	Nill	Nill	100	1000	E. coli	Nill	Nill
Nematodes (eggs/L)	Absent	Absent	1>=	1>=	Nemato	Absent	Absent

11.4 Summary of Executed Reuse Pilot Projects

11.4.1 Reuse Inside scheme Project

- Tertiary treated wastewater by sand filtration and UV disinfection with a capacity of 10 m^3/hr.
- Planted 40 Donums of lands Inside Nablus WWTP
- The main objective of this scheme is getting results to be as educational project.
- Funded by KfW with 426,000 €.
- The system is controlled by an irrigation controller that use Radio frequency to give the open and close command to the valves, each 18 plot get its specific amount of water inserted by the controller, as a pilot project each crop should get the specific water requirement separately as the crop water requirement, also the fruit trees and alfalfa is connected to a fertilizer (chemical injector Type) controlled by the irrigation controller.

Figure (24): Planted lands inside Nablus plant (reuse inside scheme)

Table (3): Type of crops which have been planted in Reuse inside Scheme pilot project

Common name	Name In Arabic	Age (Year)	Root stock	pollinator %
Almond Tree	لوز	3	GF	5%
Pistachio	فستق حلبي	3		10%
pecan Walnut	جوز بيكان	3	Pecan seed	
Walnut	جوز	3		
Pomelo	بوملي	3	Bitter orange	
Lemon	ليمون	3	Bitter orange	
Olive Tree	زيتون	1.5		
Pomegranate	رمان	3		
Apple	تفاح آنا	2	Malos	10%
Persimmon	فرسمونا	2	Local seedlings	
Apricot	مشمش	2	GF	
Peach	دراق	2	GF	
Avocado	افوغادو	2	West India	20%
Fodder crops	Alfalfa, barly, vetch		seeds	

11.4.2 Compete Reuse Project

- Tertiary treated wastewater by gravel filters and chlorination unit, with a capacity of 60 m^3/hr.
- The project is planted around 140 Donums of farmer's lands outside Nablus WWTP fence.
- The goal of the project is to create new opportunities and show the farmers of the area that the treated wastewater is suitable for planting.
- Funded by USAID within Compete project with 500,000 $.
- The method of irrigation is Surface Drip irrigation System.
- The system is controlled manually, it takes its water from a reservoir tank placed at a high point and it delivers water by gravity. The tank supplied from a pumping station in the WWTP

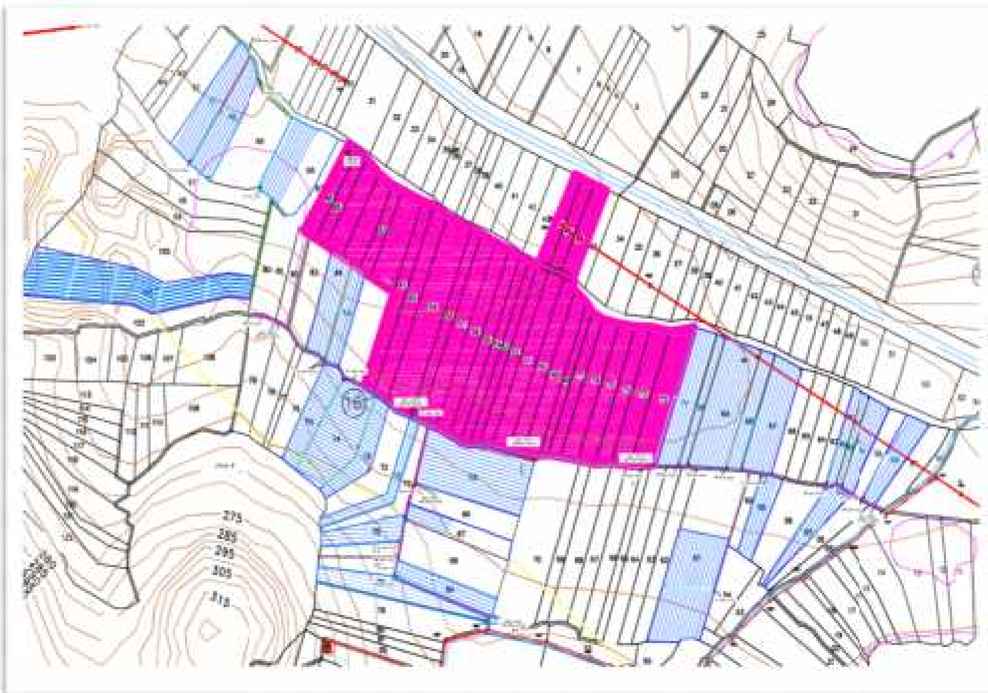


Figure (25): Trees planted in USAID (Compete project) depicted in blue color

Table (4): Type of Trees which have been planted in Compete Reuse pilot project

Common name	Name In Arabic	Age (Year)	container size (litre)	Root stock	Variety	Pollinator	pollinator %
Almond Tree	لوز	3	7	GF	Om Al Fahm	K 53-54	5%
Olive Tree	زيتون	1.5	10		K18		
Pomegranate	رمان	3	10		Wonderful		
Apple	تفاح آنا	2	15	Malos	Ana	Ein Shemer	10%
Apricot	مشمش	2	10	GF	Hamawe		
Fig	تين	2	15				

11.4.3 Reuse outside scheme (under implementation)

- 120 Donum, outside the plant
- Tertiary treatment by Disc filters and UV unit
- Treatment capacity= 100 m^3/hr
- Funded by German Government and EU through KfW

Figure (26): Intended planting lands in Reuse outside scheme of 120 donums.

Table (5): Type of Trees which have been planted in Compete Reuse pilot project

Common name	Name In Arabic	Age (Year)	container size (litre)	Root stock	Variety	Pollinator	pollinator %
Almond Tree	لوز	2	10	GF	Om Al Fahm	K 53-54	5%
Olive Tree	زيتون	2	20		K18		
Pecan walnut Tree and Alfalfa (Intercropping)	جوز البيكان وبرسيم حجازي (زراعات بينية)	3	20		Pecan		
Alfalfa	برسيم				seed		

11.5 Overview on future Reuse projects

11.5.1 Strategic Reuse Project 2,000+

- Planting around 2,000+ Donums
- Tertiary treatment by sand filters and UV unit
- Treatment capacity= 10,000 m^3/day
- Funded by German Government through KfW with a finance of 10,000,000 €.

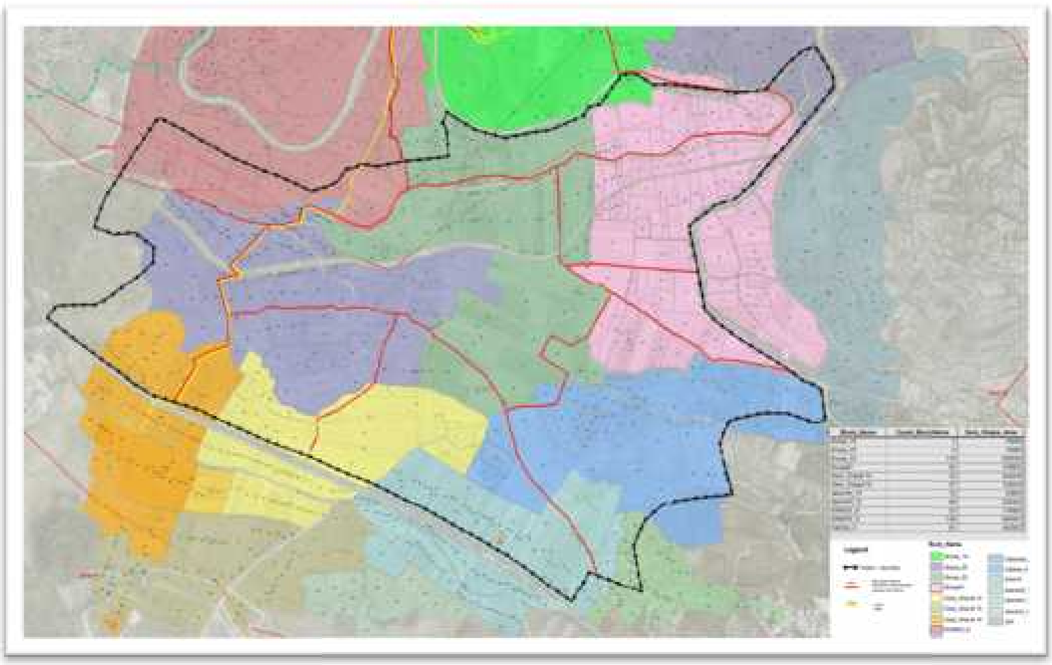


Figure (27): Wastewater Reuse Project-Nablus 2,000+

11.6 Results

The growth status of the plants which have been planted inside the Nablus WWTP was monitored. Table (4) shows the assessment of agricultural experts for the growth status of the different plants types. Also figure (28) shows the growth of olive trees in two different pictures which have been captured within duration of less than one year.

Table (6): Results from reuse pilot project inside scheme

Crop and planting date	Growth status
Almond Tree	Very Good
Pistachio	Excellent
Pecan	Excellent
Walnut (Camel eye)	Excellent
Pommel	Good
Lemon	Good

Crop and planting date	Growth status
Olive Tree	Excellent
Pomegranate	Excellent
Apple	Excellent
Persimmon	good
Apricot	Excellent
Peach	Excellent
Avocado	Very Good

Figure (28): A comparison between AlfaAlfa area (before and after)

11.7 Summary of all reuse projects of Nablus Plant

This section is summarizing reuse projects of Nablus plant.

Table (7): Summary of Nablus Plant reuse projects

No	Reuse Projects	Area (Donum)	Quantity of TWW (m^3) \Year	Cost (Euro)	Date of Taking Over
1	Reuse Inside WWTP scheme (Pilot)	40	35,000	462,000	Jan-2017
2	Compete Project (Pilot)	140	80,000	500,000	June-2017
3	Reuse outside WWTP scheme	120	115,000	1,500,000	Jan-2019
4	Wastewater Reuse Project-Nablus	2,000+	70% of treated water	10,000,000	End of 2020

12. Photovoltaic system

Within the frame of financial and technical cooperation Nablus Municipality and Nurnberg city -Germany has signed financial agreement to implement photovoltaic system at the Wastewater Treatment Plant Nablus West. The project has been implemented and started use of sun energy on May 2017. The total produced energy in 2018 was 123,814 Kwh.

The project aimed at supply and install ground mounted On-grid PV Systems at Wastewater Treatment Plant -Nablus West with capacity of 123 kWp and east-west arrays orientation as pilot project. This pilot project contributed with about 10% of the total power demand of the WWTP.

Figure (29): photovoltaic system

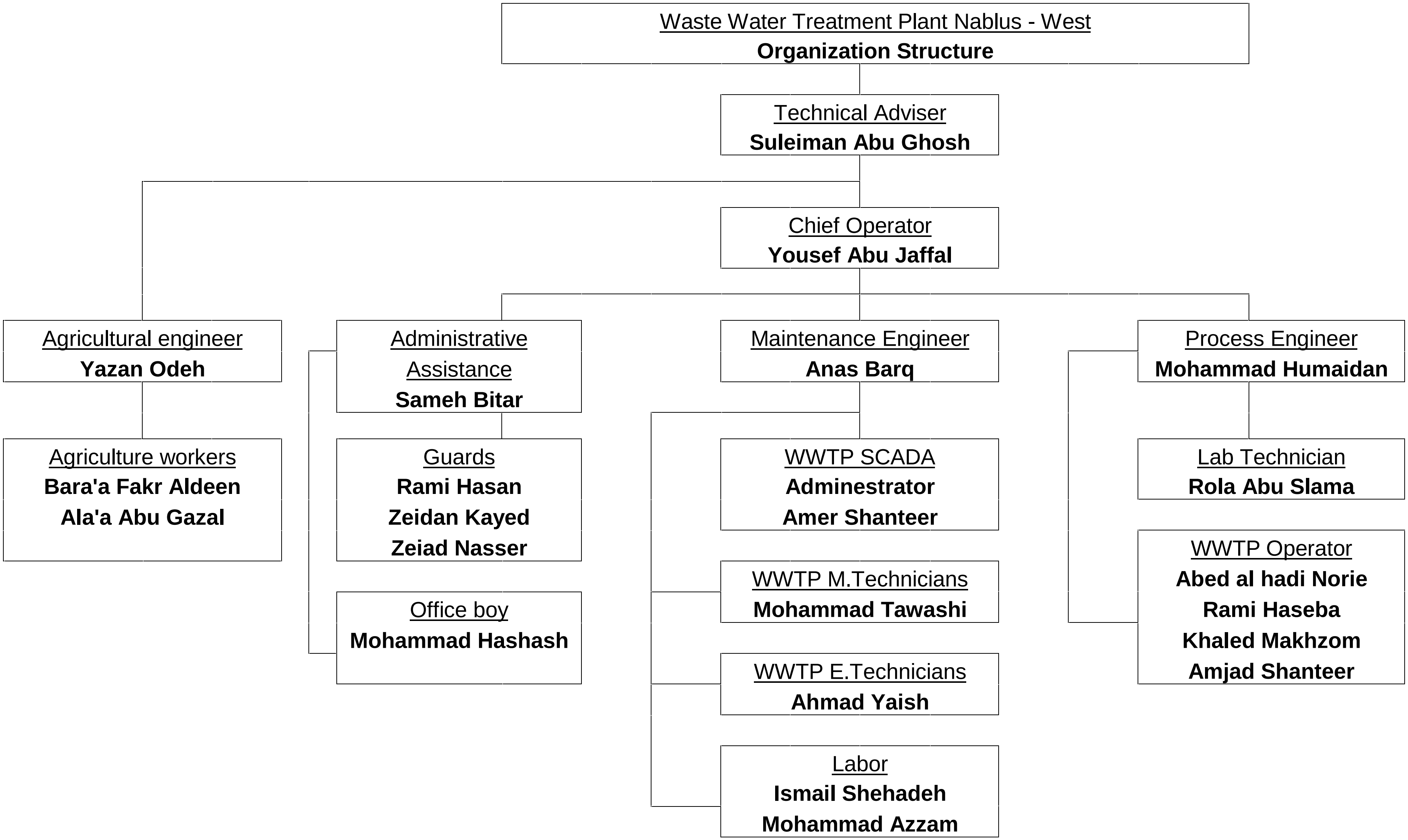
13. Future Improvements

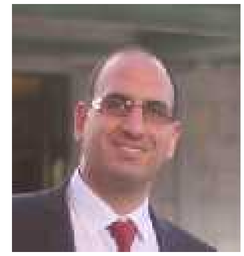
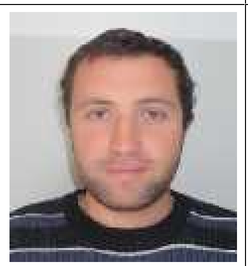
- Implementation of the Covering of the sludge storage yard.
- Using of tertiary treated water for irrigation in the reuse for outside scheme for different crops
- Using of dewatered digested sludge in agriculture as pilot projects for further Investigations
- Installing more PV solar panels to increase the covering rate of the energy demand and using more renewable green energy.

14. Problems & Challenges in 2019

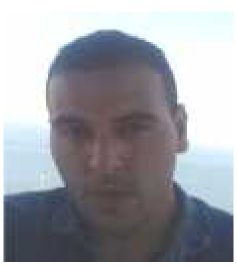
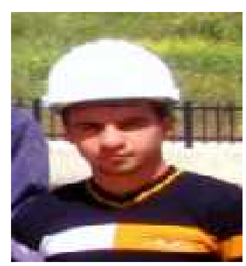
- Unavailability of spare parts in local market.
- Keep the staff of the WWTP.
- Sludge Disposal:
    1. High Cost of sludge disposal in Zeharet Al-Fenjan at 75 NIS/ton.
    2. As per Palestinian standard, it is not allowed to reuse sludge in agriculture due to high Water content in sludge of 75%

15. Staff


Waste Water Treatment Plant Nablus - West
Organization Structure
Technical Adviser
Suleiman Abu Ghosh
Chief Operator
Yousef Abu Jaffal
Agricultural engineer
Yazan Odeh
Agriculture workers
Bara'a Fakr Aldeen
Ala'a Abu Gazal
Administrative Assistance
Sameh Bitar
Guards
Rami Hasan
Zeidan Kayed
Zeiad Nasser
Office boy
Mohammad Hashash
Maintenance Engineer
Anas Barq
WWTP SCADA Adminestrator
Amer Shanteer
WWTP M.Technicians
Mohammad Tawashi
WWTP E.Technicians
Ahmad Yaish
Labor
Ismail Shehadeh
Mohammad Azzam
Process Engineer
Mohammad Humaidan
Lab Technician
Rola Abu Slama
WWTP Operator
Abed al hadi Norie
Rami Haseba
Khaled Makhzom
Amjad Shanteer

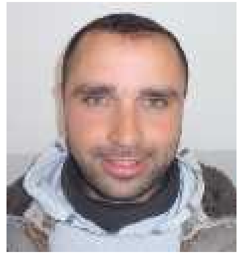
Suleiman Abu Ghosh - Technical Adviser		Yousef Abu Jaffal -Nablus WWTP Chief Operator	
Mohammad Homeidan -Process Engineer & Lab Officer in Nablus WWTP		Anas Barq - Electrical Engineer	
Sameh Bitar -Administrative Secretary & Accountant		Rola Abu Slama -Lab Technician	
Amer Shanteer - WWTP SCADA Administrator		Yazan Oudeh -Agricultural engineer	

<u>Operators</u>

			
Khaled Makhzom	Amjad Shanteer	Rami Hasiba	Abdel hadi Norie

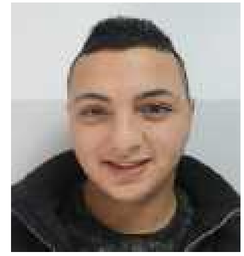
<u>Electro mechanic Technicians</u>

Mohammad Tawashi



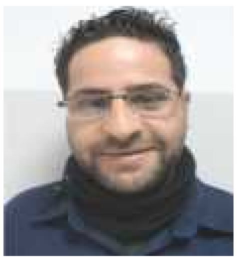
Ahmad Yaish

<u>office boy</u>

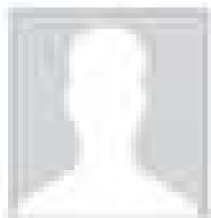


Mohammad Hashash

Labor

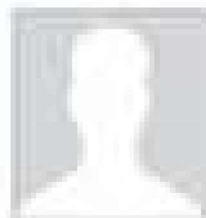


Mohammad Azzam

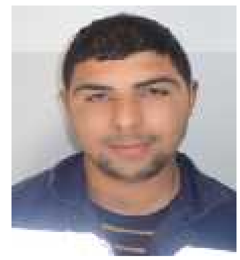


Ismail Shehadeh

<u>Agriculture</u>

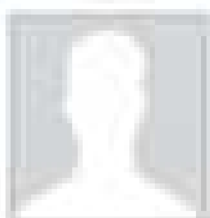


Ala’a Abu Gazal

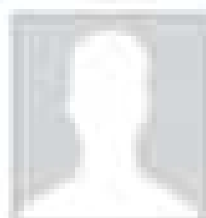


Bara’a Fakrldeen

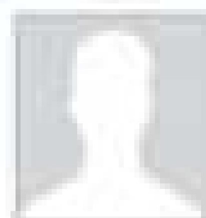
<u>Guards</u>



Rami Hasan



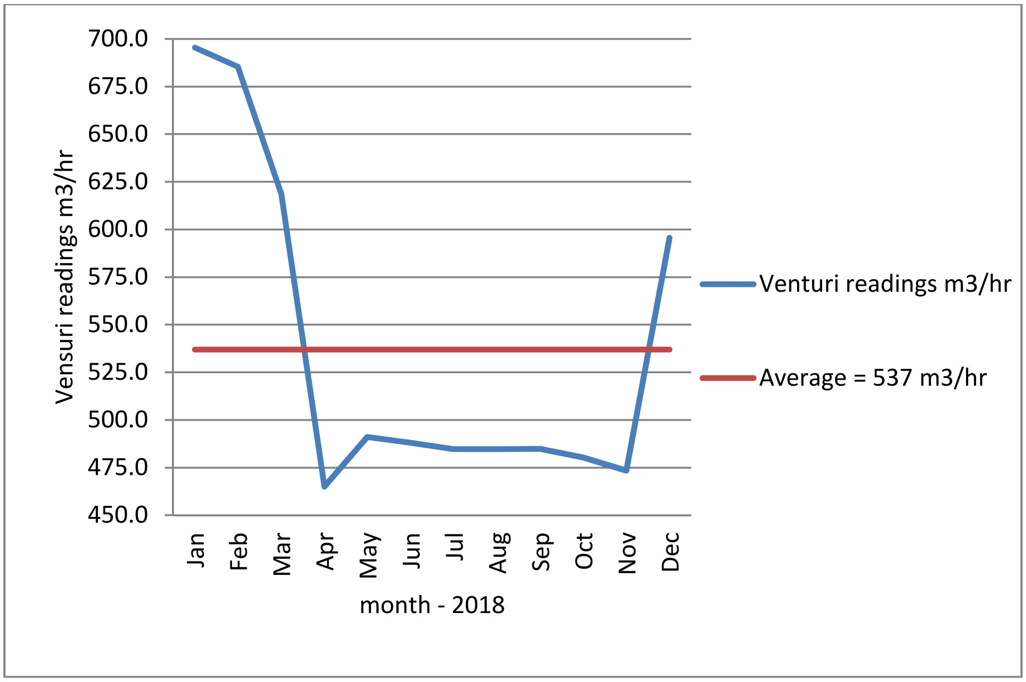
Zeidan Kayed



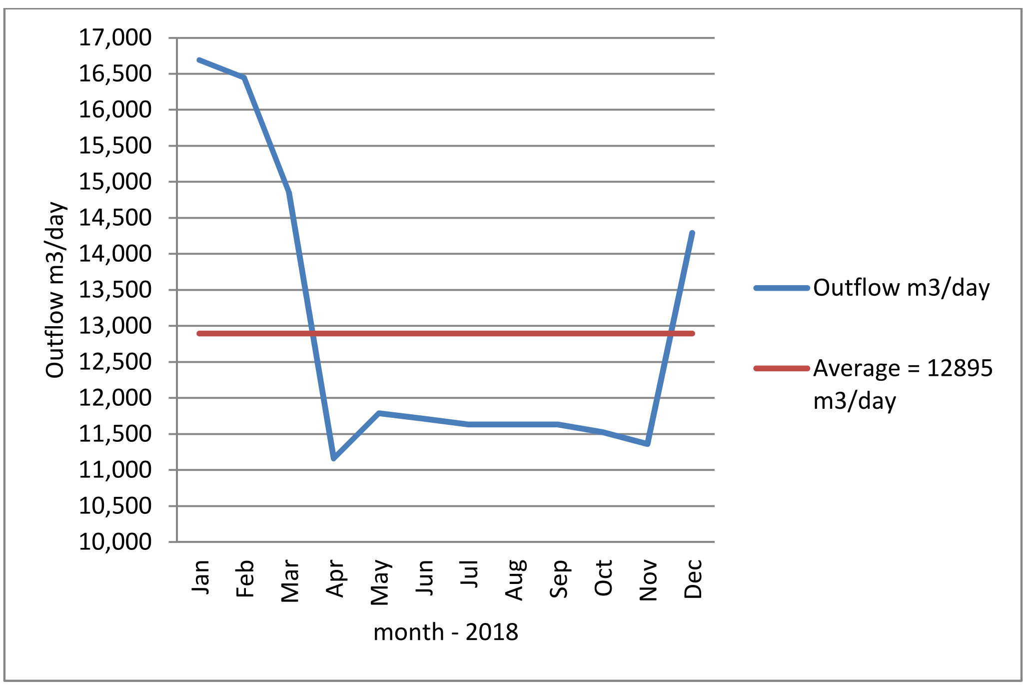
Zeiad Nasser

16. Annexes

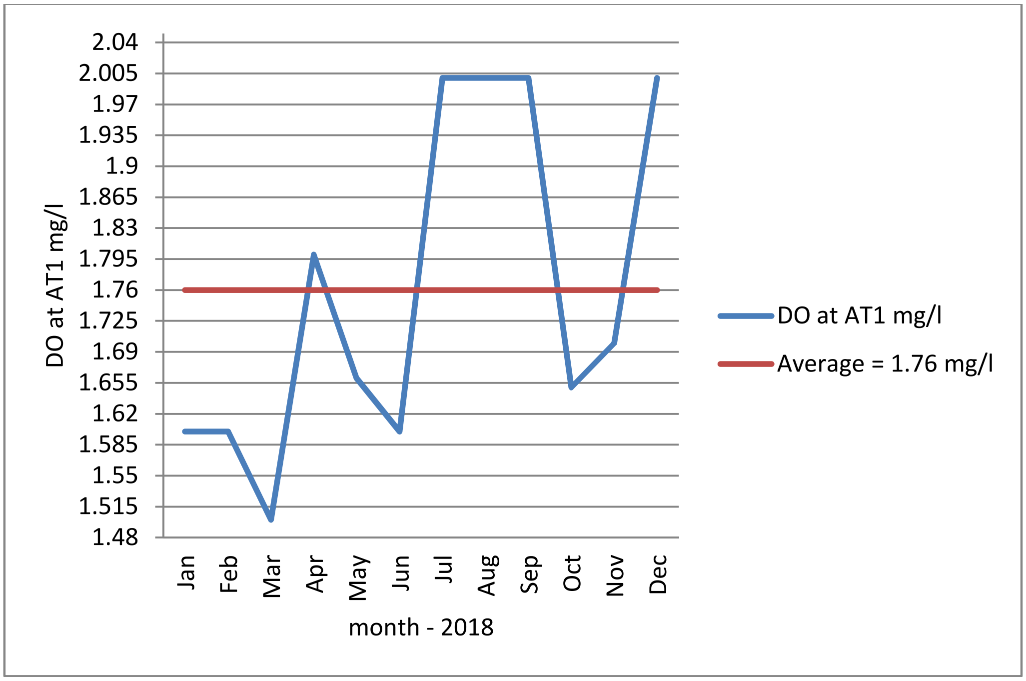
Annex 01: Graphs



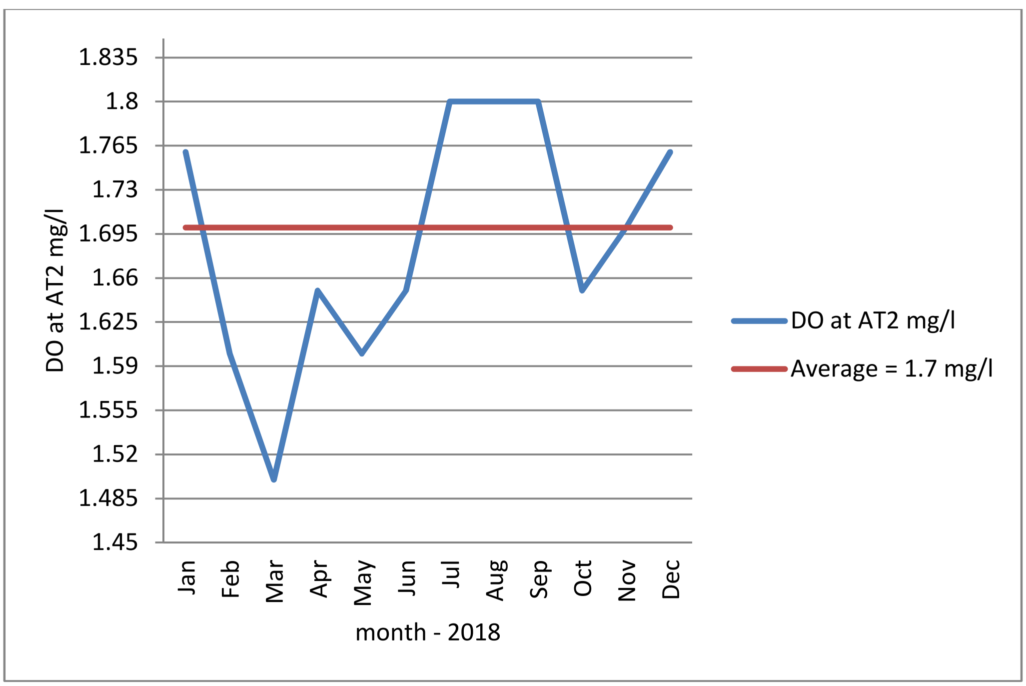
Graph 1: Average wastewater effluent



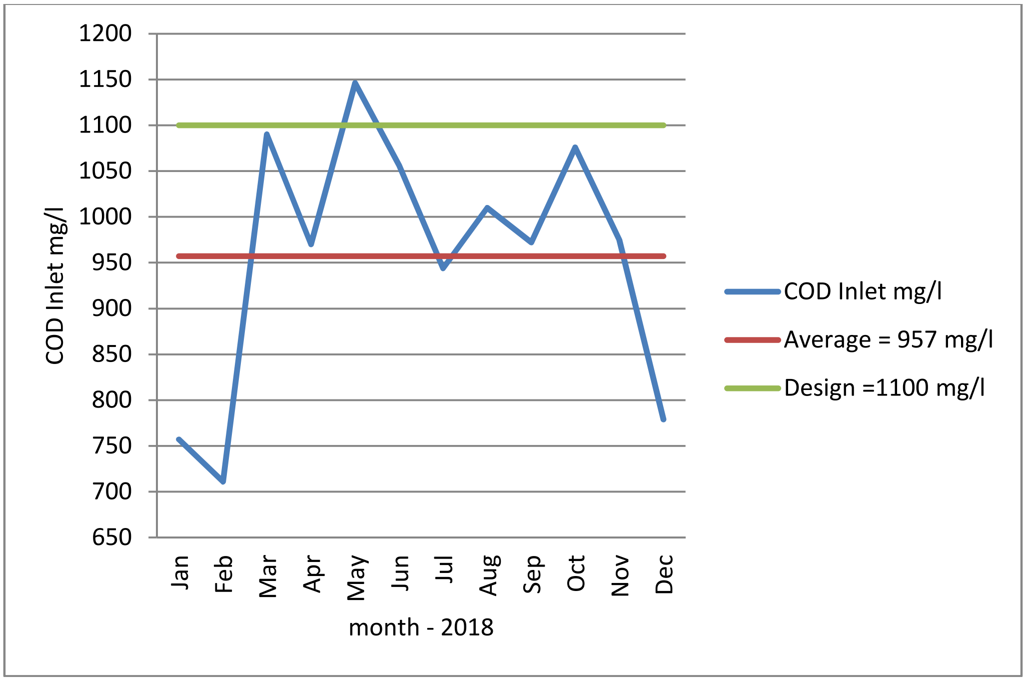
Graph 2: Average treated wastewater effluent



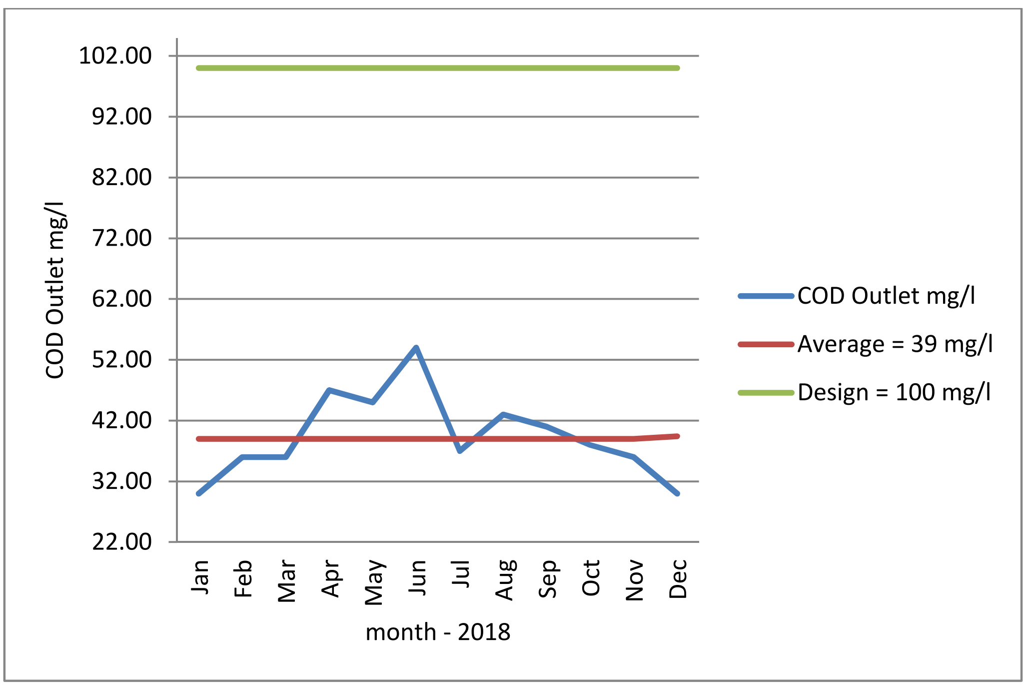
Graph 3: Monthly dissolved oxygen concentration pattern in the aeration tank no. (1)



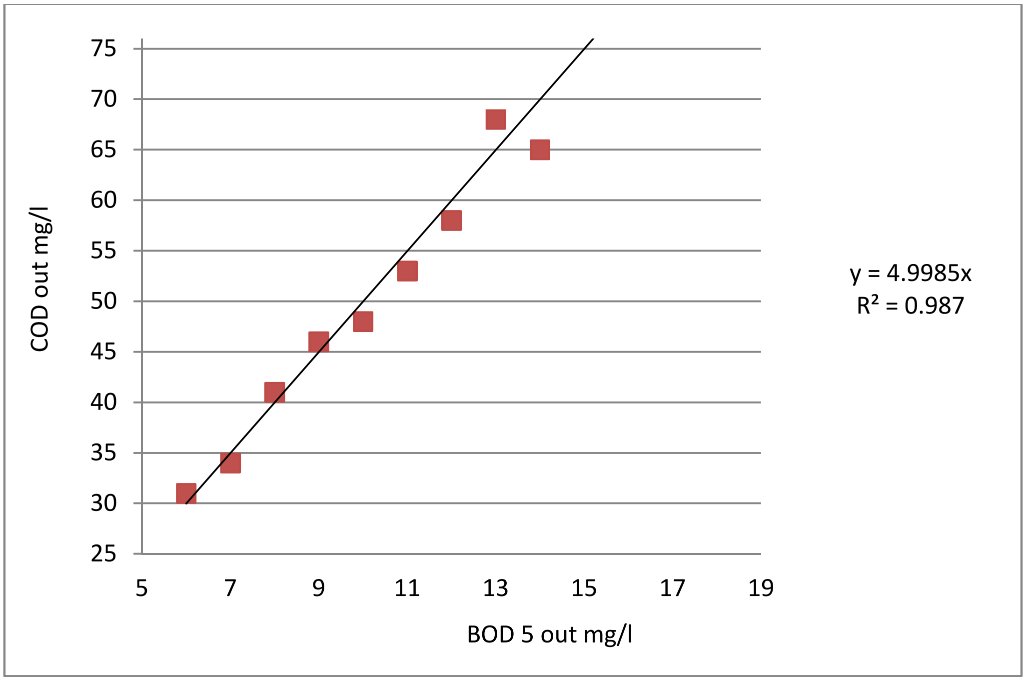
Graph 4: Monthly dissolved oxygen concentration pattern in tank no. (2)



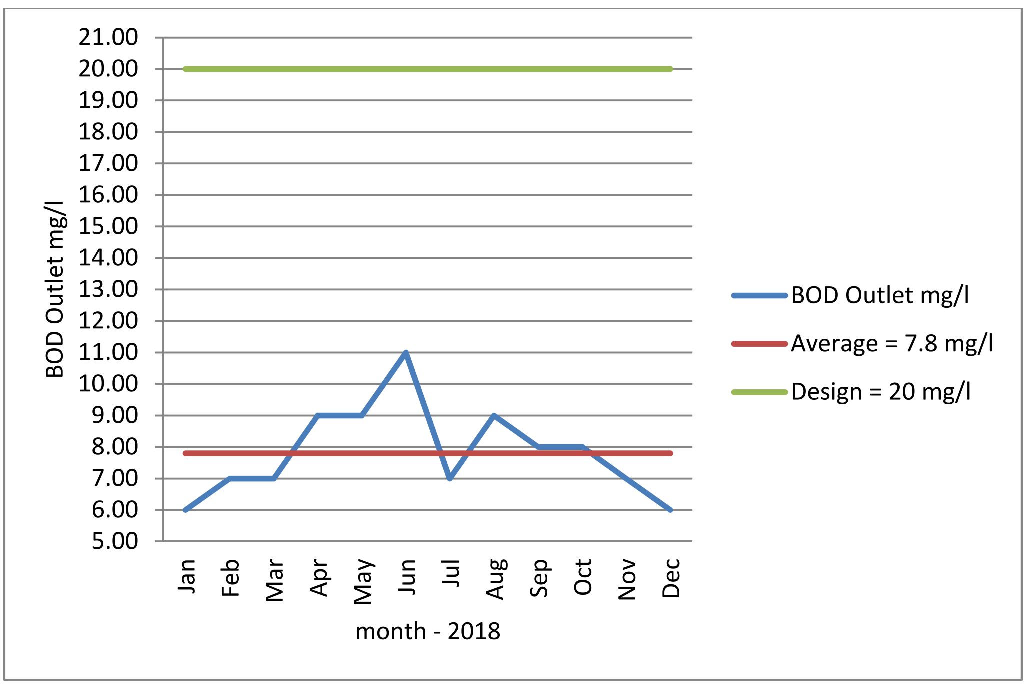
Graph 5: The COD concentration in the influent of WWTP



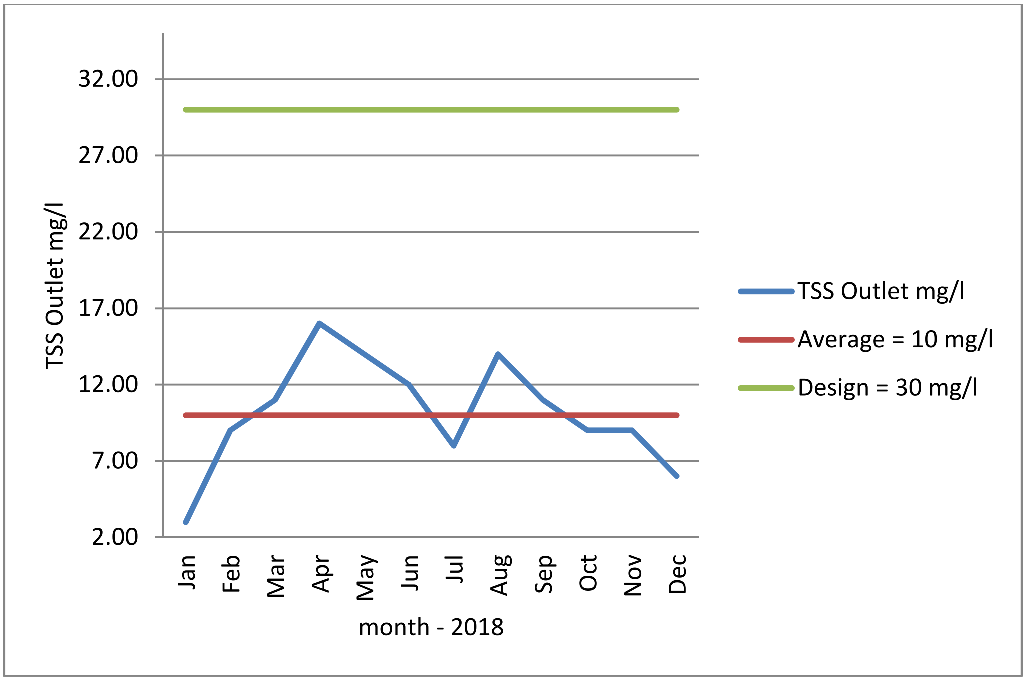
Graph 6: The COD concentration in the effluent of the treated waste water



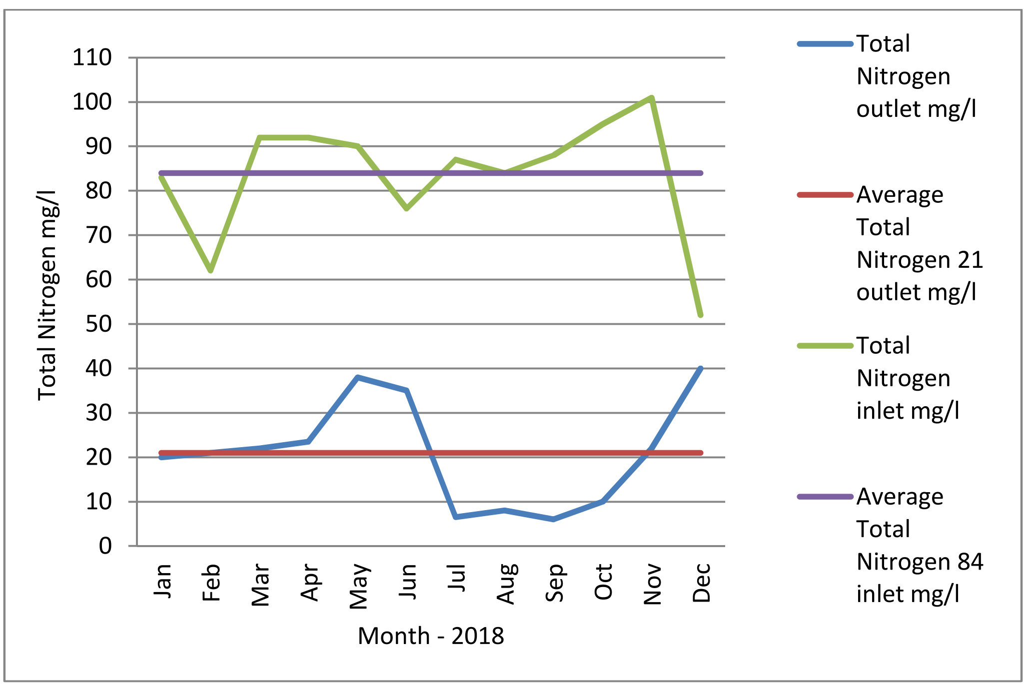
Graph 7: The correlation between COD_{out} and BOD_{5eff}



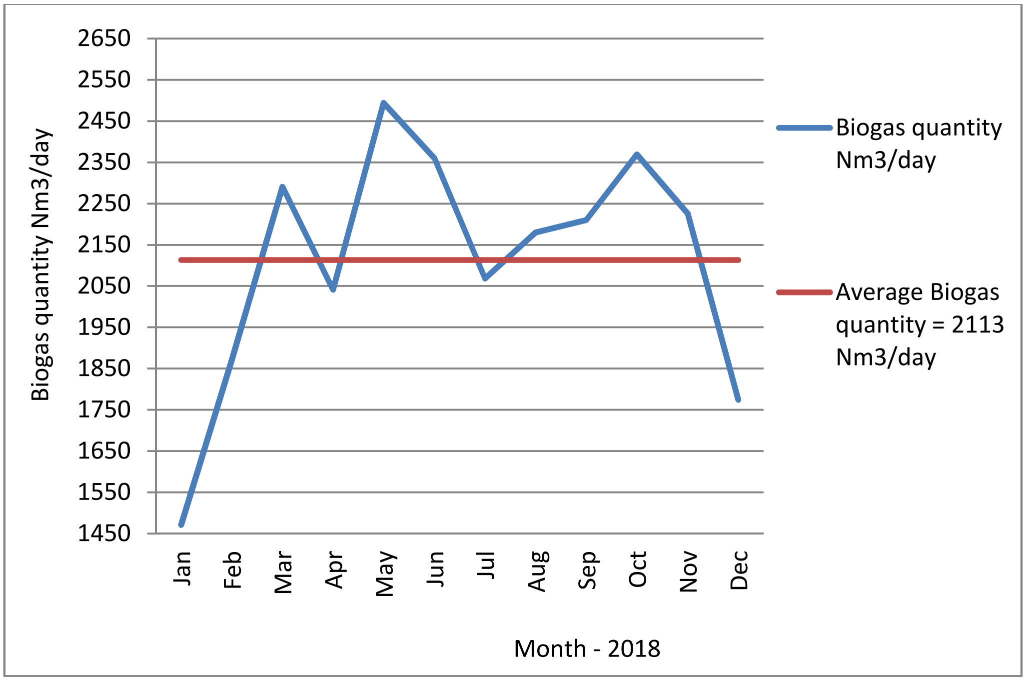
Graph 8: The BOD_5 concentration in the effluent of the treated wastewater



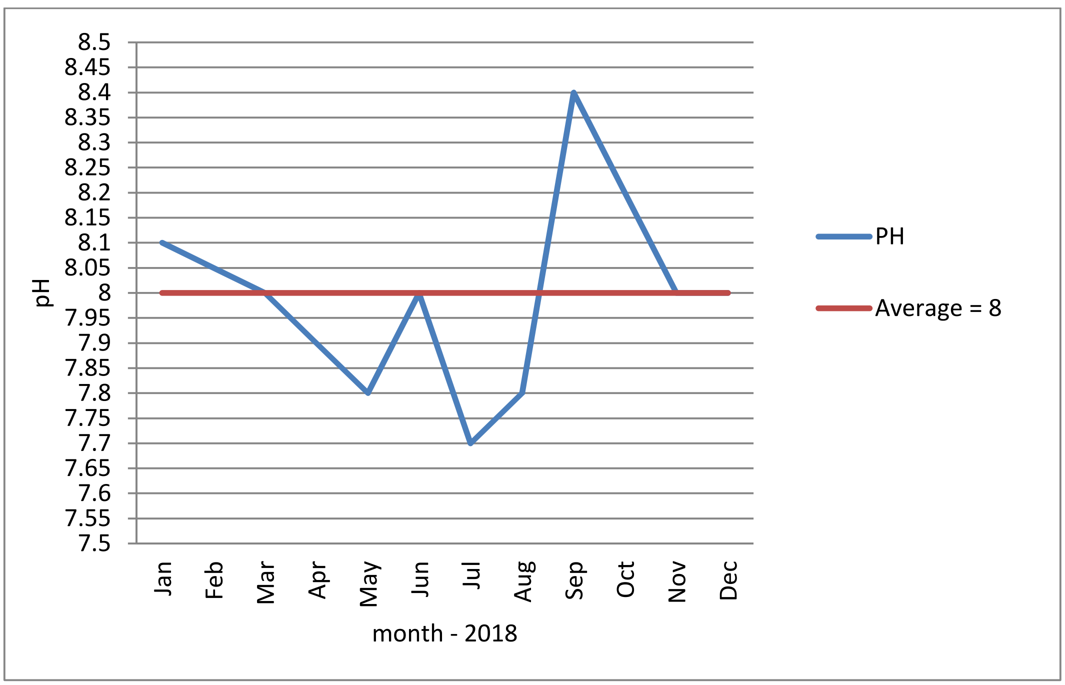
Graph 9: TSS concentration of the treated wastewater (TSS)



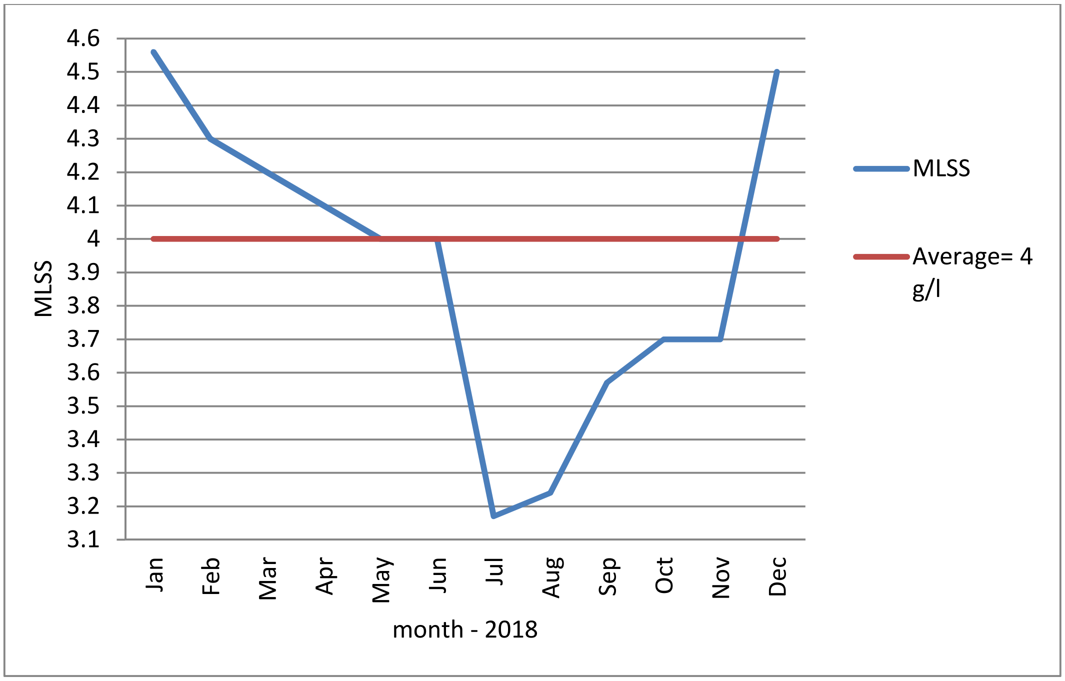
Graph 10: Total Nitrogen for influent and effluent (TN)



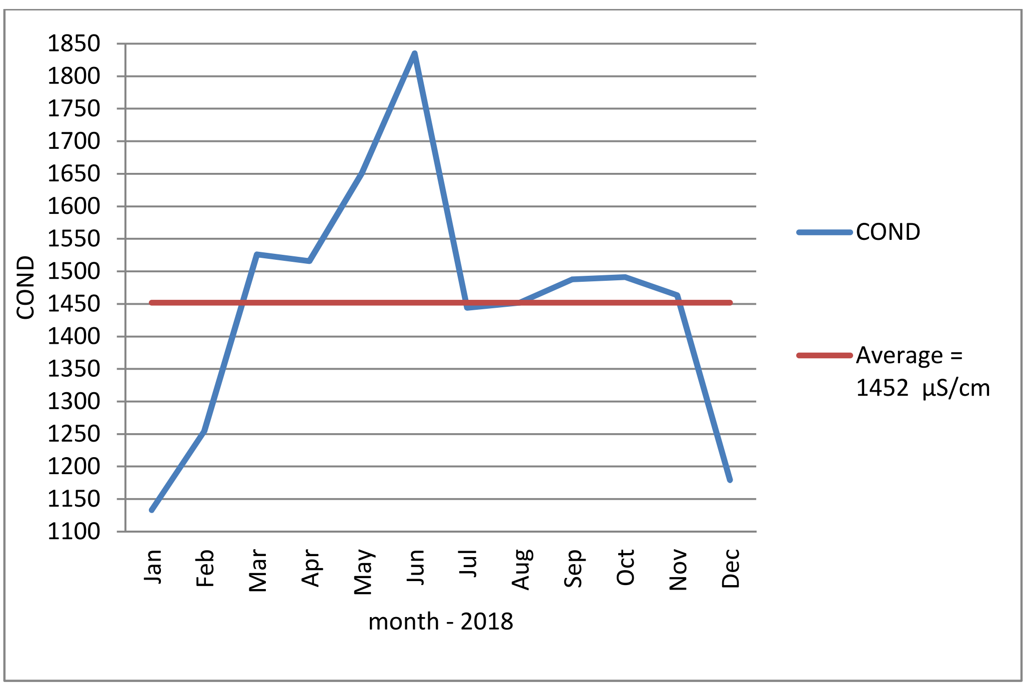
Graph 11: The average produced quantities of biogas



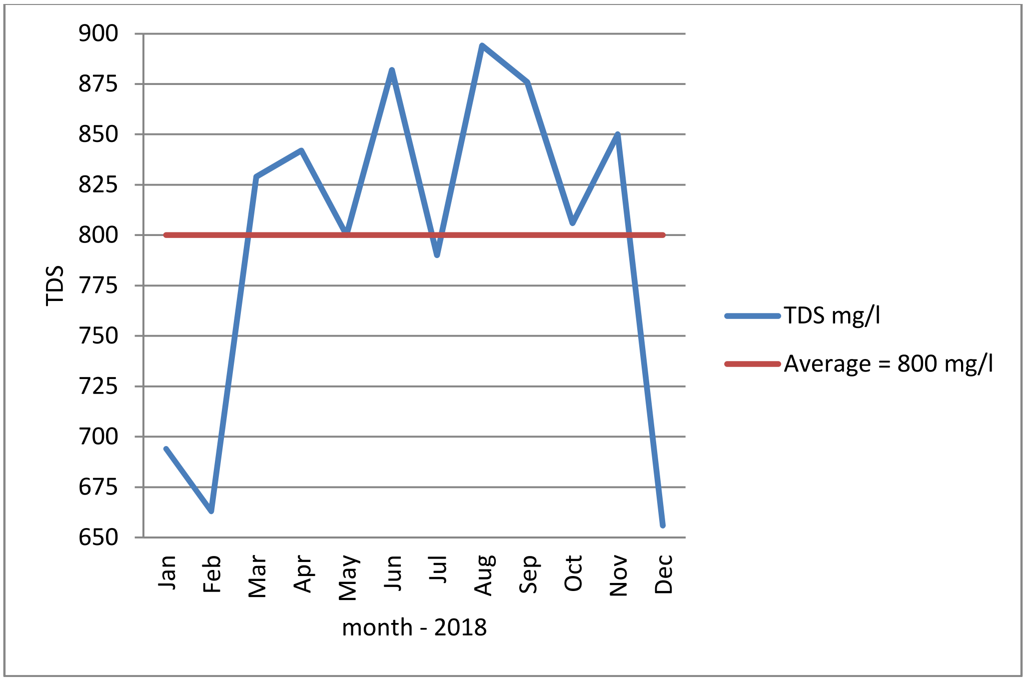
Graph 12: Average pH of the inlet wastewater



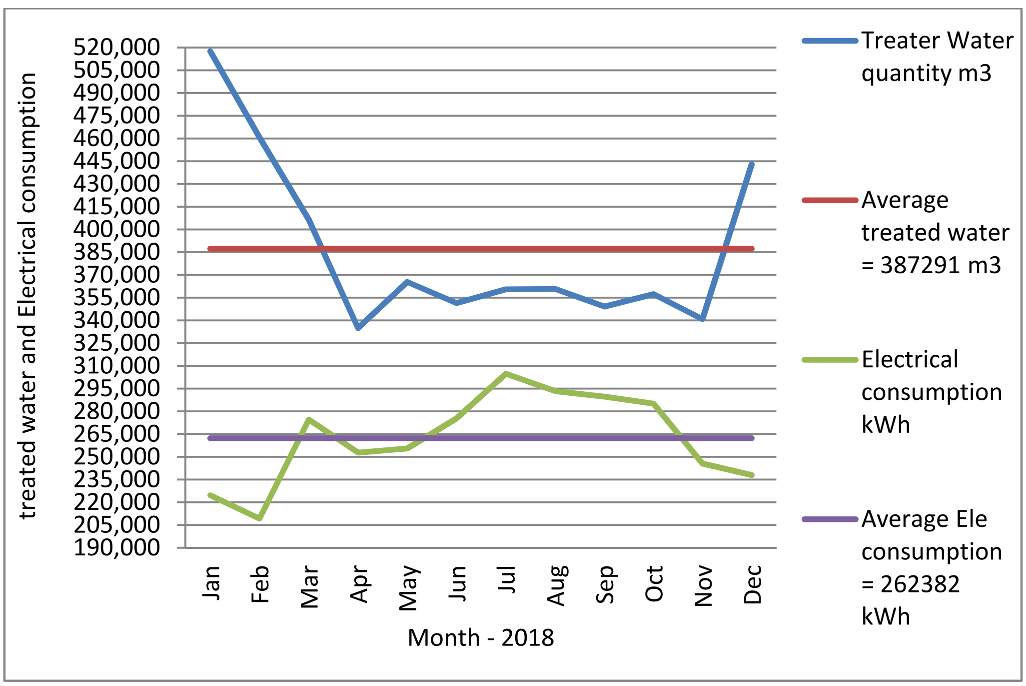
Graph 13: Mixed liquor suspended solids concentration (MLSS) in aeration tanks



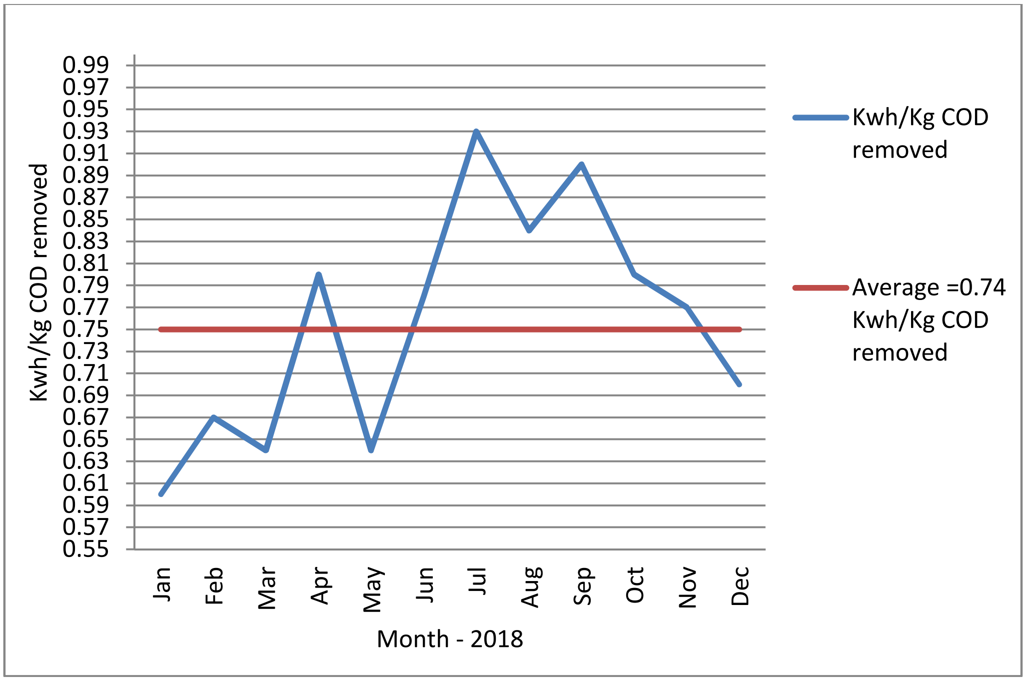
Graph 14: Conductivity of the inlet flow



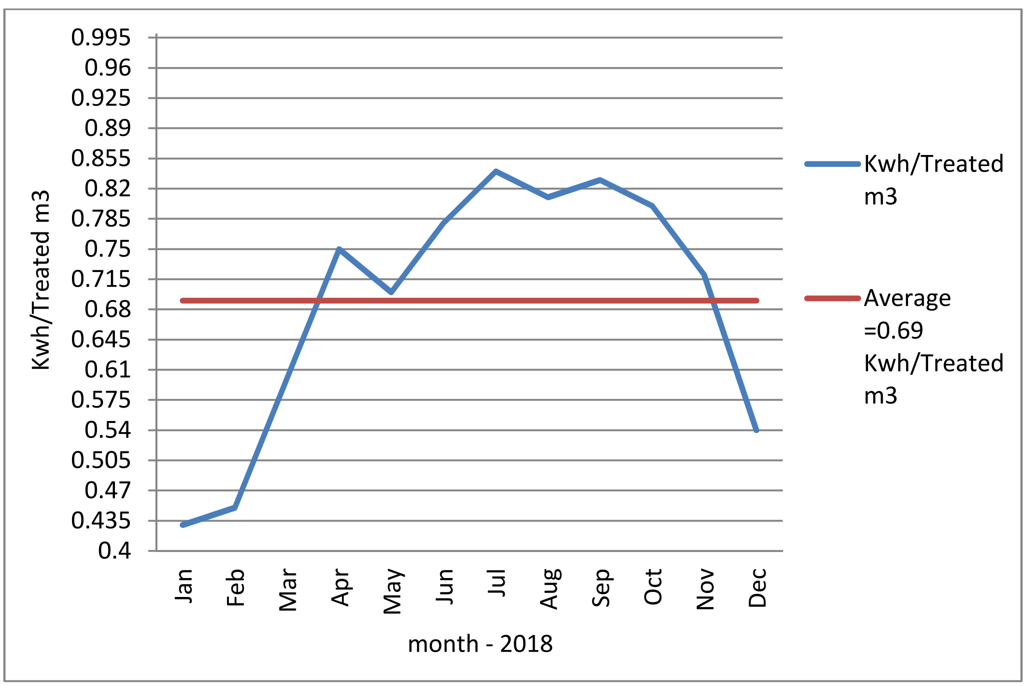
Graph 15: Total dissolved solids in the effluent



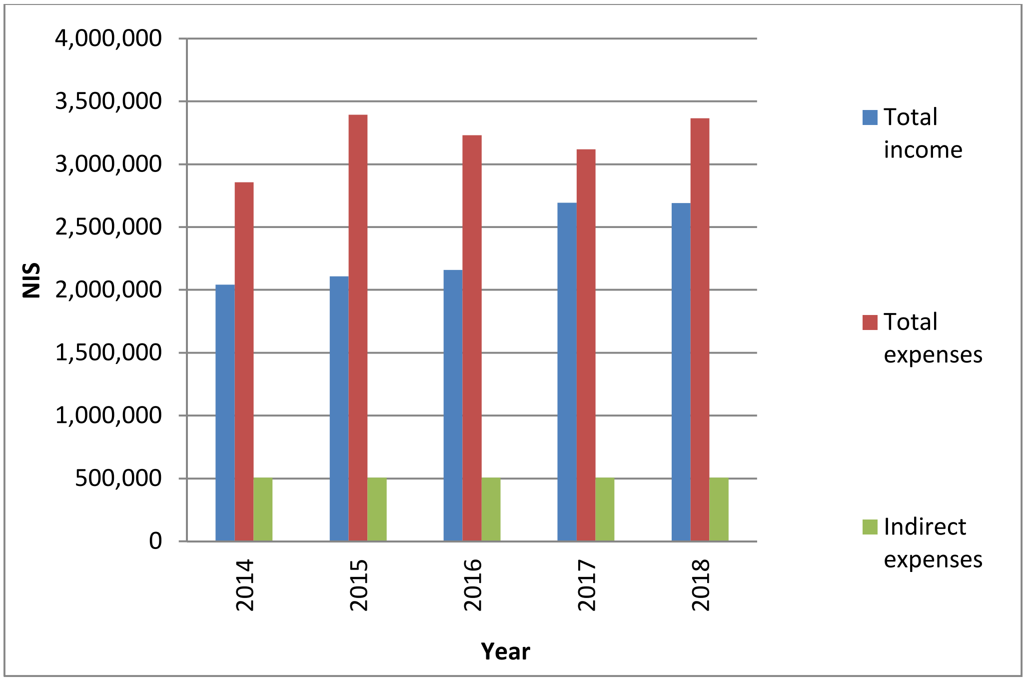
Graph 16: Average monthly treated wastewater and power consumption



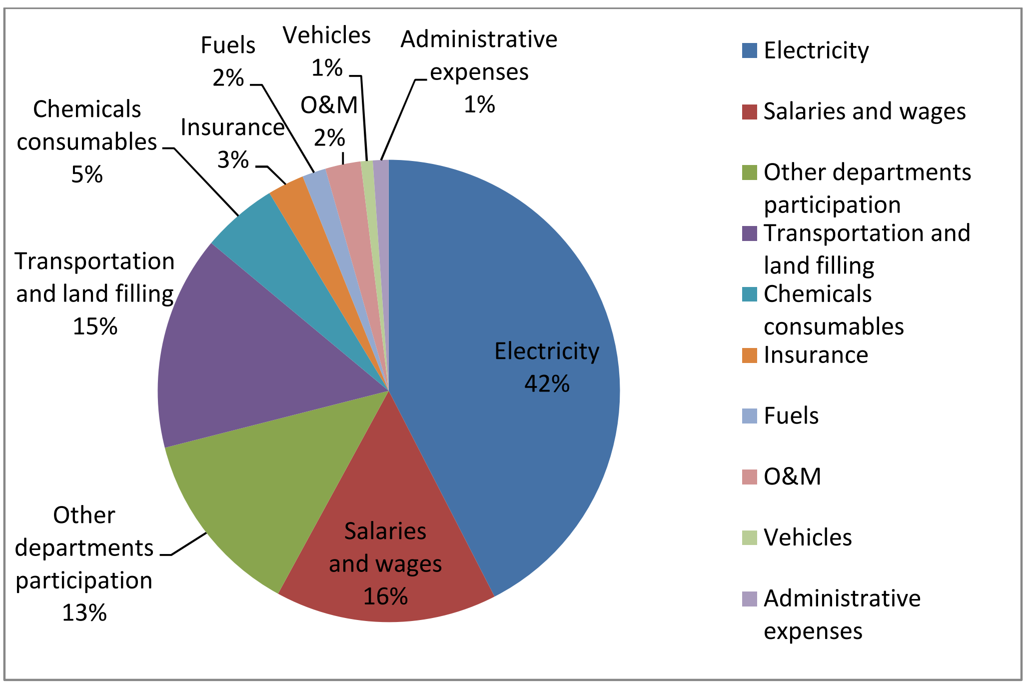
Graph 17: Power requirement kWh/kg COD treated



Graph 18: Power requirement kWh/m^3 treated



Graph 19: Expenditures versus collection



Graph 20: Expenditures breakdown 2018

Annex 03: Performance summary

Parameters	Design value 2020	Treatment efficiency %	Average	Month - 2016											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average inlet flow m^3/d	14,000	-----	12,895	16,690	16,447	14,855	11,162	11,787	11,712	11,632	11,634	11,635	11,526	11,362	14,293
Inlet COD mg/L	1,100	-----	957	779	975	1,076	972	1,010	944	1,056	1,146	970	1,090	711	757
Outlet COD mg/L	100	96%	39	30	36	38	41	43	37	54	45	47	36	36	30
Outlet BOD_5 mg/L	20	98%	8	6	7	8	8	9	7	11	9	9	7	7	6
Inlet BOD_5 mg/L	550		478	378	356	545	485	573	528	472	505	486	538	485	389
Sludge age (days)	13.7	-----	16	16	20.2	20	11	8	13	11	11	16	15	21	26
MLSS g/L	3	-----	4	4.56	4.3	4.2	4.1	4	4	3.17	3.24	3.57	3.7	3.7	4.5
TSS_{inlet} mg/L	500		439	347	357	455	430	552	455	417	483	439	495	461	371
TSS_{outlet} mg/L	30	98%	10	6	9	9	11	14	8	12	14	16	11	9	3
kWh/kg COD	0.8	-----	0.76	0.7	0.77	0.8	0.9	0.84	0.93	0.78	0.64	0.8	0.64	0.67	0.6

Annex 04: Power consumption

Month	Avg	2018											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated wastewater quantity m^3	391,798	517,378	460,520	460,520	334,871	365,390	351,361	360,591	360,658	349,040	357,300	340,846	443,095
Total electrical consumption kWhr	262,382	151,635	132,018	113,047	119,796	58,270	90,486	141,308	109,188	121,780	96,603	80,040	135,008
PV electrical production kWhr						21,000	21,573	20,042	17,740	16,160	12,642	6,900	7,757
CHP electrical production kWhr		73,099	77,282	161,560	132,992	176,220	163,355	143,342	166,347	151,790	175,823	158,550	95,228
kWhr per m^3	0.69	0.43	0.45	0.60	0.75	0.70	0.78	0.84	0.81	0.83	0.80	0.72	0.54

Annex 05: Additional lab Tests in WWTP Lab

			2018											
/ Test	Values	Average	Dec	Nov	Oct	Sep	Aug	Jul	Jun	May	Apr	Mar	Feb	Jan
COD out mg/l	Average	39	29.00	36.00	38.00	41.00	43.00	37.00	54.00	45.00	47.00	35.00	36.00	30.00
	Max	54	36.00	46.00	46.00	56.00	52.00	49.00	85.00	62.00	82.00	46.00	47.00	44.00
	Min	31	25.00	30.00	32.00	30.00	28.00	30.00	40.00	38.00	35.00	29.00	32.00	20.00
BOD out mg/l	Average	7.8	6.00	7.00	8.00	8.00	9.00	7.00	11.00	9.00	9.00	7.00	7.00	6.00
	Max	11	7.00	9.00	9.00	11.00	10.00	9.80	17.00	12.00	16.00	9.00	9.00	9.00
	Min	6	5.00	6.00	6.00	6.00	5.00	6.00	8.00	8.00	7.00	6.00	6.00	4.00
NH4-N out mg/l	Average	5	0.00	1.00	1.50	0.00	1.40	1.30	20.00	11.70	21.40	0.90	2.00	3.70
	Max	7	0.00	1.00	1.50	0.00	1.70	2.30	29.70	11.70	24.80	0.90	3.60	7.00
	Min	4	0.00	1.00	1.50	0.00	1.20	0.30	10.20	11.70	18.00	0.90	0.40	0.30
NO3-N out mg/l	Average	9	12.00	8.00	9.00	4.60	4.60	2.60	8.70	17.90	0.70	12.90	16.80	15.00
	Max	11	20.40	10.30	12.00	4.60	5.20	2.60	8.70	17.90	0.70	12.90	19.00	16.00
	Min	8	6.30	6.30	6.00	4.60	4.00	2.60	8.70	17.90	0.70	12.90	14.60	14.00
TN out mg/l	Average	21	41.50	22.00	10.00	6.00	8.00	6.50	48.00	38.00	12.00	22.00	21.00	20.00
	Max	28	78.00	24.00	10.00	7.00	9.00	8.00	66.00	41.00	12.00	22.00	24.00	29.00
	Min	15	5.00	19.00	10.00	5.00	7.00	5.00	30.00	34.00	12.00	22.00	17.00	15.00
PO4-P out mg/l	Average	3	3.18	3.30	3.30	4.00	3.25	3.96	5.25	2.00	2.00	4.06	4.00	1.30
	Max	4	3.18	3.80	3.30	4.20	4.00	4.00	5.60	2.00	2.00	5.12	4.00	1.46
	Min	3	3.18	2.80	3.30	3.80	2.50	3.88	4.90	2.00	2.00	3.00	4.00	1.16
TSS out mg/l	Average	10	6.00	9.00	9.00	11.00	14.00	8.00	12.00	14.00	16.00	11.00	9.00	3.00
	Max	24	12.00	20.00	24.00	32.00	30.00	20.00	30.00	26.00	46.00	24.00	20.00	6.00
	Min	4	2.00	2.00	2.00	2.00	2.00	2.00	2.00	4.00	2.00	2.00	20.00	2.00
MLSS mg/l	Average	4	4.50	3.70	3.00	3.57	3.24	3.17	4.00	4.00	4.10	4.20	4.30	4.56
	Max	5	5.20	4.50	3.40	4.10	3.64	3.71	4.50	6.00	6.40	4.60	5.19	5.29
	Min	3	3.70	2.70	2.60	3.00	2.86	2.66	3.70	3.00	3.00	3.90	3.45	3.37

Annex 06: External laboratory analysis

Quality of the sludge (NWWTP) with comparison of standard (59/2015)

Elements	Sampled on		Obligatory Tech.Ins 59/2015	Method of Testing
	05/09/2016	15/01/2017		
Cd (ppm)	0.27	0.48	20	Birzeit Lab, ICP instrument
Cu (ppm)	71.63	123.9	1,000	Birzeit Lab, ICP instrument
Ni (ppm)	6.21	11.2	300	Birzeit Lab, ICP instrument
Pb (ppm)	7.5	13.1	750	Birzeit Lab, ICP instrument
Zn (ppm)	243.46	360.3	2,500	Birzeit Lab, ICP instrument
Cr (ppm)	6.93	13.4	400	Birzeit Lab, ICP instrument
As (ppm)	N.D	0.29	N.A	Birzeit Lab, ICP instrument
Mo (ppm)	1.21	0.4	N.A	Birzeit Lab, ICP instrument
Se (ppm)	N.D	N.D	N.A	Birzeit Lab, ICP instrument
Hg (ppm)	0.58	0.47	16	Birzeit Lab, DMA-80 instrument
Phosphorus (ppm)	3,299	6,771	N.A	Birzeit Lab, ICP instrument
FC (cfu/g)	4,300	-	N.A	Birzeit Lab, iso instrument
Salmonella (cu/g)	Nil	Nil	N.A	Birzeit Lab, iso instrument
Conductivity µs/cm	-	1,180		Birzeit Lab, iso instrument

Annex 07 : Quality of the Sludge Tests Results at different moisture content from Birzeit University_Labs

Item	Results - June 2018			Comparison with standard of		
Elements	Sludge 70% moisture	Sludge 50% moisture	Sludge 10% moisture	1st class	2nd class	3rd class
As (ppm)	N.D	N.D	N.D	41	75	75
Cd (ppm)	N.D	N.D	N.D	40	40	85
Cr (ppm)	10.4	22	44.2	900	900	3,000
Cu (ppm)	50.7	116	209	1,500	3,000	4,300
Hg (ppb)	229	588	1,020	17	57	57
Mo (ppm)	N.D	N.D	N.D	75	75	75
Ni (ppm)	10.4	22	43	300	400	420
Se (ppm)	N.D	N.D	N.D	100	100	100
Pb (ppm)	N.D	N.D	N.D	300	840	840
Zn (ppm)	223.6	507	912	2,800	4,000	7,500
Moisture %	77.8	51.2	11.1	10%	50%	50%
FC (cfu/g)	17,000	NA	NA	1,000	2,000,000	---
Salmonella (cu/g)	Absent\25gr	Absent\25gr	Absent\25gr	3	----	---