State of Palestine
Nablus Municipality

دولـــة فلسطين
بلدية نابلس

Wastewater Treatment Plant

Nablus West

Annual Report for Operations and Reuse

2017

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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

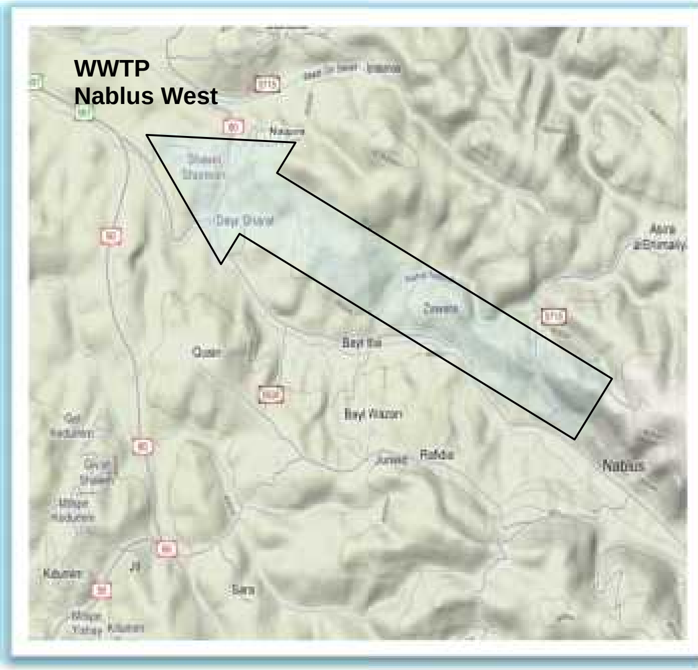

Figure (2): Direction of slope

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 three millions nine hundred and forty seven thousands (3,963,000 m^3) cubic meters of wastewater were treated in the year 2017, with an electrical consumption of two millions nine hundred and thirty six thousands (2,998,000 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 7.7 mg/l and TSS was 13 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.

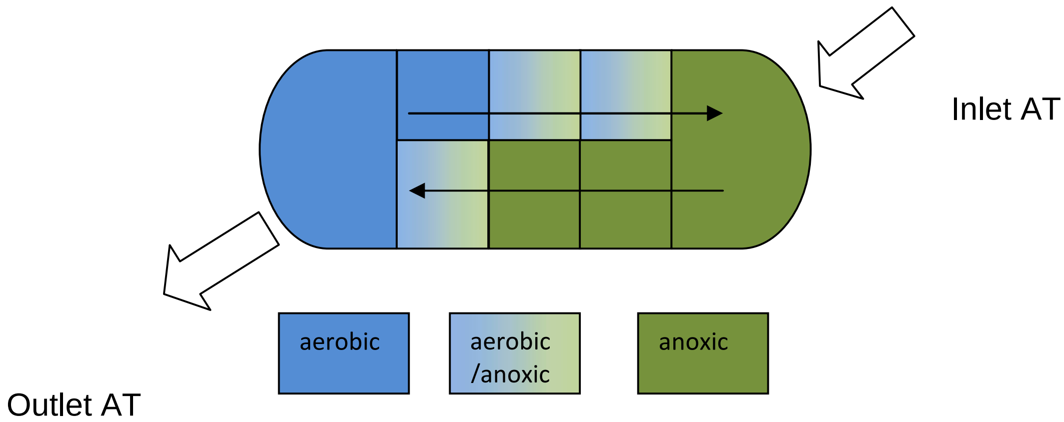

Figure (5): Aeration tank with implemented de-nitrification zone

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 (3650 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 Two 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).

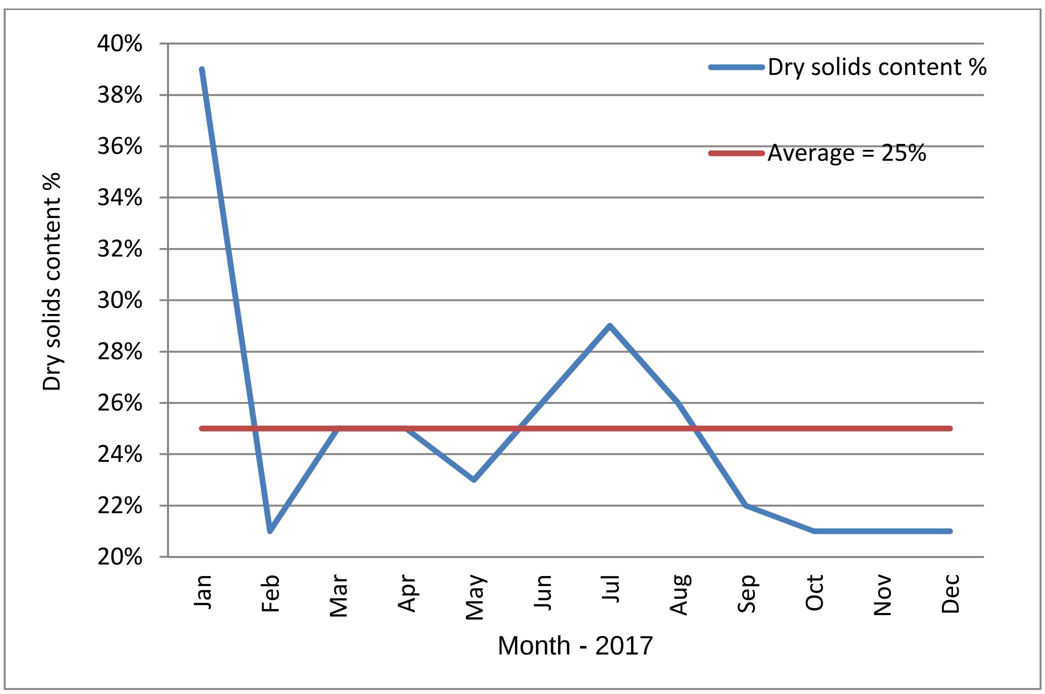

Figure (7): Dry solids content after mechanical dewatering.

6.1 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.

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 (8): Nablus WWTP SCADA system

8. PERFORMANCE OF WWTP

8.1 Influent flow

The performance of WWTP Nablus West during 2017 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 2017 to December 2017 were analyzed.

Figure (9) 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 plant protection design capacity.

The average daily wastewater flow in the year 2017 was approximately 10883 m³/day . The amount of incoming wastewater will increase gradually over the next years.

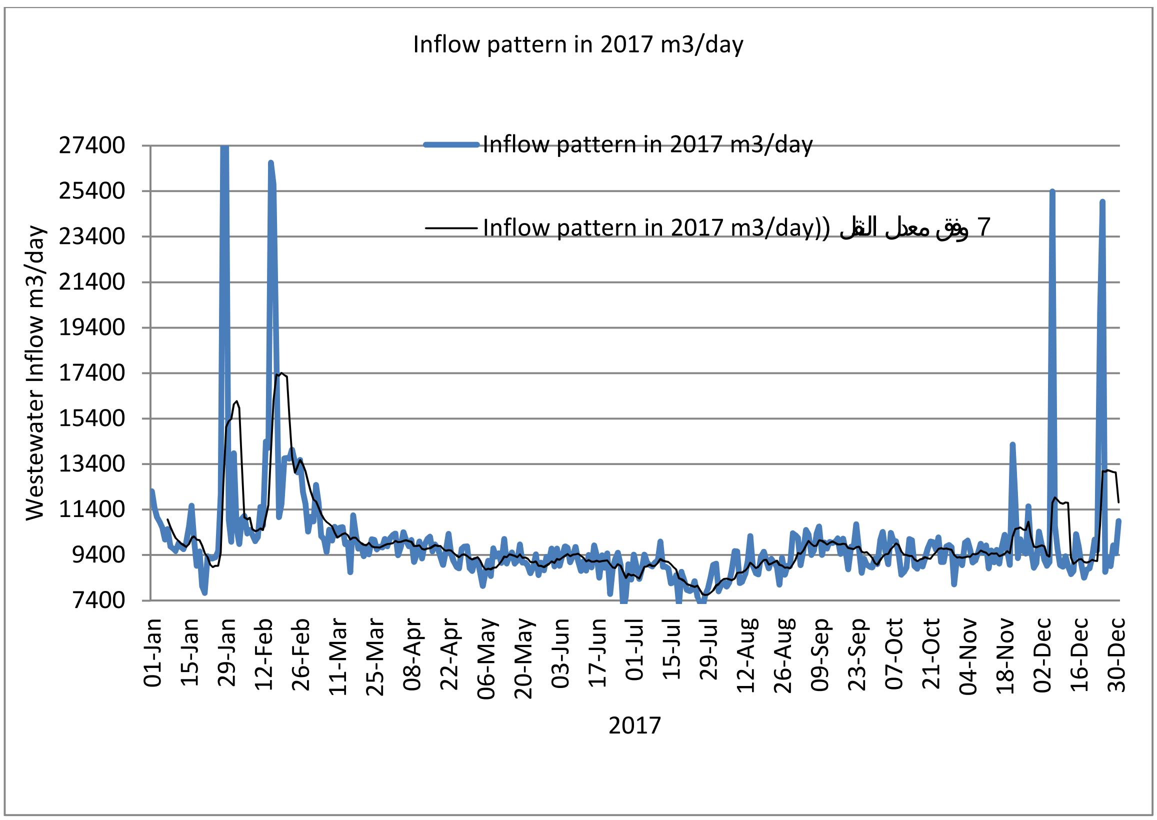

Figure (9): Hydrograph of the daily treated wastewater inflow

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 11,449 kg/d and the total COD load over the year of 2017 was 4,178,854 kg/year. The COD load at the effluent in the same period was 154,760 kg/year. The cleaning performance is approximately 96%.

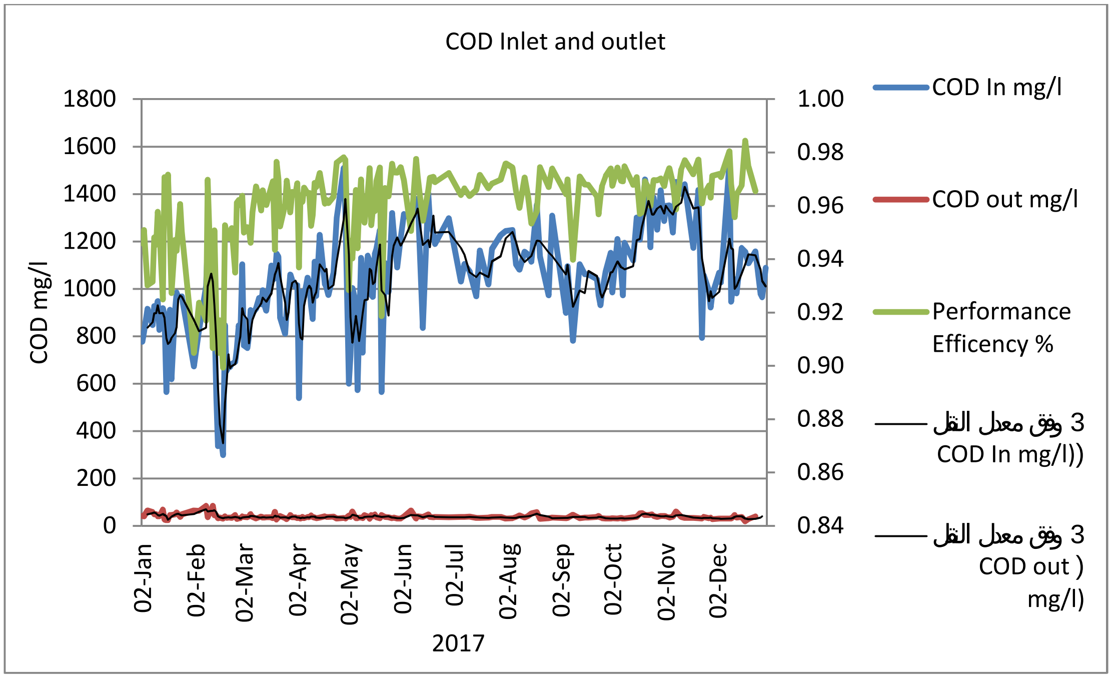

Figure (10): Influent and effluent concentration of COD

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 4,843 kg/d. The reduction of suspended solids was in average approximately 97%.

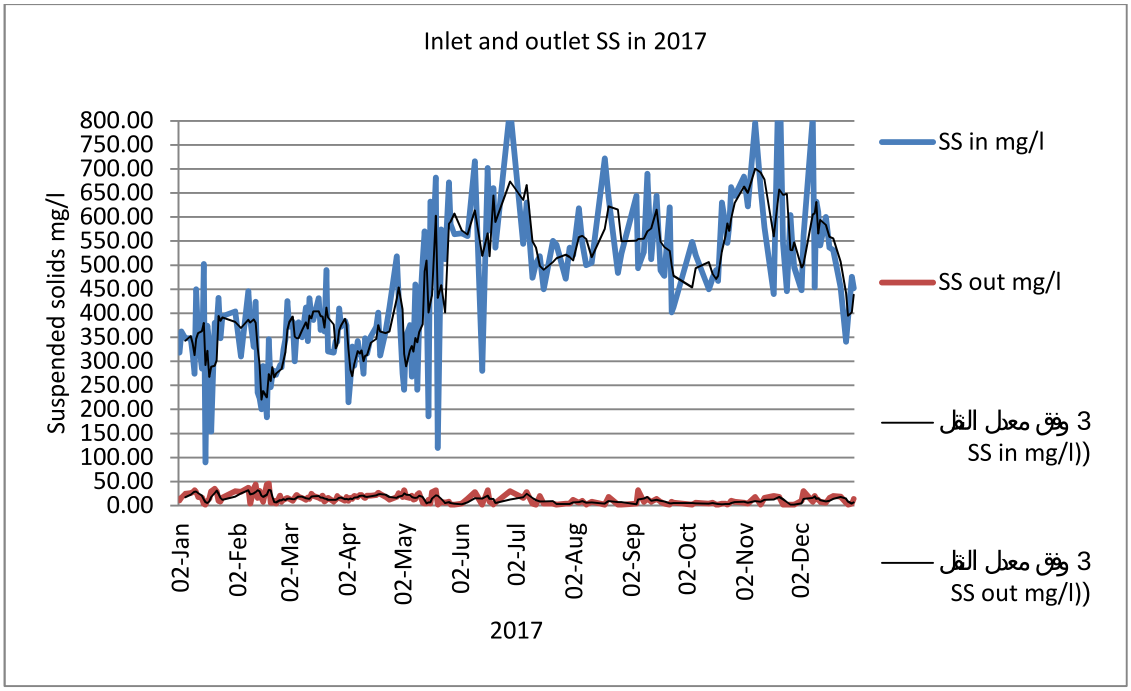

Figure (11): Suspended solids of the inlet and outlet of the treatment plant

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 m³ of treated wastewater, and below 0.8 kWh of kg COD removed , however in Nablus WWTP is 0.77 kwh/m^3 and is 0.73 kg/COD removed respectively. Deviations from this value can be attributed to the circumstances of daily plant operation.

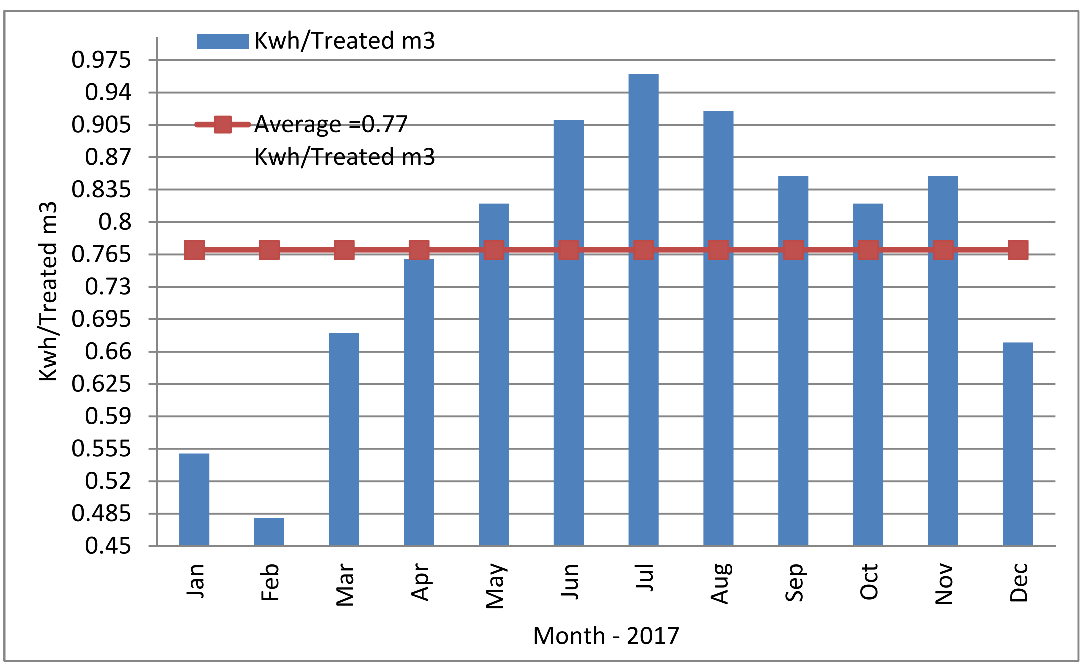

Figure (12): Monthly values of power consumption per treated m³ of wastewater

8.4 Gas production

Part of produced gas at this stage was used for heating the digester. However, the excess used by CHP unit (Installed and operated in 2017). The average gas production in the year of 2017 was 2,473 nm^3/d.

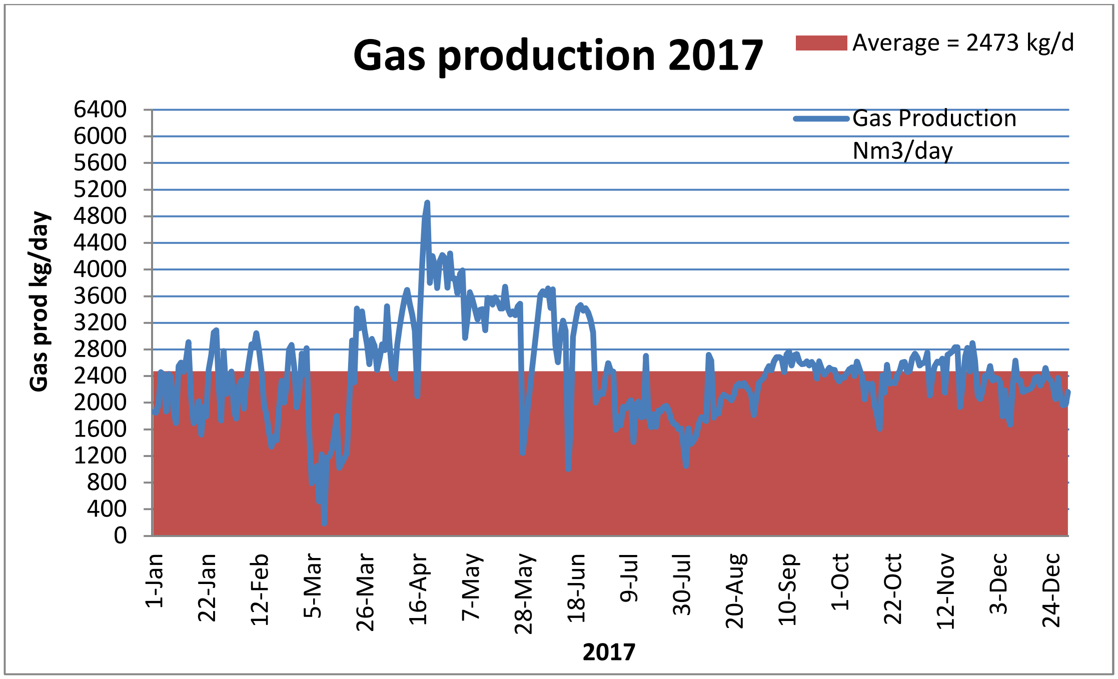

Figure (13): Gas production of the digester

In 2017 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 sustainability for the operation of the CHP engine. It treats the produced biogas from anaerobic digester from H_2S gas and Siloxane. These gases are dangerous for the engine and could cause engine failure.

Figure (14): 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. It is expected to cover around 80% of total electrical demand as more organic load reaches to the Treatment plant from the nearby villages of Nablus West.

Figure (15): Nablus West CHP engine.

8.7 Nablus CHP electrical figures

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

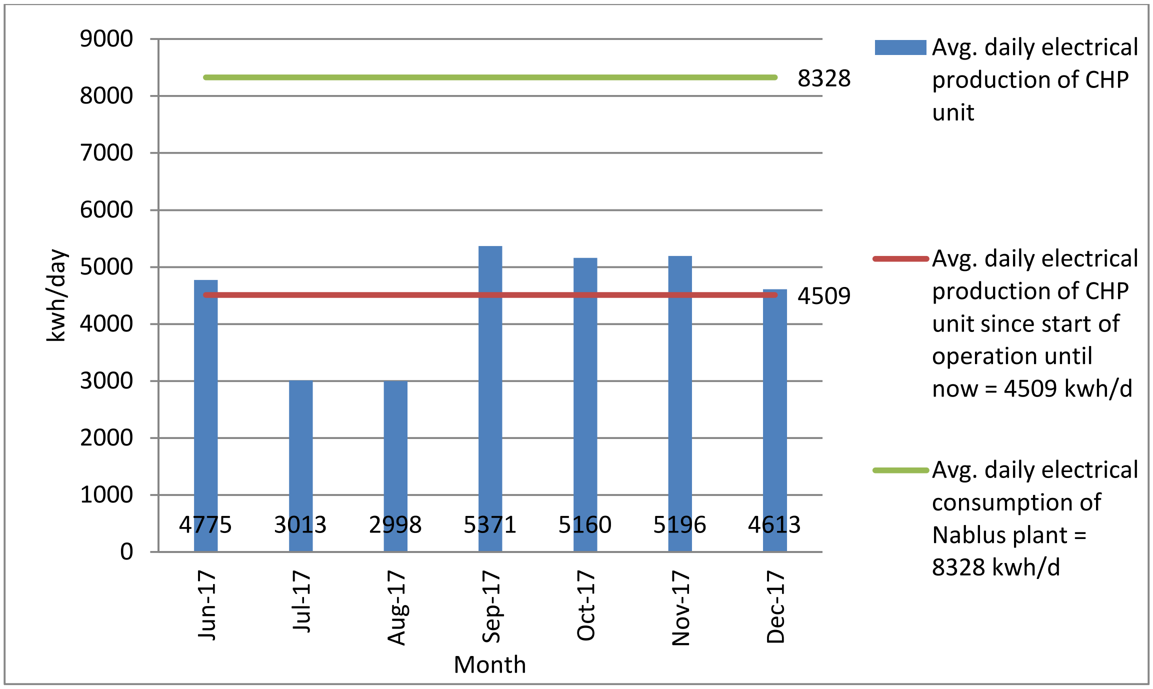

Figure (16): Electrical consumption of plant with comparison of CHP electrical production

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.

10. STAFF TRAINING AND ORGANIZATION STRUCTURE

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

- Practical training on the CHP maintenance in Jordan. This training was done as (on the job training) under the umbrella of Consulaqua consulting company. Four mechanical and electrical technicians were trained in Irbid WWTP.
- Theoretical training for the agricultural engineer on reuse issues of treated water and sludge funded by GIZ.

11. REUSE PROJECTS

In view of the limited water resources in the West Bank, reuse of treated wastewater has a great potential to reduce part of these problems and improve crop yield. Designing wastewater treatment plants for reuse in irrigation could potentially increase agricultural yields, conserve surfaces water and balance chemical fertilizer demand. Nablus Municipality adopted the policy to reuse treated wastewater in agriculture. With reference to Ministry of Agriculture by-law 34-2012 the treated wastewater quality of Nablus WWTP has Grade (A). Four reuse projects are foreseen in the time being as shown in the following table.

Figure (17): Area's for reuse of treated WW within the boundary of Nablus WWTP

Table 1: Reuse projects by treated wastewater

No	Project	Area (Donum)	Crops	Financing	Objective	Quantity of TWW (m^3) \Year	Operating party	Cost (Euro)	Status Taking Over/foreseen steps
1	**Reuse Inside WWTP scheme Figures 14,15**	40	Avocado-Olive-Apple-Almond-Pomegranate-Pirsamon-Pistachio-Apricot-Walnut-Pecan-Citruss-peach-Alfalfa-Barly-Vetch	EU+ German Government through KfW	Educational Pilot project	35,000	Nablus Municipality	462,000	Jan-2017
2	**Reuse outside WWTP scheme Figure 16**	120	Olive-Almond- Alfalfa	EU+ German Government through KfW	Pilot project	115,000	Deir Sharaf WUA	1,500,000	July-2018
3	**Compete Project Figure 17**	140	Olive-Almond - Pomegranate-Apple-Fig	USAID	Pilot project	80,000	Deir Sharaf WUA	500,000	June-2017
4	**Reuse outside 2800 Figure 18**	2800	Alfaalfa-Pecan-Walnut - almond-alfalfa-olive	German Government through KfW	To reuse all TWW in Agriculture	3,000,000	Deir Sharaf WUA	10 millions	End 2019

Figure (18): Reuse inside scheme

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Figure (19): Sand filtration and ultraviolet disinfection units

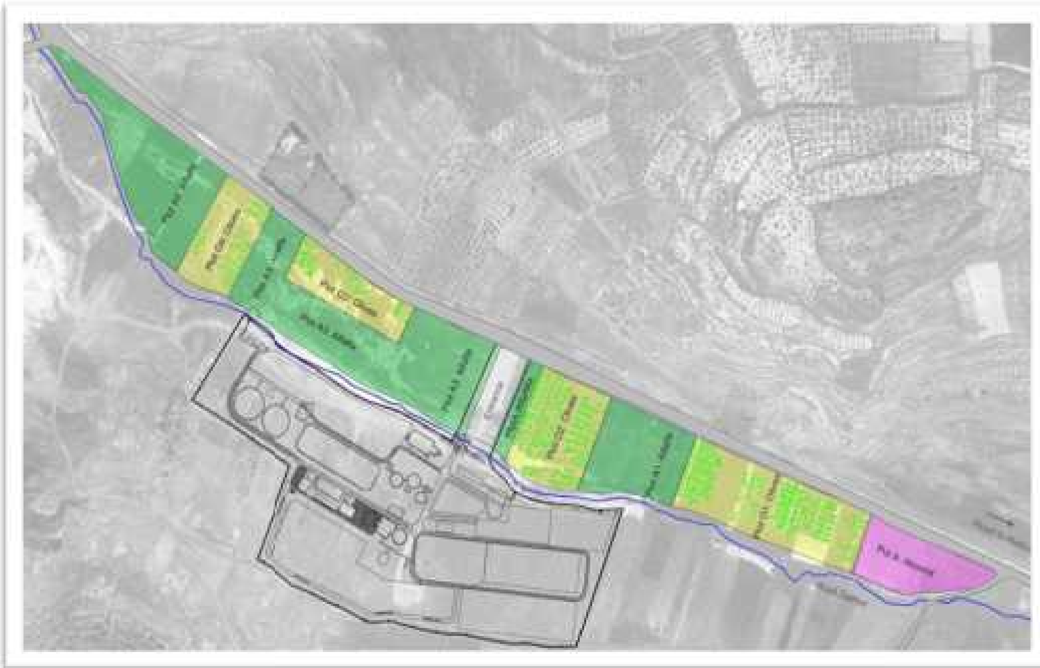


Figure (20): Reuse outside scheme

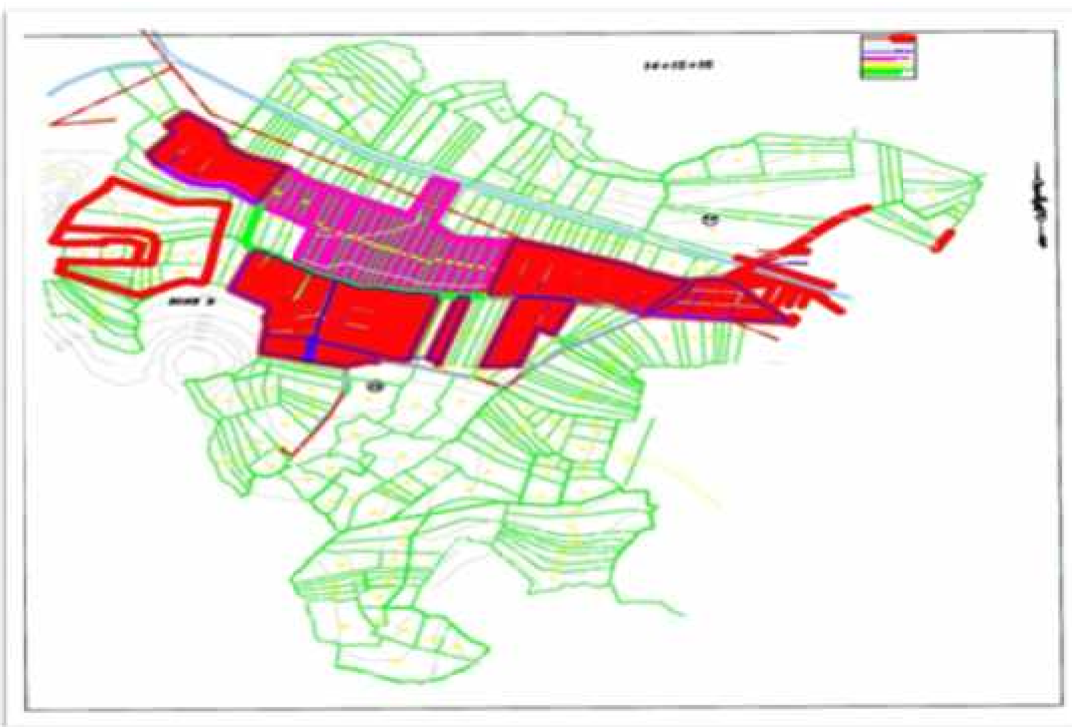


Figure (21): Reuse outside scheme (USAID)

Figure (22): Reuse outside scheme 2800 donum (KfW)

The growth status of the plants which have been planted inside the Nablus WWTP was monitored. Table (2) shows the assessment of agricultural experts for the growth status of the different plants types. Also figure (23) shows the growth of AlfaAlfa in two different pictures which have been captured within duration of less than one month.

Table 2 : 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
Olive Tree	Excellent
Pomegranate	Excellent
Apple	Excellent
Persimmon	good
Apricot	Excellent
Peach	Excellent
Avocado	Very Good

Figure (23): A comparison between AlfaAlfa area (before and after)

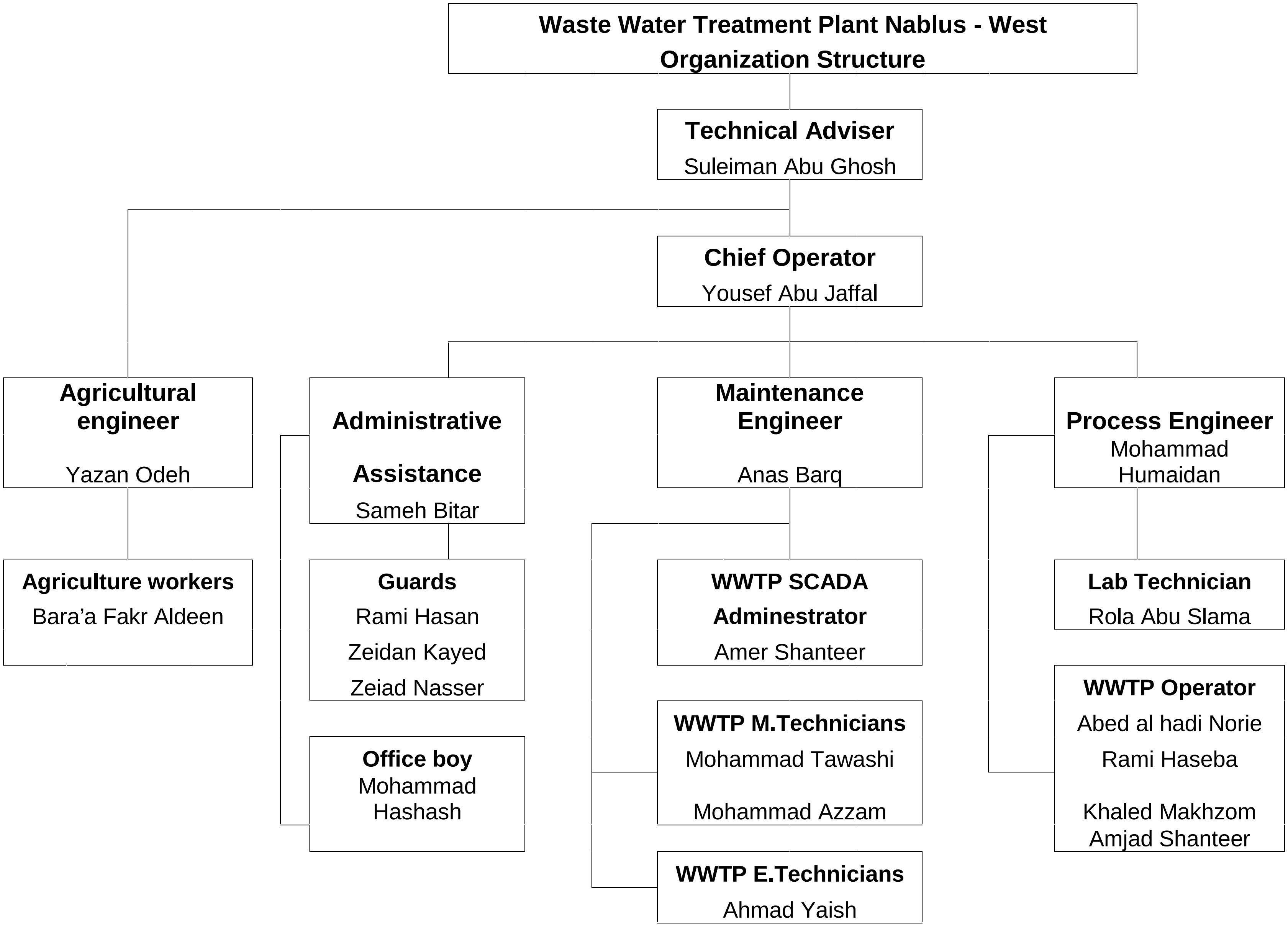
12. Future Improvements

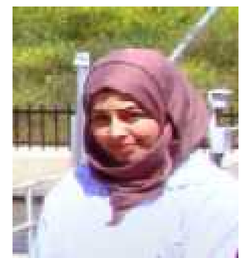
- Implementation of a stone trap at the inlet of WWTP to protect screens
- 125 KW Pilot Project of PV Solar Panel financed through Nuremberg City-Germany. The Cooperation Agreement was signed in February 2017
- Covering primary thickener tank and the sludge storage yard
- Replacement of thermal isolation sheets for the tank of the anaerobic digestion

13. Problems & Challenges in 2017

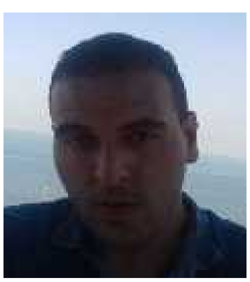
- Unavailability of spare parts in local market.
- Keep the staff of the WWTP.
- Sludge Disposal:
    1. High Cost of sludge disposal in Zeharet Al-Fenjan at 75 NIS/ton.
    2. As per Palestinian standard, it is not allowed to reuse sludge in agriculture due to high Water content in sludge of 75%

14. Staff


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

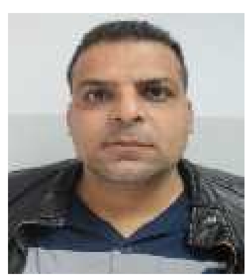
Suleiman Abu Ghosh - Technical Adviser 	Yousef Abu Jaffal -Nablus WWTP Chief Operator 
Mohammad Homeidan -Process Engineer & Lab Officer in Nablus WWTP 	Anas Barq - Electrical Engineer 
Sameh Bitar -Administrative Secreta & Accountant 	Rola Abu Slama -Lab Technician 
Amer Shanteer - WWTP SCADA Administrator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

Operators

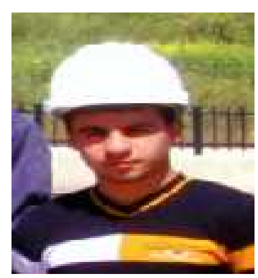


Khaled Makhzom

Amjad Shanteer



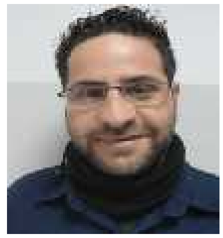
Rami Hasiba



Abdel hadi Norie

Electro mechanic Technicians


Mohammad Tawashi

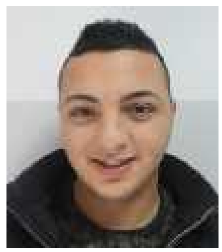

Mohammad Azzam


Ahmad Yaish

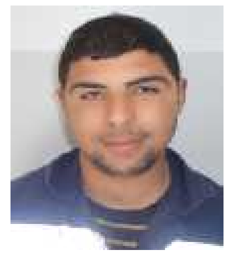
Labour


Mohammad Antar

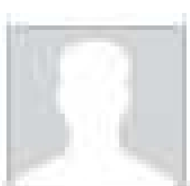
office boy


Mohammad Hashash

Agriculture


Bara’a Fakrldeen

Guards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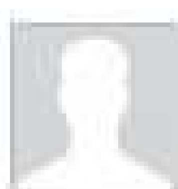
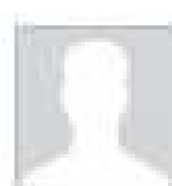
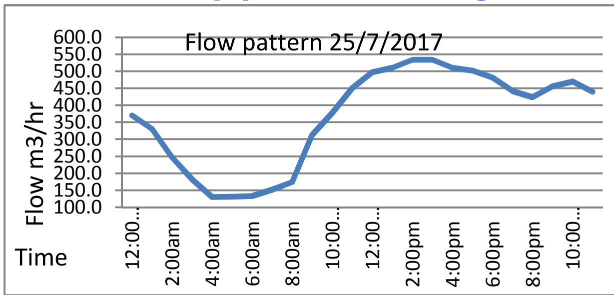
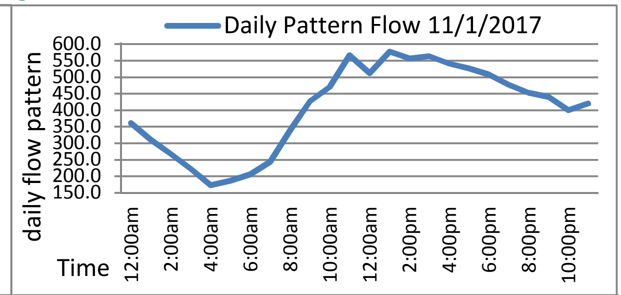

Zeidan Kayed

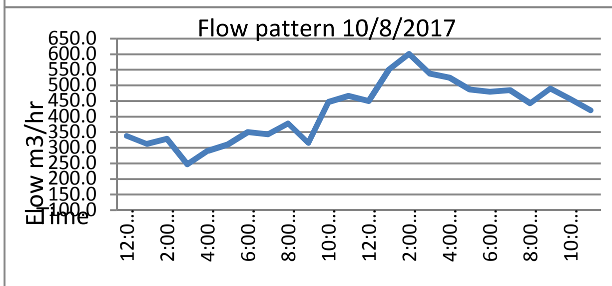

Zeiad Nasser

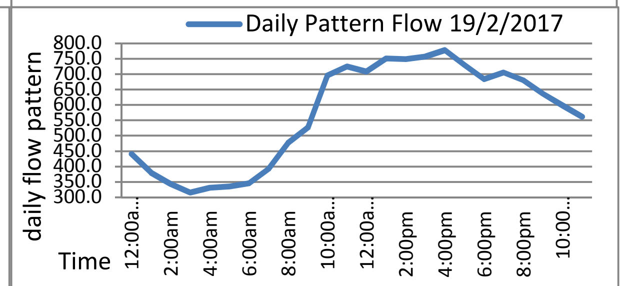
15. Annexes

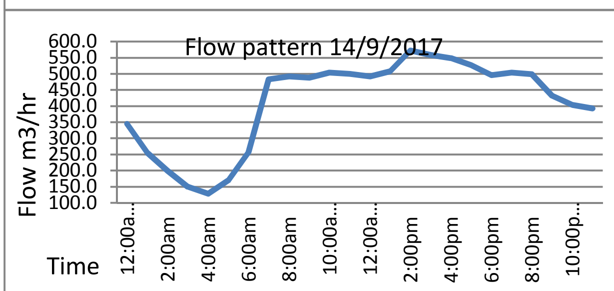
Annex 01: Daily pattern readings of daily inlet flow

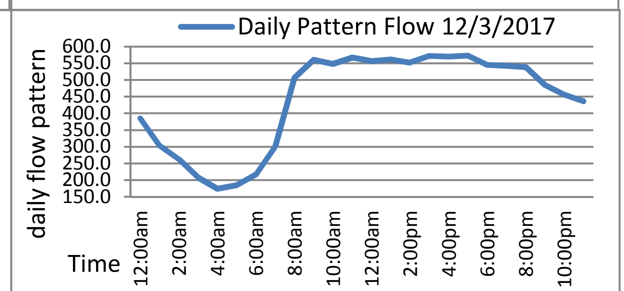


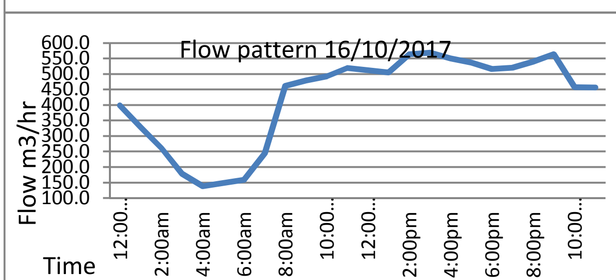


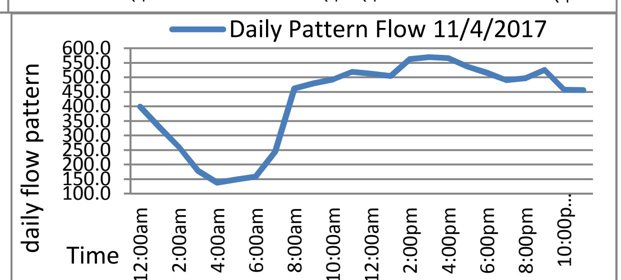


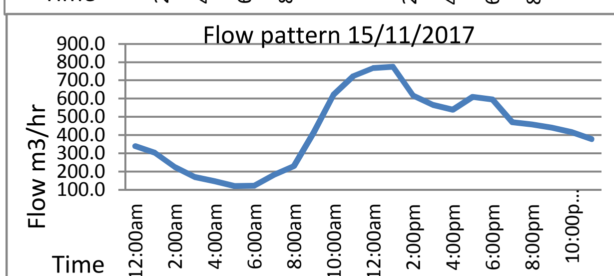


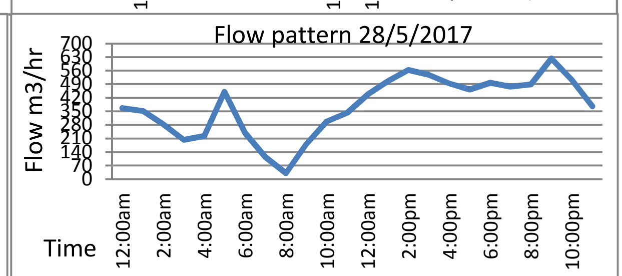


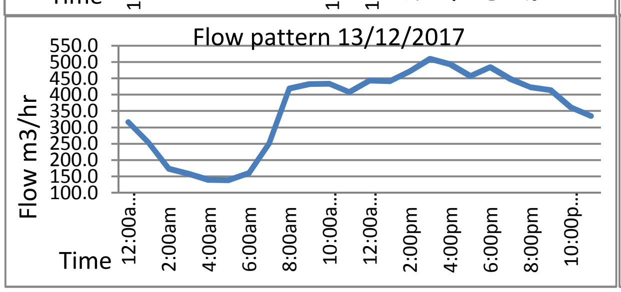


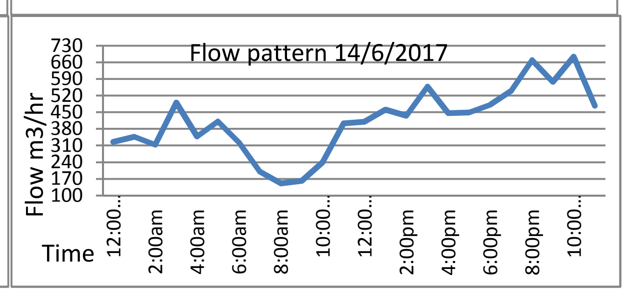




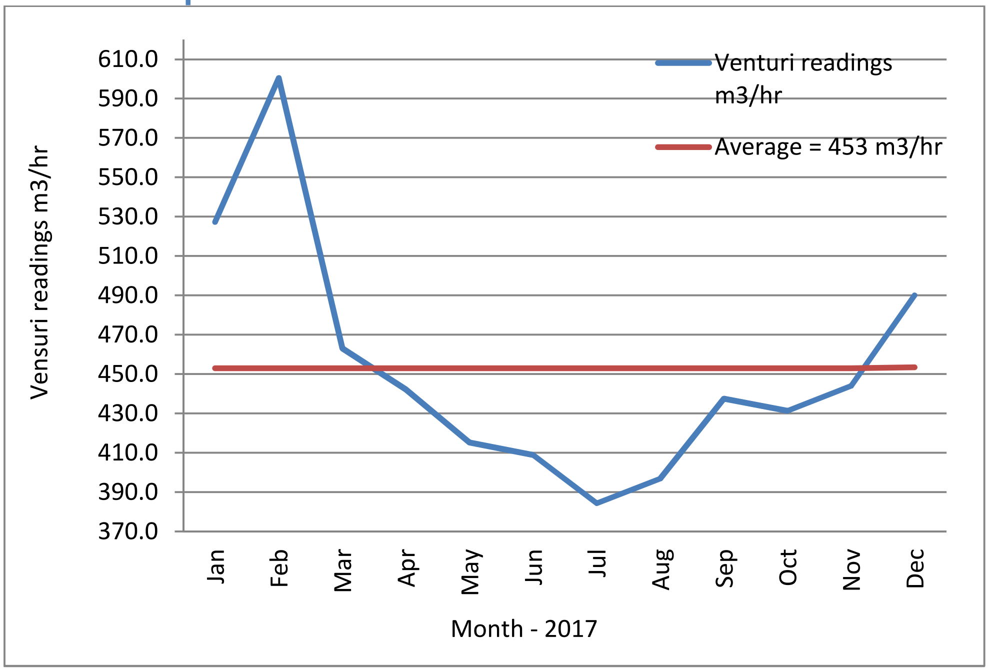




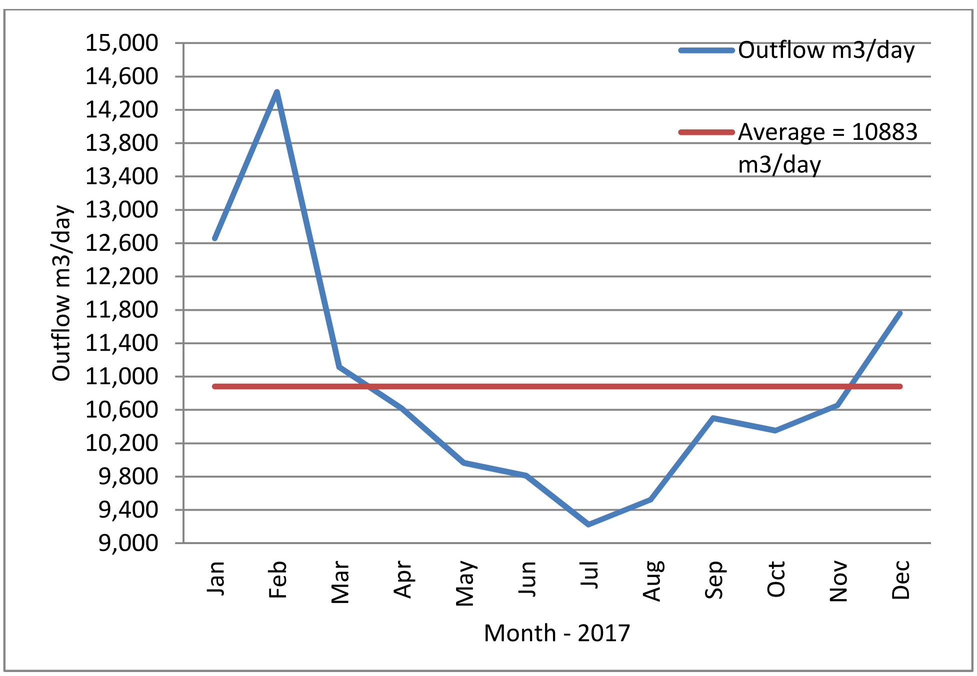




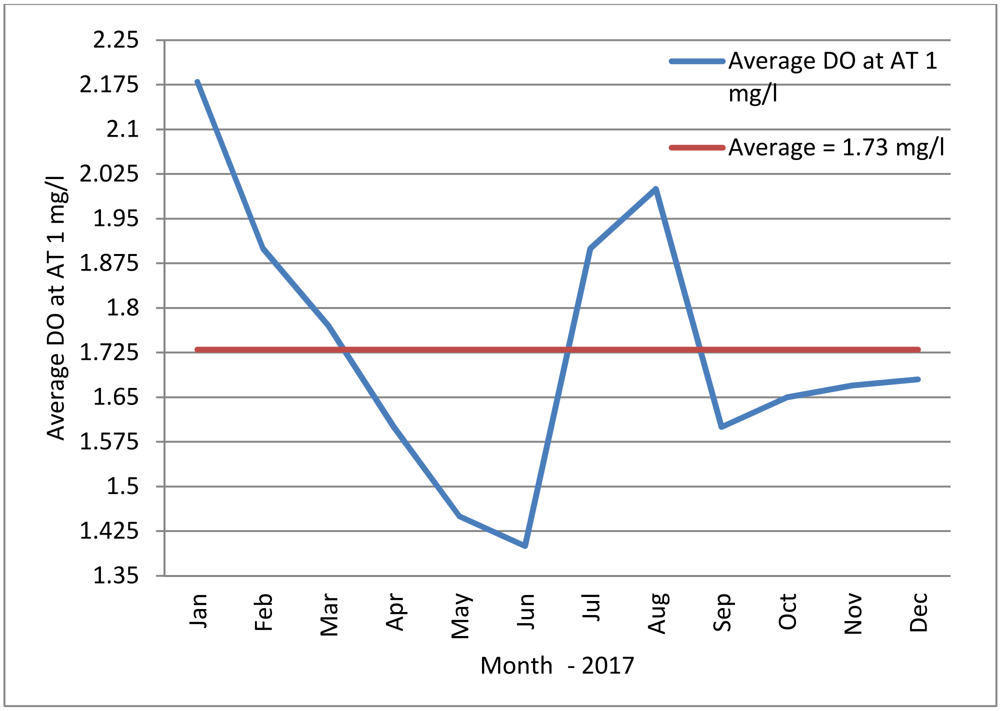
Annex 02: Graphs



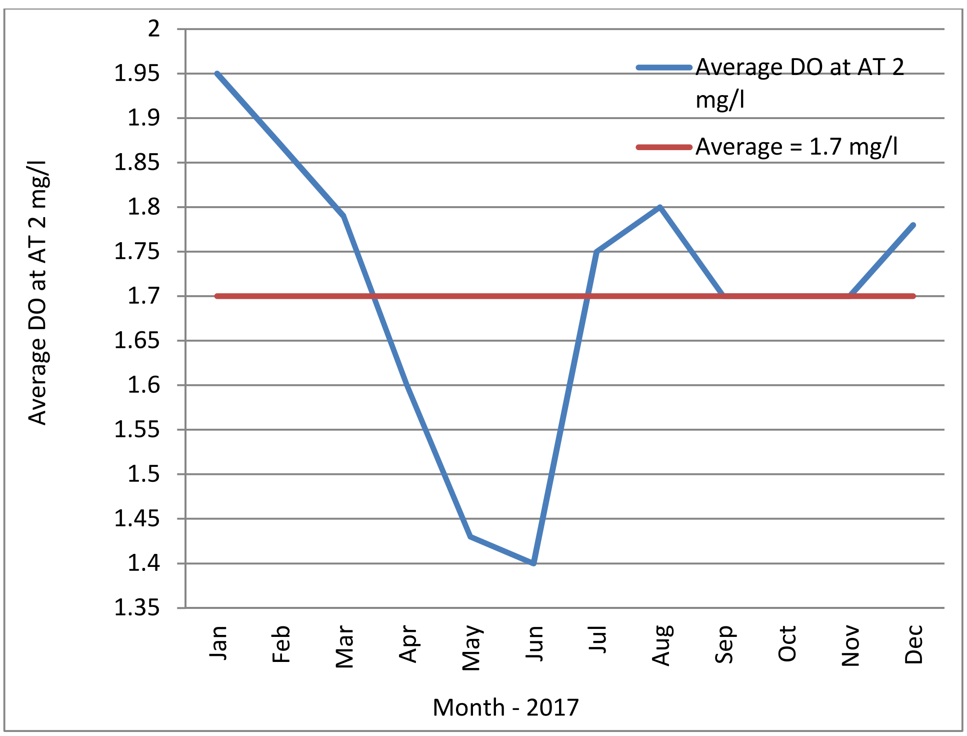
Graph 1: Average wastewater effluent



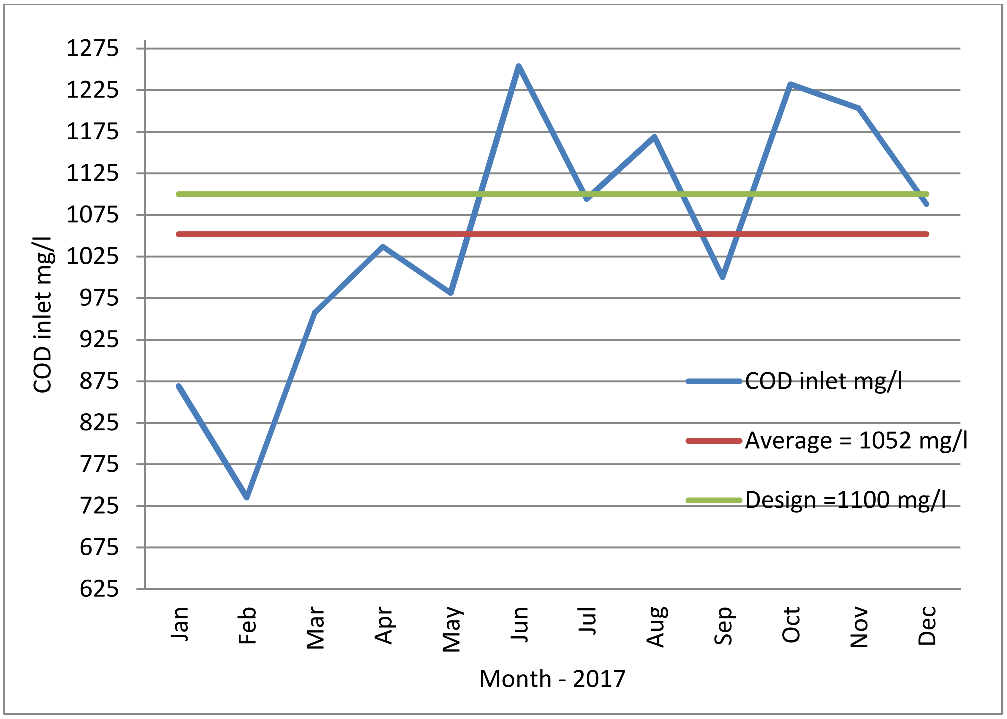
Graph 2: Average treated wastewater effluent



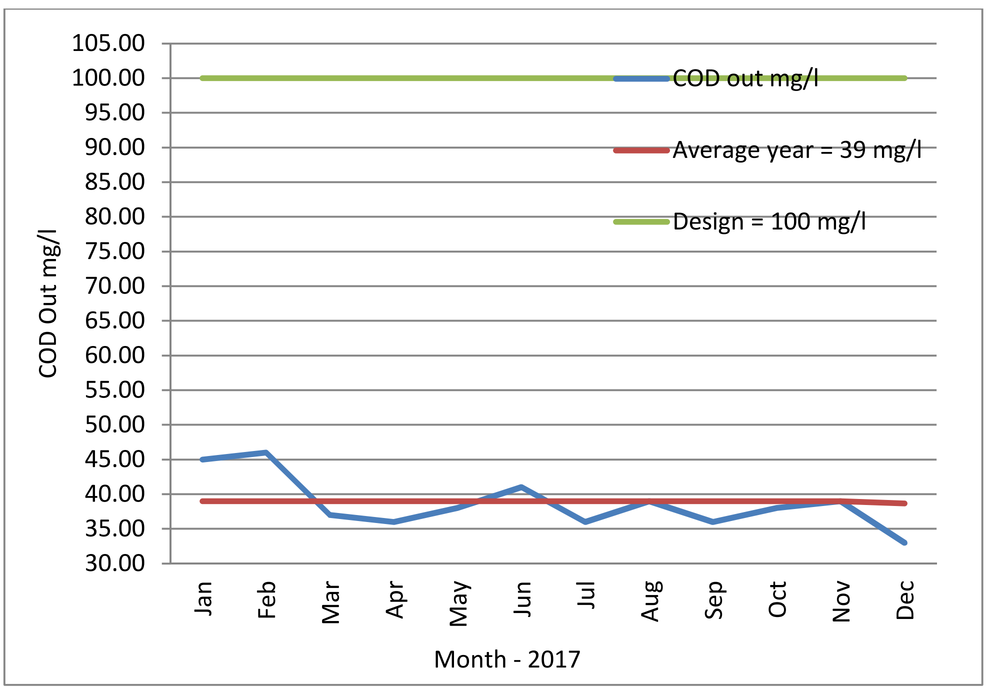
Graph 3: Monthly dissolved oxygen concentration pattern in the aeration tank no. (1)



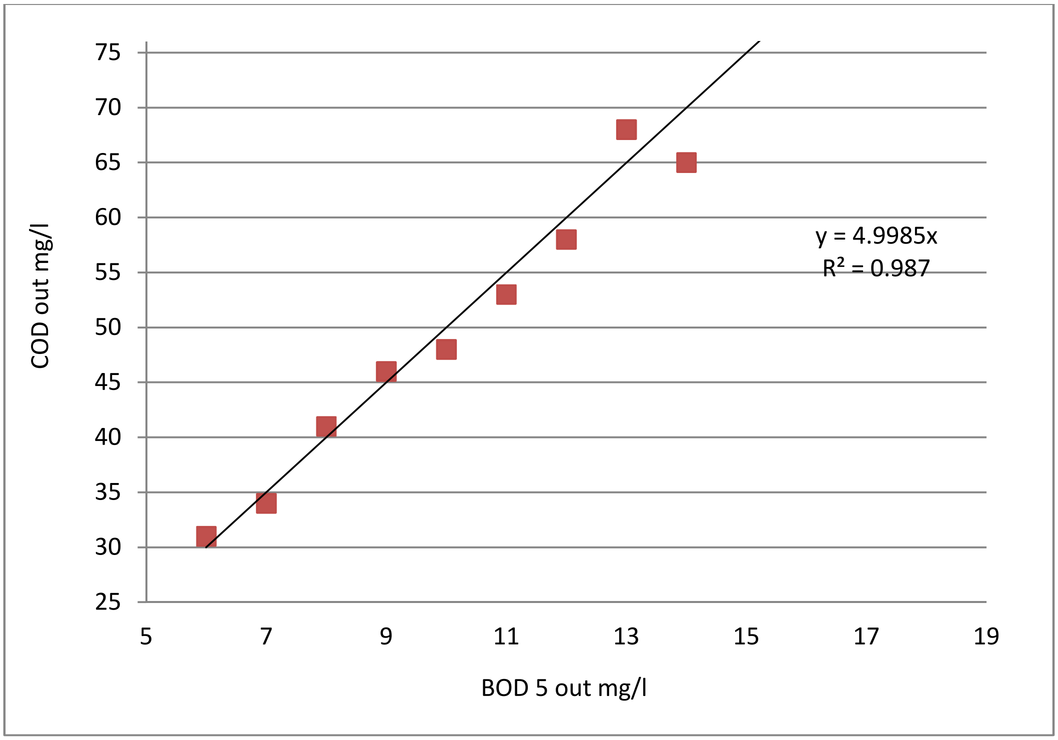
Graph 4: Monthly dissolved oxygen concentration pattern in tank no. (2)



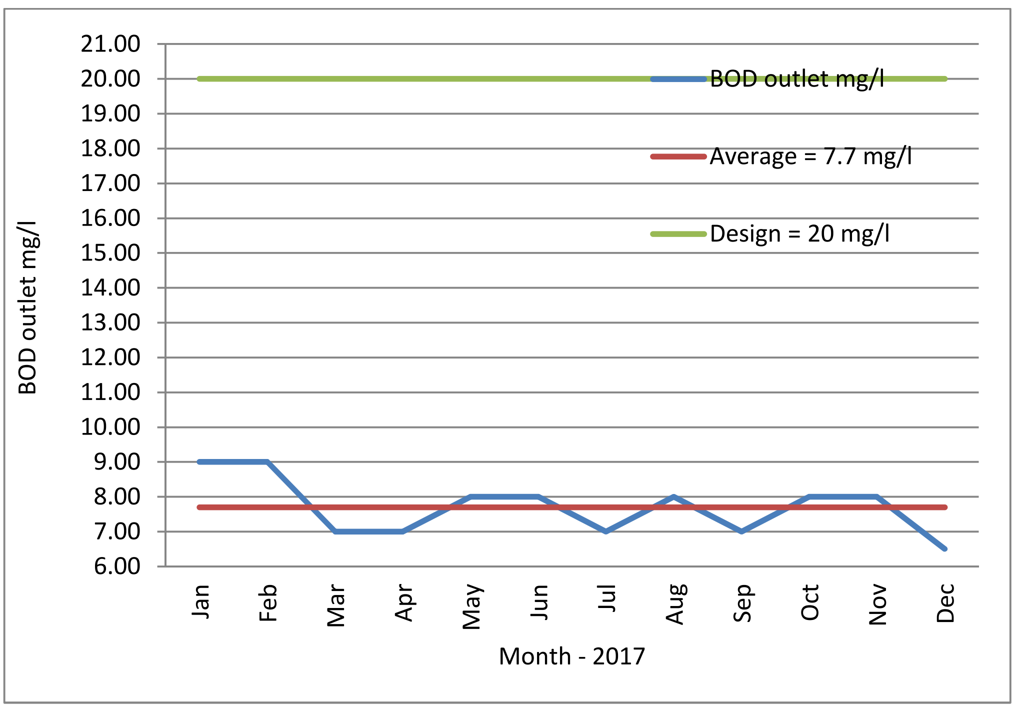
Graph 5: The COD concentration in the influent of WWTP



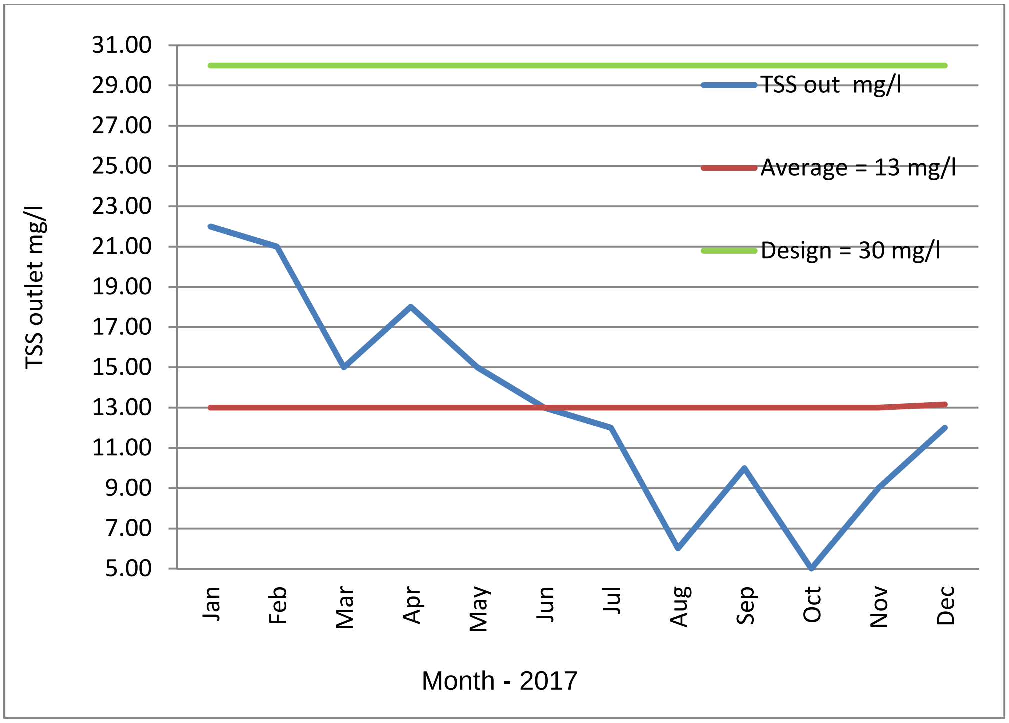
Graph 6: The COD concentration in the effluent of the treated waste water



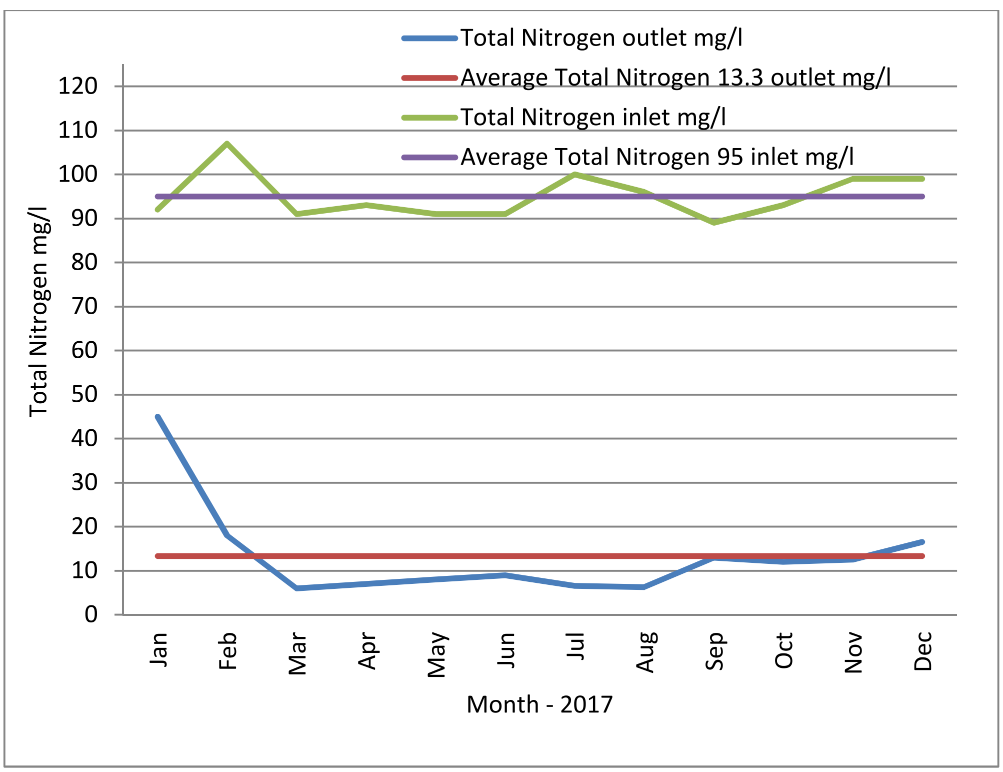
Graph 7: The correlation between COD_{out} and BOD_{5eff}



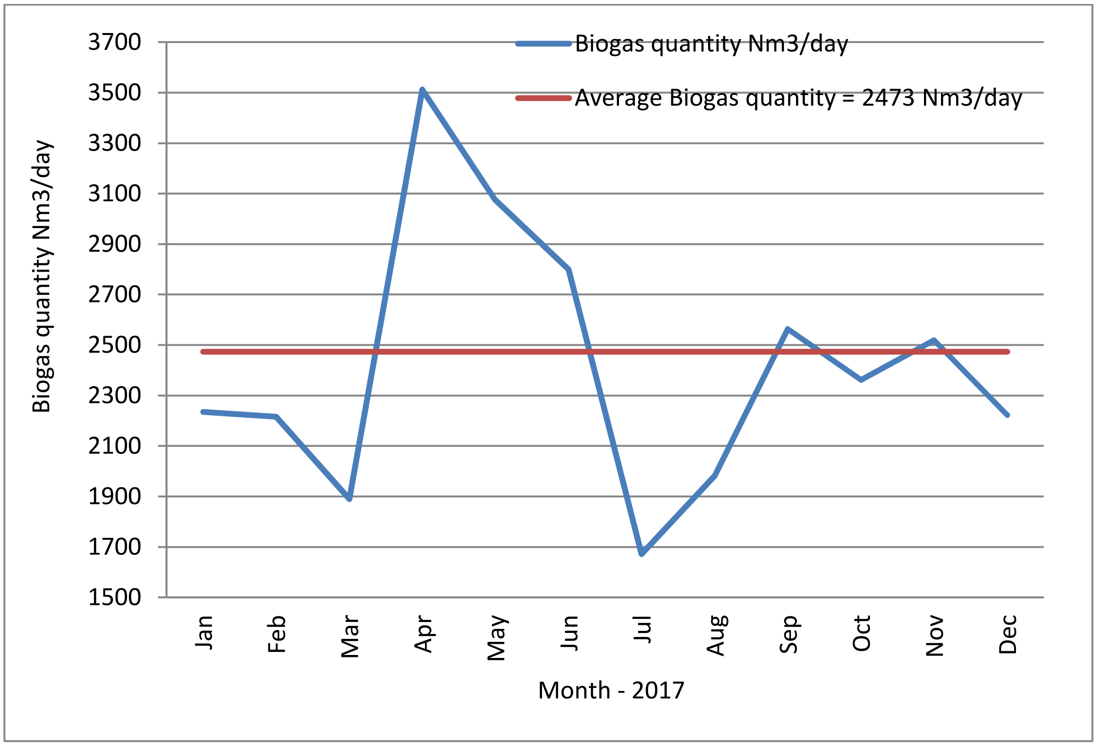
Graph 8: The BOD_5 concentration in the effluent of the treated wastewater



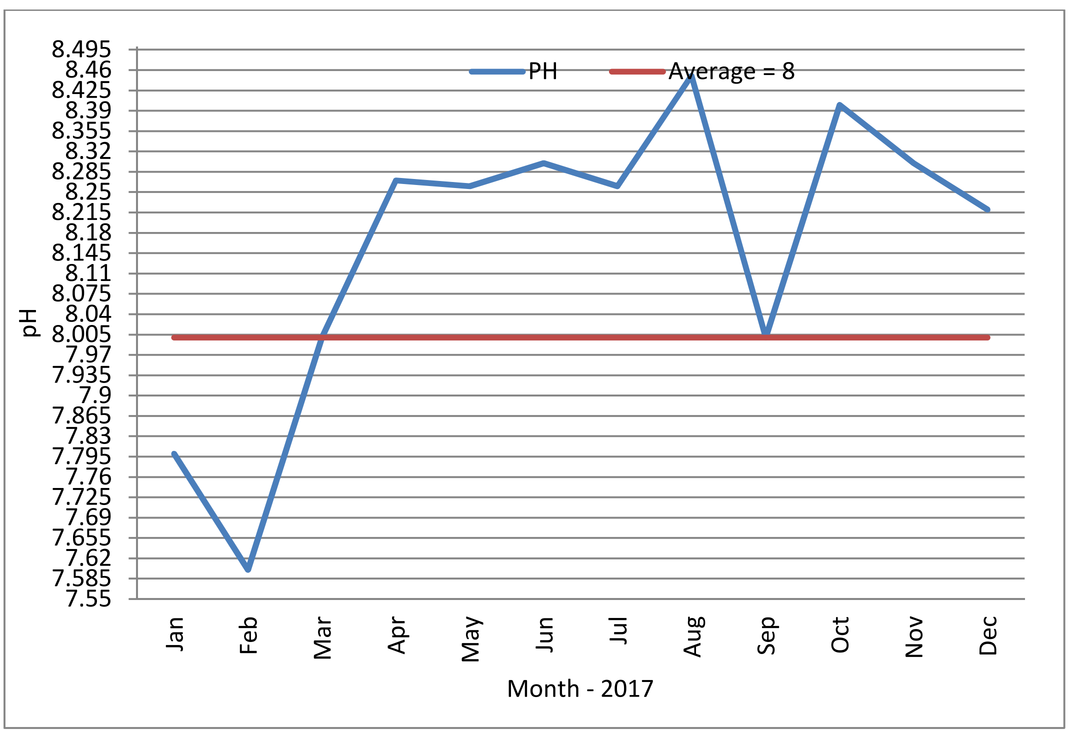
Graph 9: TSS concentration of the treated wastewater (TSS)



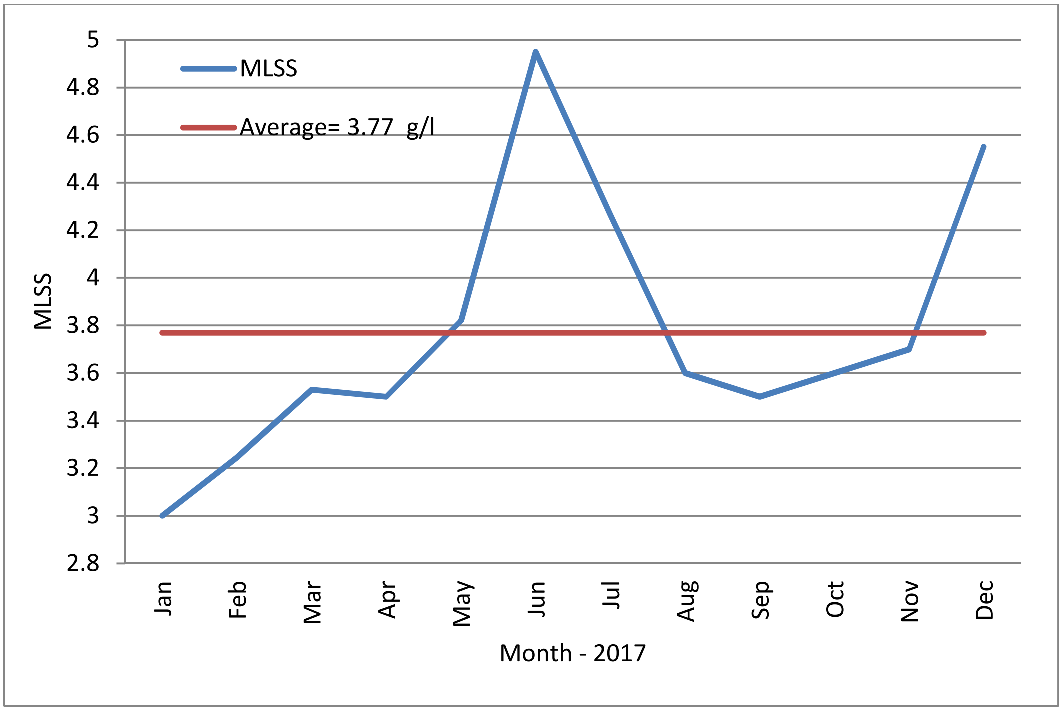
Graph 10: Total Nitrogen for influent and effluent (TN)



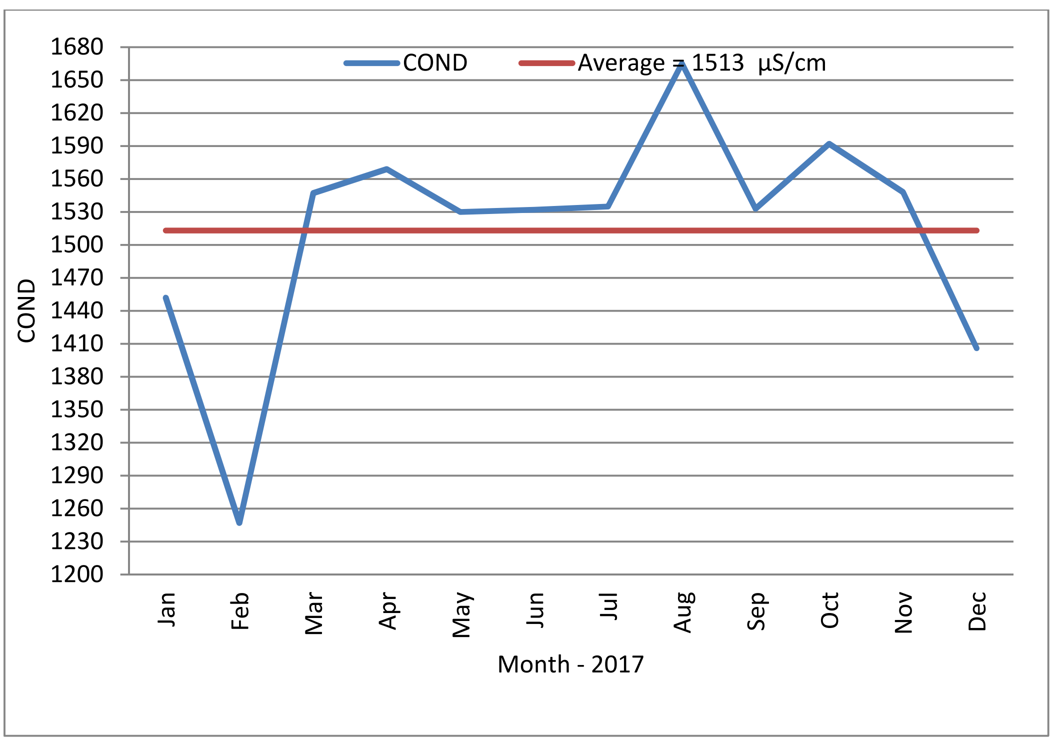
Graph 11: The average produced quantities of biogas



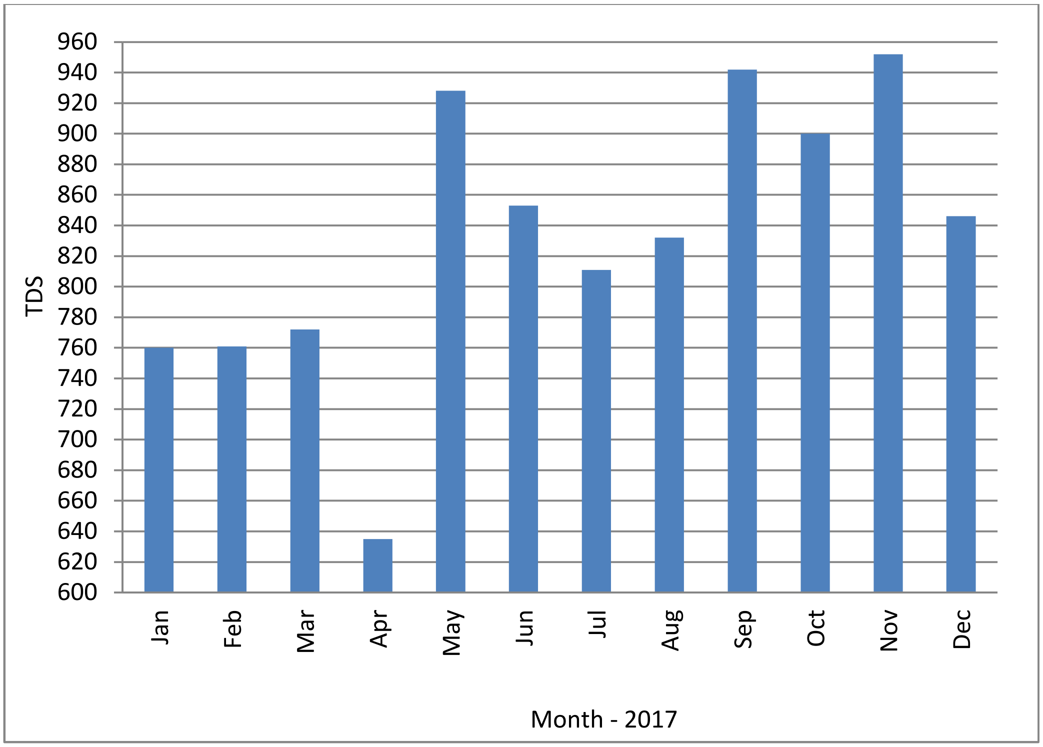
Graph 12: Average pH of the inlet wastewater



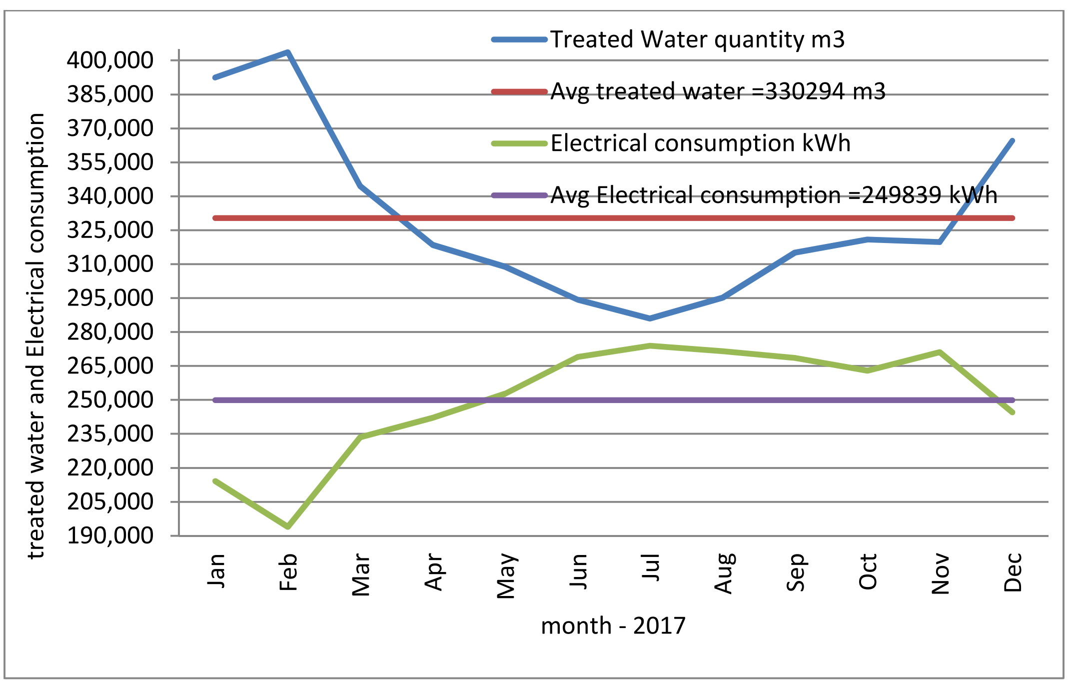
Graph 13: Mixed liquor suspended solids concentration (MLSS) in aeration tanks



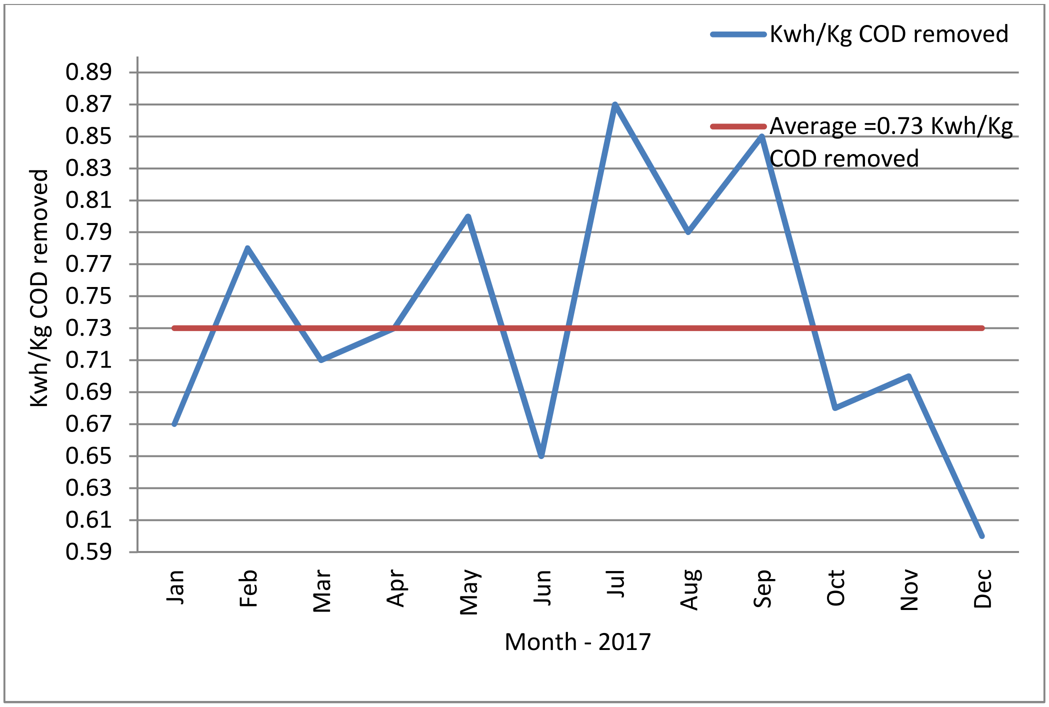
Graph 14: Conductivity of the inlet flow



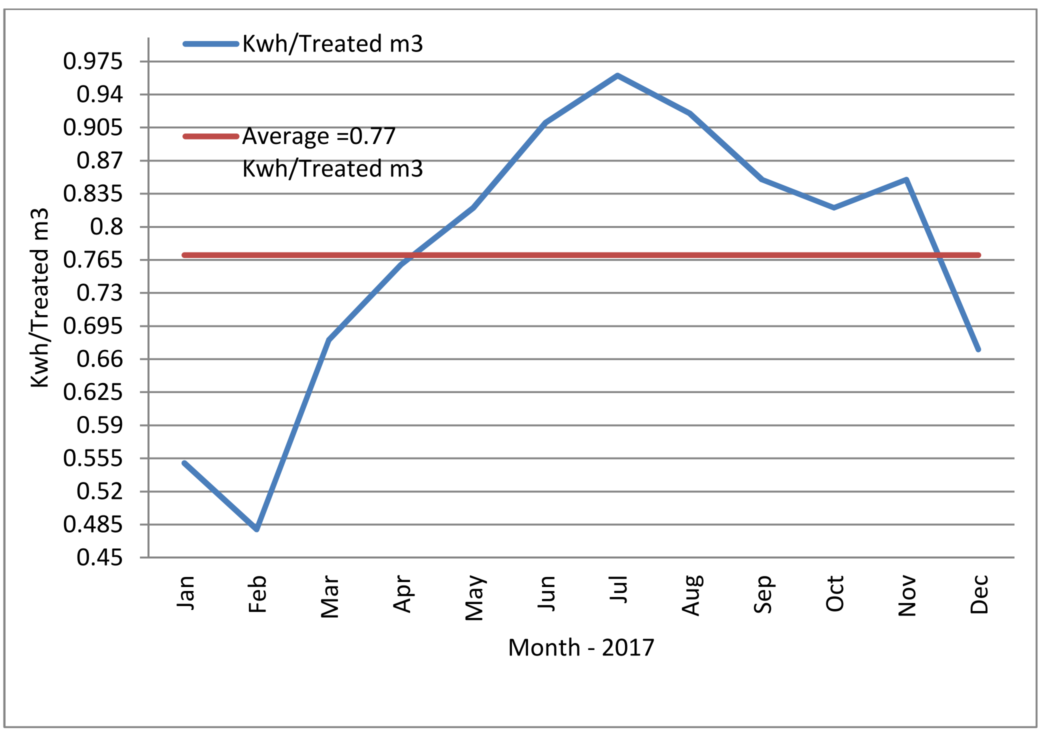
Graph 15: Total dissolved solids in the effluent



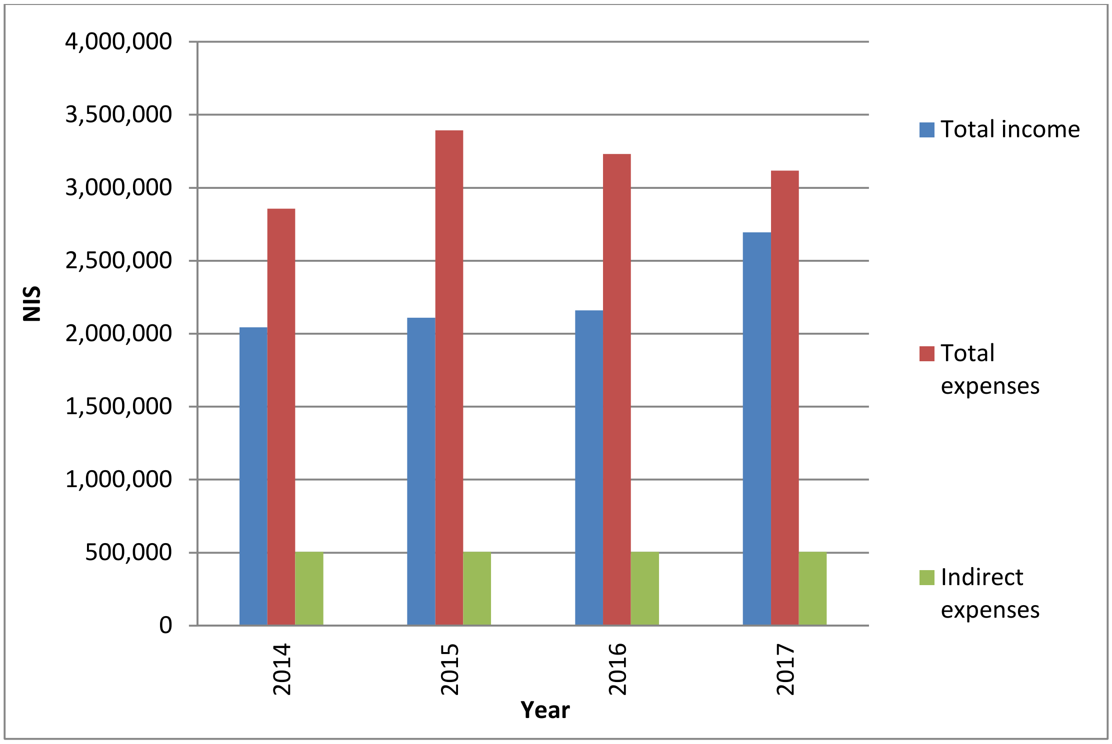
Graph 16: Average monthly treated wastewater and power consumption



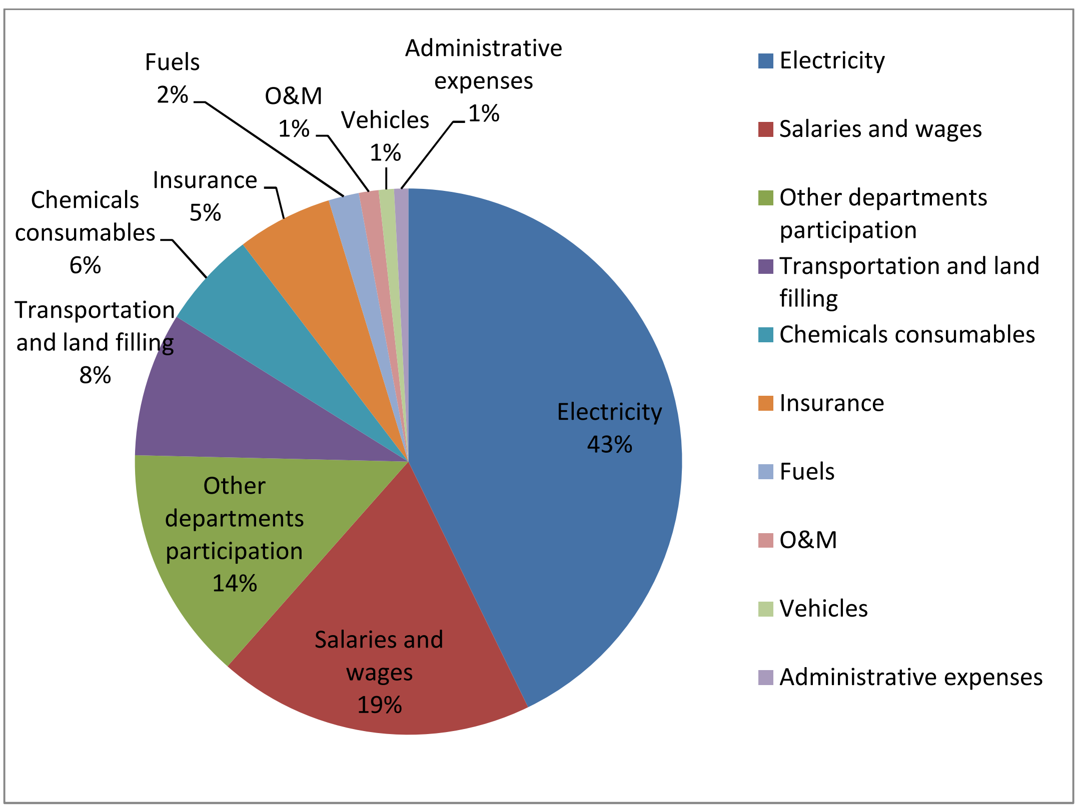
Graph 17: Power requirement kWh/kg COD treated



Graph 18: Power requirement kWh/m^3 treated



Graph 19: Expenditures versus collection



Graph 20: Expenditures breakdown 2017

Annex 03: Performance summary

Parameters	Design value 2020	Treatment efficiency %	Average	Month - 2017											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average inlet flow m^3/d	**14000**	**-----**	10883	12657	14413	11112	10615	9965	9812	9223	9523	10500	10352	10660	11760
Inlet COD mg/L	**1100**	**-----**	1052	864	732	957	1035	981	1269	1094	1169	1000	1232	1203	1088
Outlet COD mg/L	**100**	**96%**	39	45	46	37	36	38	41	36	39	36	38	39	33
Outlet BOD_5 mg/L	**20**	**99%**	7.7	9	9	7	7	8	8	7	8	7	8	8	6.5
Inlet BOD_5 mg/L	**550**		526	432	366	478	517	490	634	547	584	500	615	601	544
Sludge age (days)	**13.7**	**-----**	18	19	17	16	14.5	15.4	20	17.5	18	21	20	20	20.2
MLSS g/L	**3**	**-----**	3.77	3	3.66	3.53	3.5	3.3	4.95	4.3	3.6	3.5	3.6	3.7	4.55
TSS_{inlet} mg/L	**500**		474	355	300	377	304	430	602	522	562	534	546	629	522
TSS_{outlet} mg/L	**30**	**97%**	13	22	21	15	18	15	13	12	6	10	5	9	12
TN out	**30**		13.3	45	18	6	7	8	9	6.6	6.3	13	12	12.5	16.5

Annex 04: Power consumption

Month	Avg	2017											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated wastewater quantity m^3	330,288	392,381	403,560	344,468	318,454	308,906	294,351	285,900	295,204	315,040	320,914	319,719	364,555
Total electrical consumption kWhr	249,839	214,198	193,860	233,542	242,157	252,791	202,106	180,512	178,615	102,002	102,987	109,994	101,511
CHP electrical production kWhr		-	-	-	-	-	66,850	93,410	92,941	166,509	159,981	161,101	142,995
kWhr per m^3	0.76	0.55	0.48	0.68	0.76	0.82	0.91	0.96	0.92	0.85	0.82	0.85	0.67

Annex 05: Additional lab Tests in WWTP Lab

/ Test	Values	Average	2017											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
COD out mg/l	Average	**39**	45.00	46.00	37.00	36.00	38.00	41.00	36.00	39.00	36.00	38.00	39.00	33.00
	Max	**57.0**	69.00	85.00	59.00	44.00	60.00	64.00	39.00	57.00	47.00	54.00	60.00	46.00
	Min	**28.5**	24.00	29.00	27.00	30.00	29.00	30.00	33.00	29.00	32.00	30.00	31.00	18.00
BOD out mg/l	Average	**7.7**	9.00	9.00	7.00	7.00	8.00	8.00	7.00	8.00	7.00	8.00	8.00	6.50
	Max	**11.4**	14.00	17.00	12.00	9.00	12.00	13.00	7.80	11.00	9.40	11.00	12.00	9.00
	Min	**5.7**	5.00	6.00	5.00	6.00	6.00	6.00	6.60	6.00	6.40	6.00	6.00	3.60
NH4-N out mg/l	Average	**0.4**	0.25	0.00	0.15	0.00	0.50	0.45	0.90	--	0.80	--	--	0.30
	Max	**0.5**	0.40	0.00	0.30	0.00	0.50	0.90	0.90	--	0.80	--	--	0.40
	Min	**0.3**	0.10	0.00	0.00	0.00	0.50	0.00	0.90	--	0.80	--	--	0.20
NO3-N out mg/l	Average	**8.1**	32.90	2.30	3.30	3.80	6.10	6.10	4.18	3.60	11.45	8.90	7.50	6.55
	Max	**10.2**	43.00	2.30	3.30	3.80	6.10	6.90	5.30	4.50	13.40	15.40	8.70	9.30
	Min	**5.9**	22.80	2.30	3.30	3.80	6.10	5.30	3.40	2.20	6.60	5.00	6.40	3.80
TN out mg/l	Average	**13.3**	45.00	18.00	6.00	7.00	8.00	9.00	6.60	6.30	13.00	12.00	12.50	16.50
	Max	**15.8**	50.00	18.00	6.00	7.00	8.00	11.00	8.00	9.00	17.00	19.00	18.00	18.00
	Min	**10.8**	40.00	18.00	6.00	7.00	8.00	7.00	5.00	3.00	8.00	6.00	7.00	15.00
PO4-P out mg/l	Average	**2.7**	3.93	1.90	0.85	2.14	2.69	2.64	4.65	4.40	3.30	2.30	2.40	1.30
	Max	**3.1**	3.93	1.90	0.85	2.14	2.69	2.64	6.54	4.80	3.44	3.70	2.70	1.70
	Min	**2.4**	3.93	1.90	0.85	2.14	2.69	2.64	3.48	4.00	3.14	1.50	1.90	1.10
TSS out mg/l	Average	**13**	22.00	21.00	15.00	18.00	15.00	13.00	12.00	6.00	10.00	5.00	9.00	12.00
	Max	**28.0**	40.00	46.00	25.00	27.00	32.00	32.00	30.00	12.00	32.00	10.00	20.00	30.00
	Min	**3.2**	2.00	4.00	6.00	10.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
MLSS mg/l	Average	**3.77**	3.00	3.66	3.56	3.45	3.82	4.95	4.30	3.60	3.50	3.60	4.46	4.55
	Max	**4.4**	3.40	2.38	5.00	4.20	3.64	6.38	4.90	4.22	4.40	4.50	5.00	5.20
	Min	**3.3**	2.50	3.19	3.13	2.75	3.00	4.45	3.60	3.05	3.00	2.90	3.73	3.80

Annex 06: External laboratory analysis

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

Elements	Sampled on		Obligatory	Method of Testing
	05/09/2016	15/1/2017	Tech.Ins 59/2015	
Cd (ppm)	0.27	0.48	20	Birzeit Lab, ICP instrument
Cu (ppm)	71.63	123.9	1000	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	2500	Birzeit Lab, ICP instrument
Cr (ppm)	6.93	13.4	400	Birzeit Lab, ICP instrument
As (ppm)	Not Detected	0.29	N.A	Birzeit Lab, ICP instrument
Mo (ppm)	1.21	0.40	N.A	Birzeit Lab, ICP instrument
Se (ppm)	Not Detected	Not Detected	N.A	Birzeit Lab, ICP instrument
Hg (ppm)	0.58	0.47	16	Birzeit Lab, DMA-80 instrument
Phosphorus (ppm)	3299	6771	N.A	Birzeit Lab, ICP instrument
FC (cfu/g)	4300	-	N.A	Birzeit Lab, iso instrument
Salmonella (cu/g)	Nil	Nil	N.A	Birzeit Lab, iso instrument
Conductivity µs/cm	-	1180		Birzeit Lab, iso instrument

Annex 07: Quality of tertiary treatment systems

Quality of the treated water (NWWTP) with comparison of reuse standard (34/2014)

Maximum limits for chemical and biological properties	**KfW** reuse project sampled 14\8\2017	**USAID** reuse project sampled 18/5/2017	**Quality of Tech. Spec 34-2014**			
			High Quality (A)	**Good Quality (B)**	**Medium Quality (C)**	**Low Quality (D)**
(BOD_5) mg/l	14.8	5	20	20	20	60
suspended solids (TSS) mg/l	<2	6	30	30	30	90
FC (Colony/100ml)	Nill	2	200	1000	1000	1000
(COD) mg/l	45.3	25	50	50	100	150
Dissolved Solids (TDS) mg/l	975	820	1200	1500	1500	1500
pH	7.74	7.54	6--9	6—9	6--9	6--9
Fat, Oil, & Grease mg/l	4	4	5	5	5	5
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
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
SO_4 ppm	88.73	97.40	300	300	300	300
Na ppm	177	197	200	200	200	200
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
PO_4-P ppm	16.3	11.93	30	30	30	30
Al ppm	0.10	0.05	5	5	5	5
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				
E. coli (Colony/100ml)	Absent	Absent	100	1000	1000	1000
Nematodes (eggs/L)	Absent	Absent	1>=	1>=	1>=	1>=

BDL = below detection limit

16. Photos