Wastewater Treatment Plant

Nablus West

Annual Report 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

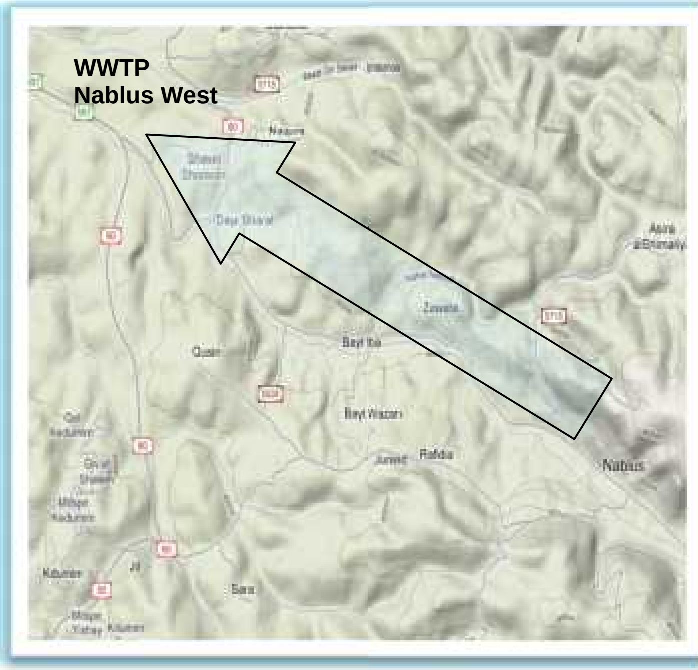


Figure (2): Direction of slope

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 five millions three hundred and twenty thousand (5,320,000 m^3) cubic meters of wastewater were treated in the year 2019, with an electrical consumption of three millions two hundred and seventy three thousand (3,273,000 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 8 mg/l and TSS was 10 mg/l. By such 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 Stone trap

The first unit in Nablus west wwtp in the stone trap, where the big stones and heavy objects captured and separated the inlet waste water, during winter times the waste water most probably contains such stuff which in turn be necessary to remove them to protect the downstream units

5.2 Screens and grit/grease removal

The wastewater treatment in Nablus west after has been passed through the stone trap continued to the 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.

5.3 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.

5.4 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.

5.4.1 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.

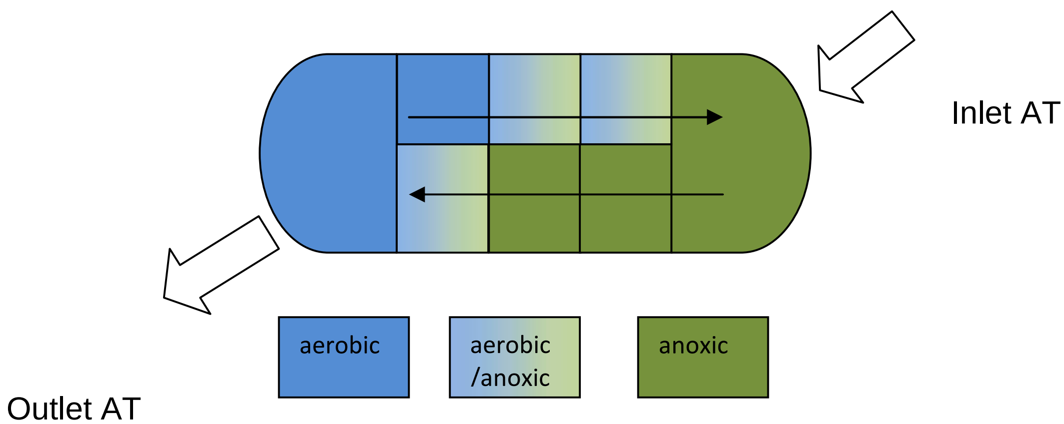


Figure (5): Aeration tank with implemented de-nitrification zone

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.

5.5 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

Three belt filter presses were used to dewatering the digested sludge coming from the digester to have solids more than 28%. Special polymers were used to improve the efficiency of the dewatering process as shown in Figure (7) it is worth to mention, a third belt filter press was installed and operated successfully thought a fund from kfw to improve the sludge treatment process.

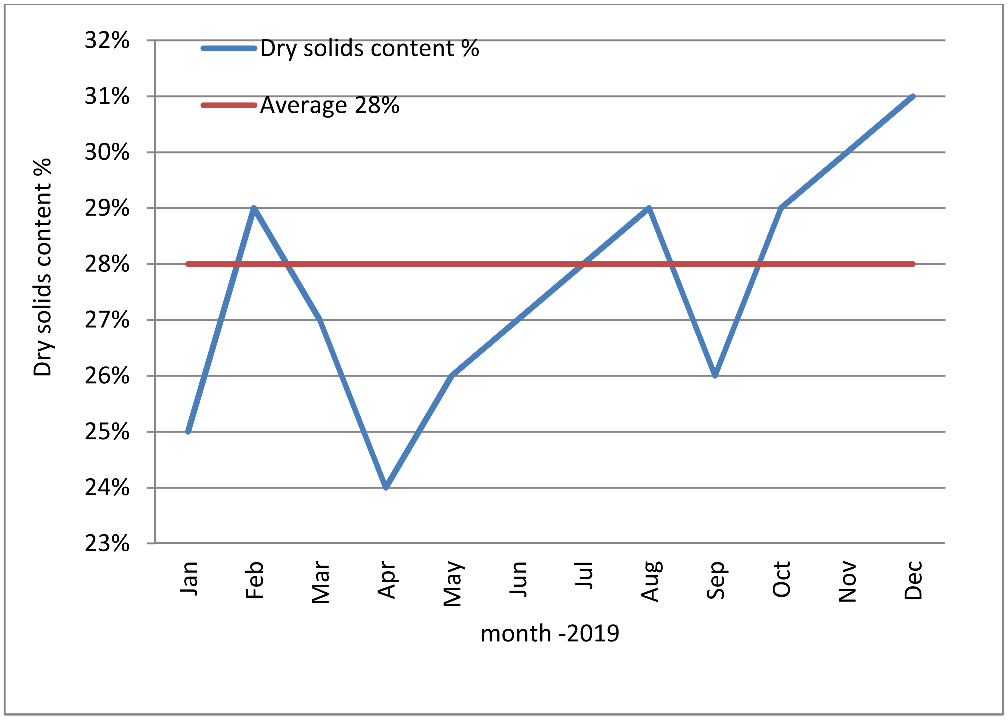


Figure (7): Dry solids content after mechanical dewatering.

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 2019, kfW funded a project to implement additional improvements on the plant. Four main improvements have been implemented and operated 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.

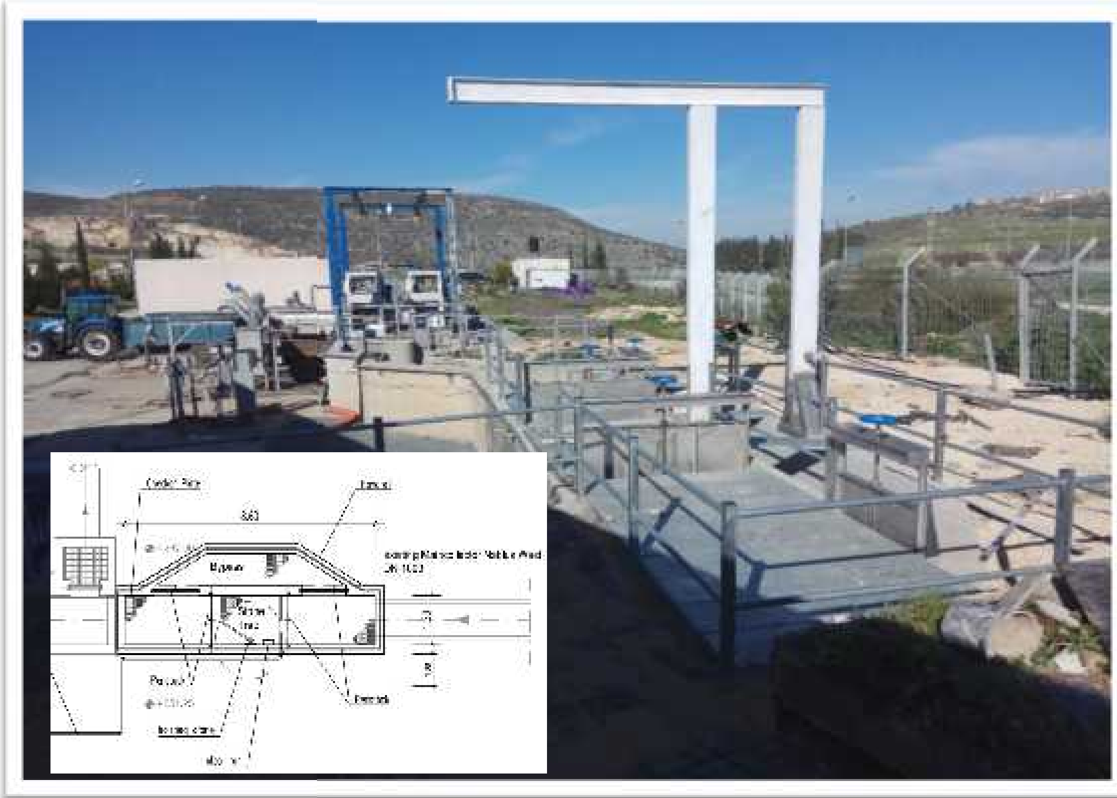


Figure (8): Stone trap at the inlet of WWTP

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 ECU coordination with Nablus WWTP, suction truck which belongs to Nablus Municipality had been worked to transport olive mills wastewater (OMW) produced from the following olive mills (Aladham from Nablus, Abu-Shadi, and Abu-laila from Qusin village). About 813 m3 have been transported and stored in OMW storage tank to be pumped into the anaerobic digester for treatment. The feeding dose rate was gradually increased from 5 to 35 m3/day. The gradual increase was aiming to alleviate the shock load to Nablus 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 49 days of feeding, which was started in 08/10/2018 and ends on 26/11/2018, the overall biogas production was increased by around 45000 Nm3/49 days which is higher than the previous year which was 12000 Nm3/month. By this increase in biogas, the CHP unit can increase the electrical production by around 117000 kWh which equals to around 58000 NIS electrical energy. No inhibition was noticed by OMW and its phenolic compounds as theoretically expected except an increase in sludge volume index of secondary settling sludge. In conclusion, Nablus municipality has followed a good strategy for disposing OMW. The disposal of OMW is now safer and vice versed the previous situation that was polluting valleys and groundwater. Not only the environmental quality is increased, also the disposal strategy is economically feasible in terms of the increasing of biogas production and electrical savings. This is considered to be one of the objectives that have been achieved by EC unit and Nablus Plant.

6.10.1 Performance comparison

In this section, comparison Table is showing the difference of the digester performance in terms of different pollution parameters. The table shows total VS load that fed to the digester and biogas production. The table compares the theoretical production of biogas for each feed type load with the real biogas production. The error was only 8% between them and related to technical issue in the flow meter of the digester feed pipe.

Feed quantity and quality of Nablus Digester during feeding of OMWW

Average	OMW	P. thickened	Excess Thickened
Volatile matter, VS (g/L)	46.9	31.9	40.7
COD (mg/L)	111472	60108	46413
Total flow pumped during OMW feeding m3	813	4474	3408
Total load kg/tot, duration	38129	142720	138722
Biogas produced per feed m3	45755.4	79923.536	31906
Total biogas produced m3	157585		
Real biogas production m3	145566		
Deficit	12019		
Percent error %	8.2		

Note: The error may relate to the malfunction of digester flow meter which disturbed by small fibers from OMW feed. The operator will dismantle it for cleaning.

6.10.2 Digester Performance evaluation

The digester reference point of operation is compared with the case after finishing OMW dosing. Alkalinity, pH, and Organic Acid, are kept at safe limits. Figure (13) shows the Difference of main pollution elements in the digester filtrate before and after the feeding season.

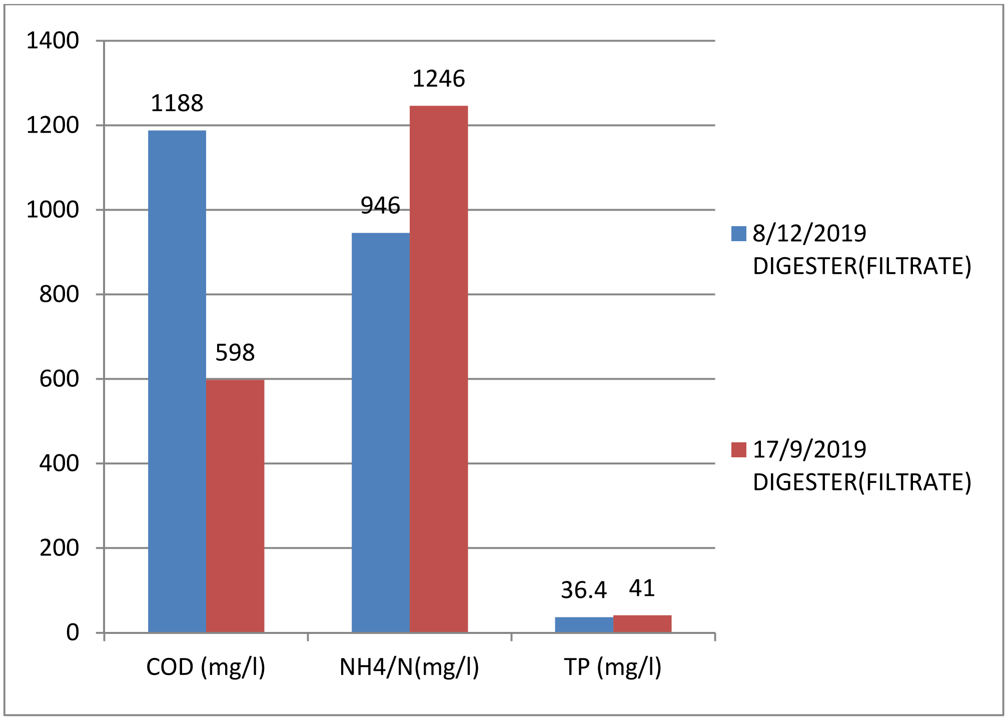


Figure (13): The behavior of qualitative parameters of Nablus plant digester

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 (14): Nablus WWTP SCADA system

8. PERFORMANCE OF WWTP

8.1 Influent flow

The performance of WWTP Nablus West during 2019 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 2019 to December 2019 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 2019 was approximately 14,570 m^3/day . The amount of incoming wastewater will increase gradually over the next years.

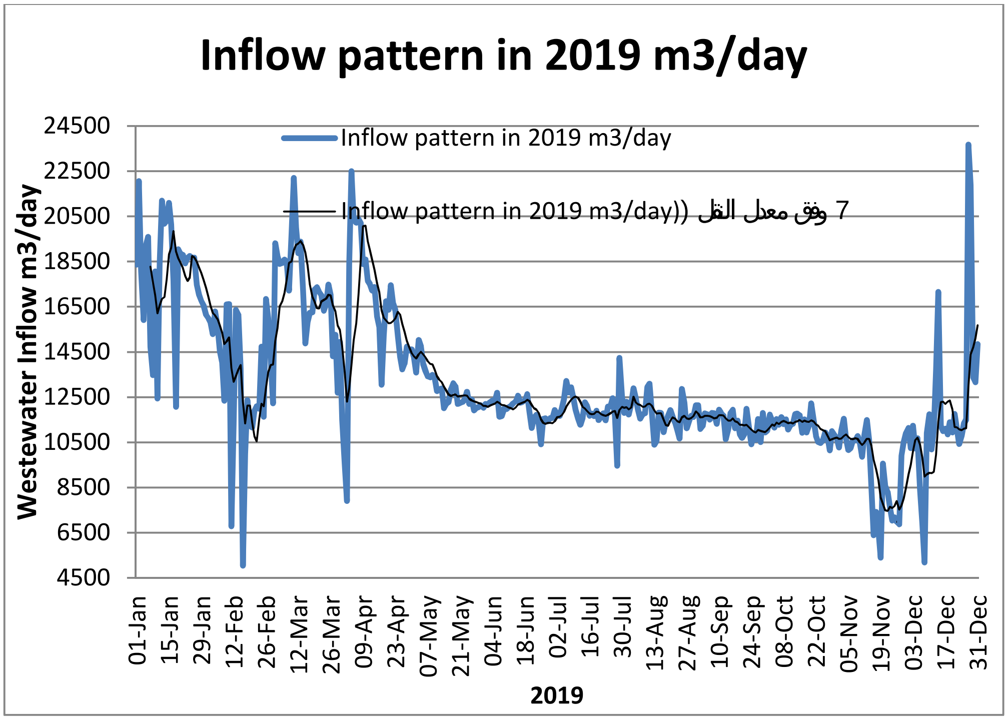


Figure (15): Hydrograph of the daily treated wastewater inflow

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 12,549 kg/d and the total COD load over the year of 2019 was 4,580,000 kg/year. The COD load at the effluent in the same period was 215,160 kg/year. The cleaning performance is approximately 96%.

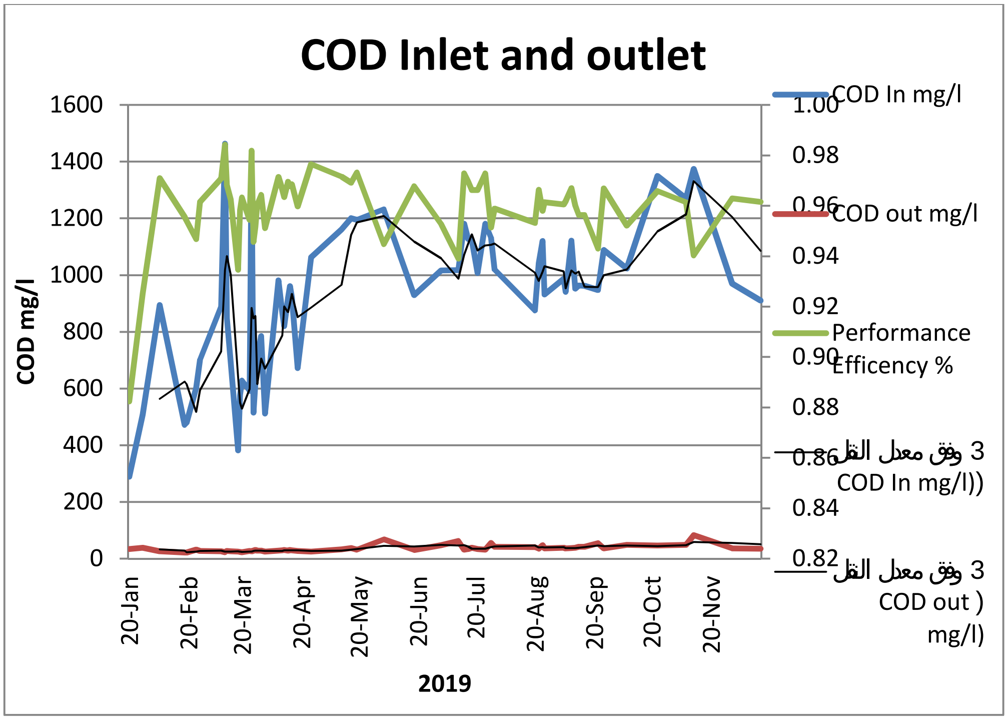


Figure (16): Influent and effluent concentration of COD

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%.

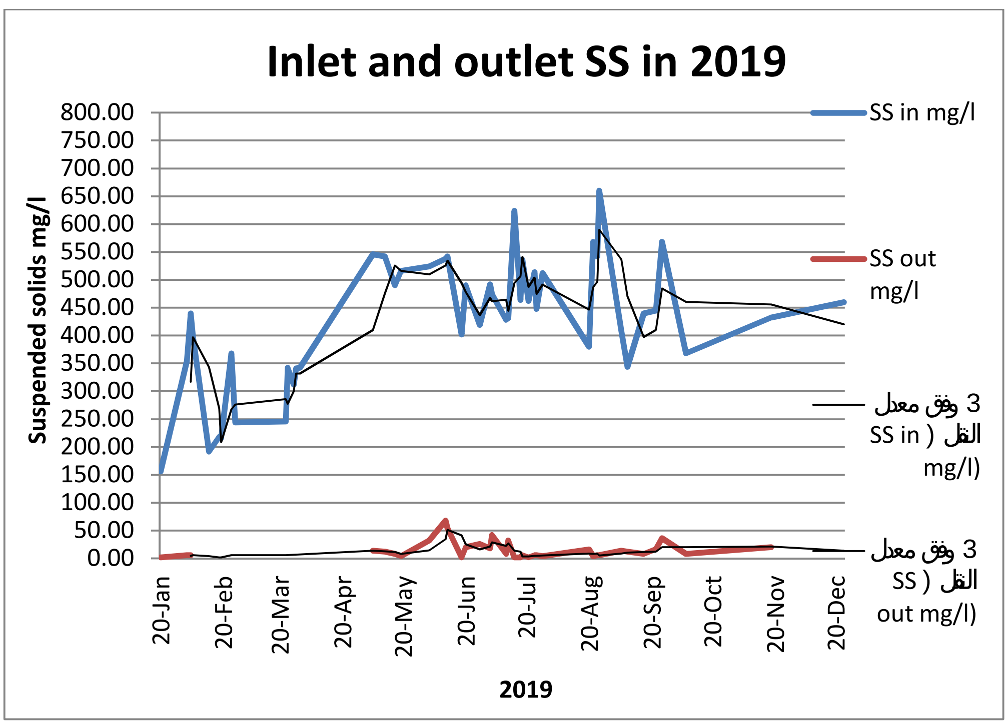


Figure (17): Suspended solids of the inlet and outlet of the treatment plant

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 the values were 0.64 kwh/m^3 and 0.71 kg/COD removed respectively. Deviations from this value can be attributed to the circumstances of daily plant operation.

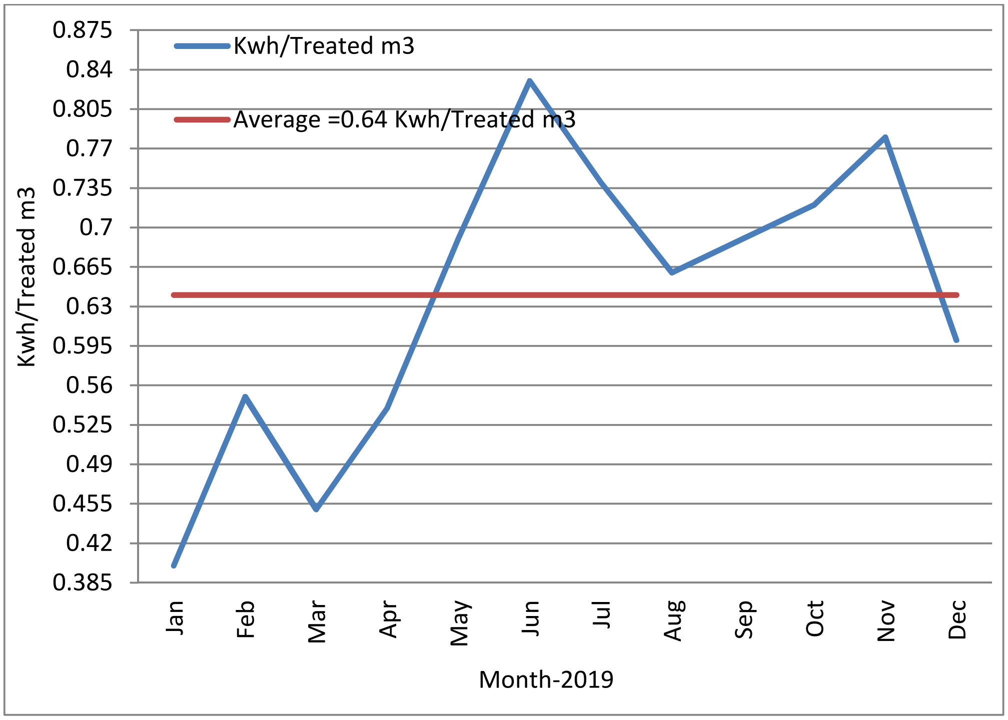


Figure (18): Monthly values of power consumption per treated m³ of wastewater

8.4 Gas production

The average gas production in 2019 was 2,003 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.

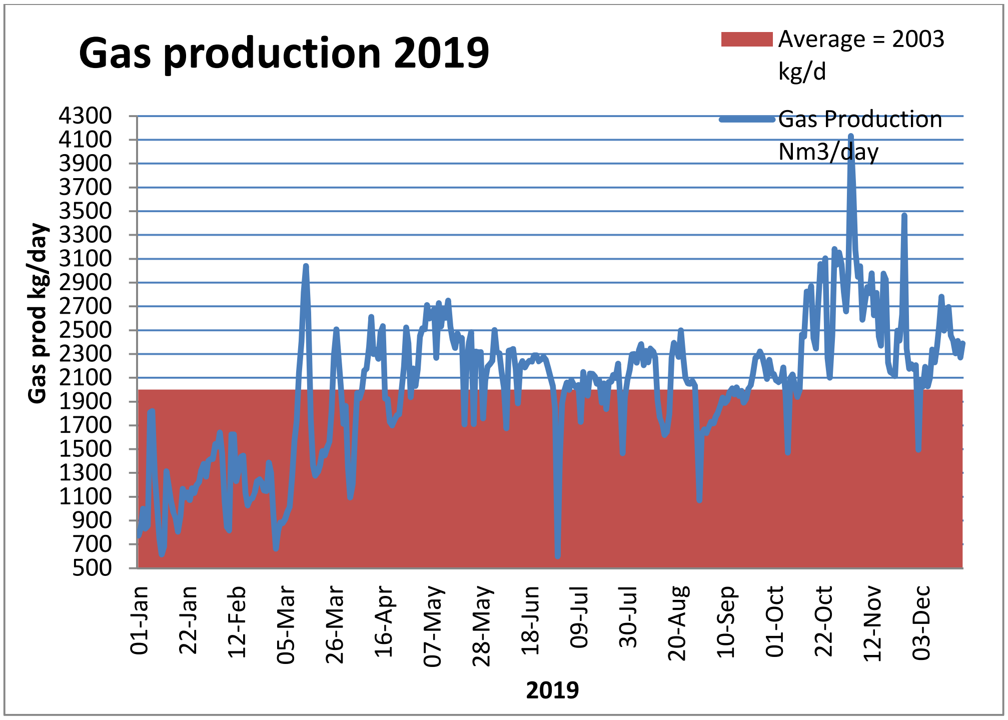


Figure (19): Gas production of the digester

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 (20): 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 (21): Nablus West CHP engine.

8.7 Nablus CHP electrical figures

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

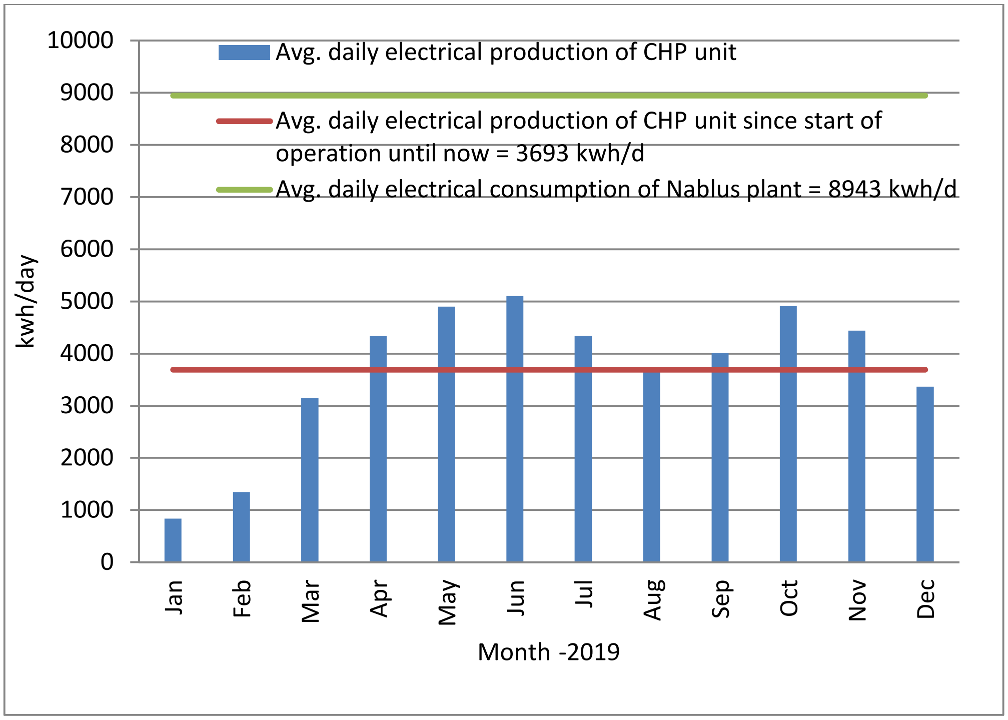


Figure (22): Electrical consumption of plant with comparison of CHP electrical production

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 maintenance operations were done in 2019 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 and theoretical training on routine and preventive maintenance of CHP and biogas bio filter for the electro mechanical staff by the Garman supplying R Schmitt Enteric co for one week trining.

11. 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 2019 was 191,122 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 (23): photovoltaic system

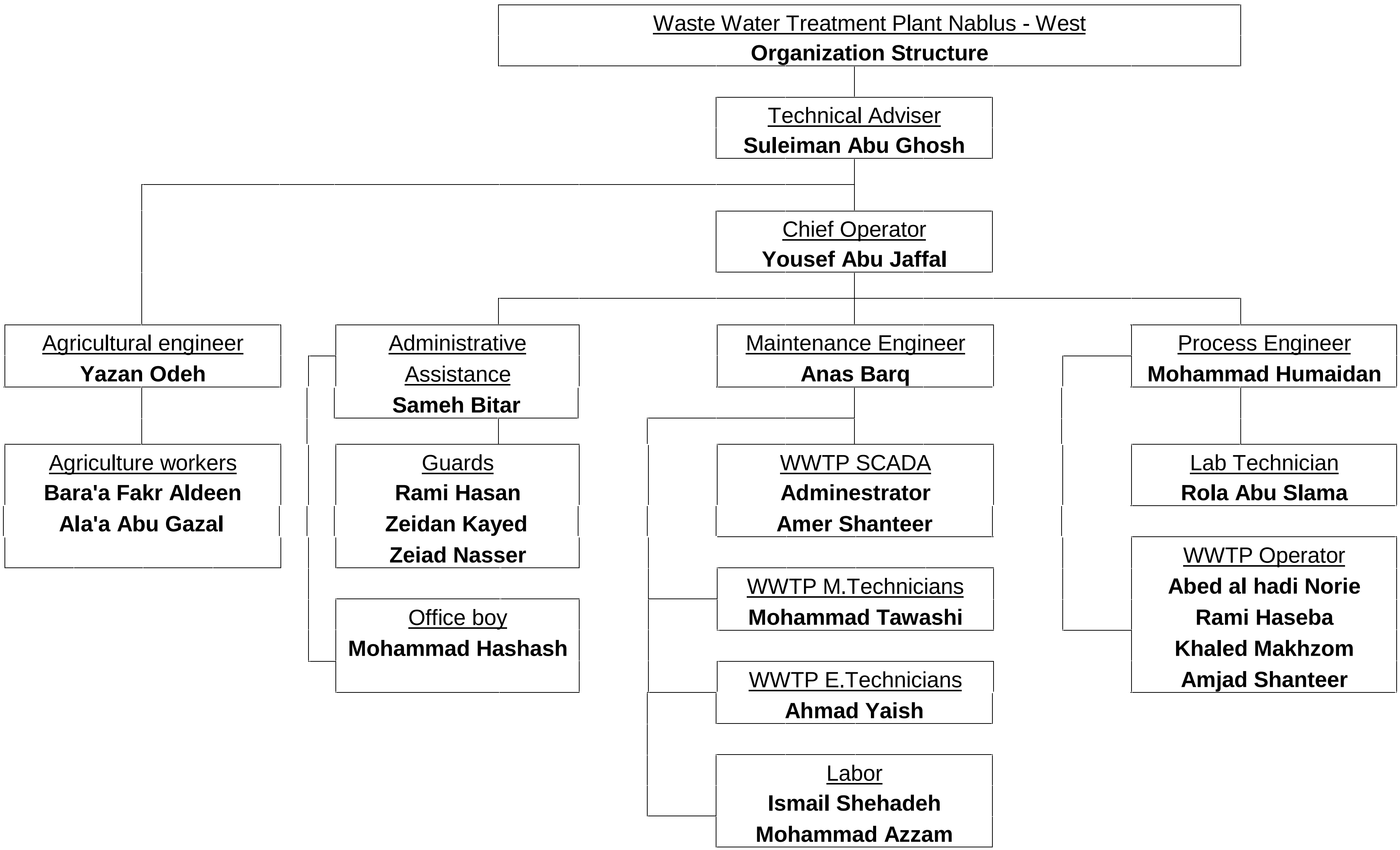
12. Future Improvements

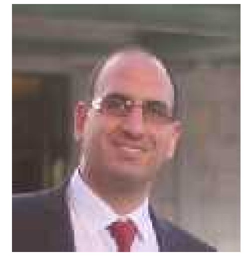
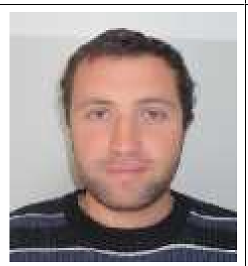
- Using of dewatered digested sludge in agriculture as pilot projects for further Investigations
- Installing more PV solar panels to increase the covering rate of the energy demand and using more renewable green energy.

13. Problems & Challenges in 2019

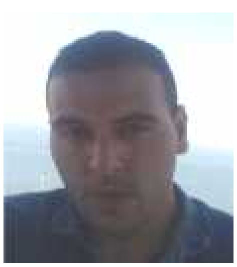
- Unavailability of spare parts in local market.
- Keep the staff of the WWTP.
- Unavailability of local maintenance companies for the gas engines
- Sludge Disposal:
  1. High Cost of sludge disposal in Zeharet Al-Fenjan at 75 NIS/ton.
  2. As per Palestinian standard, it is not allowed to reuse sludge 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
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

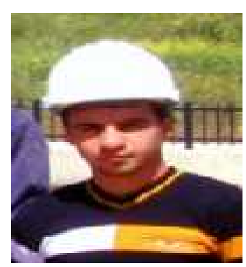
Suleiman Abu Ghosh - Technical Adviser 	Yousef Abu Jaffal -Nablus WWTP Chief Operator 
Mohammad Homeidan -Process Engineer & Lab Officer in Nablus WWTP 	Anas Barq - Electrical Engineer 
Sameh Bitar -Administrative Secretary & Accountant 	Rola Abu Slama -Lab Technician 
Amer Shanteer - WWTP SCADA Administrator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

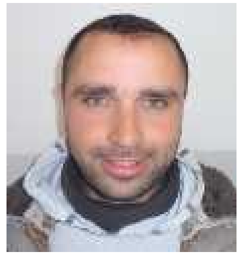
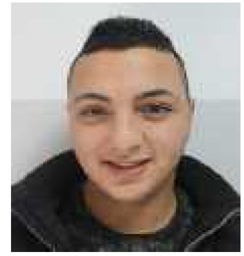
Operators

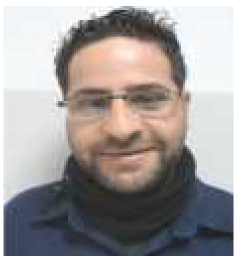
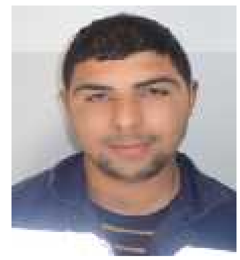

Khaled Makhzom

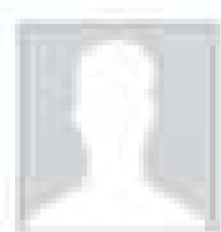

Amjad Shanteer


Rami Hasiba


Abdel hadi Norie

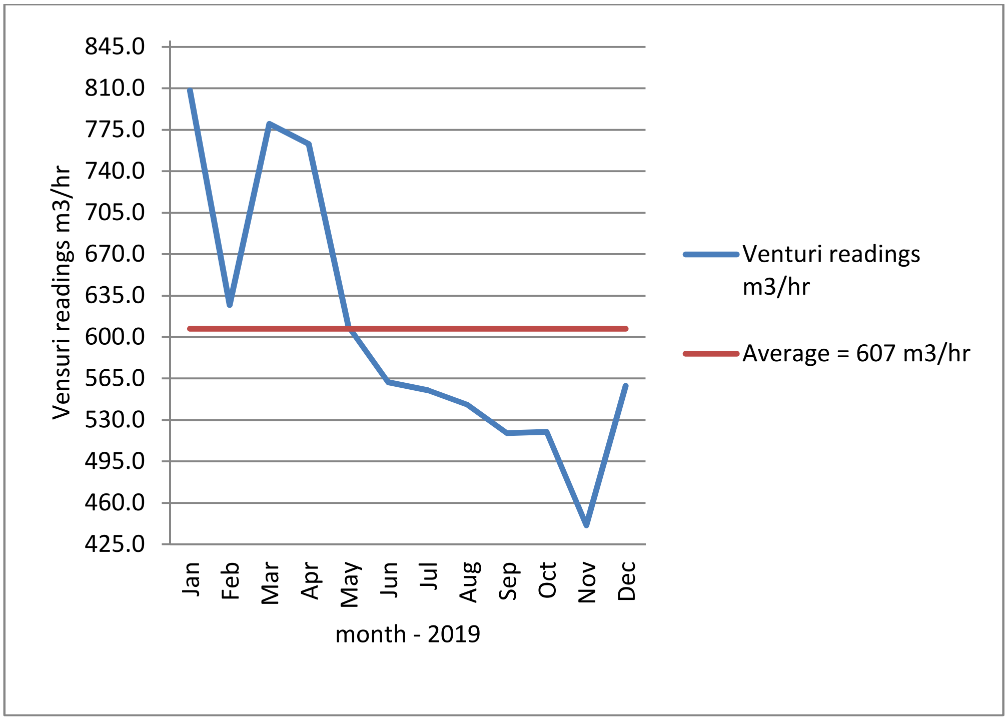
Electro mechanic Technicians		office boy
 Mohammad Tawashi	 Ahmad Yaish	 Mohammad Hashash

Labor		Agriculture	
 Mohammad Azzam	 Ismail Shehadeh	 Ala’a Abu Gazal	 Bara’a Fakrldeen

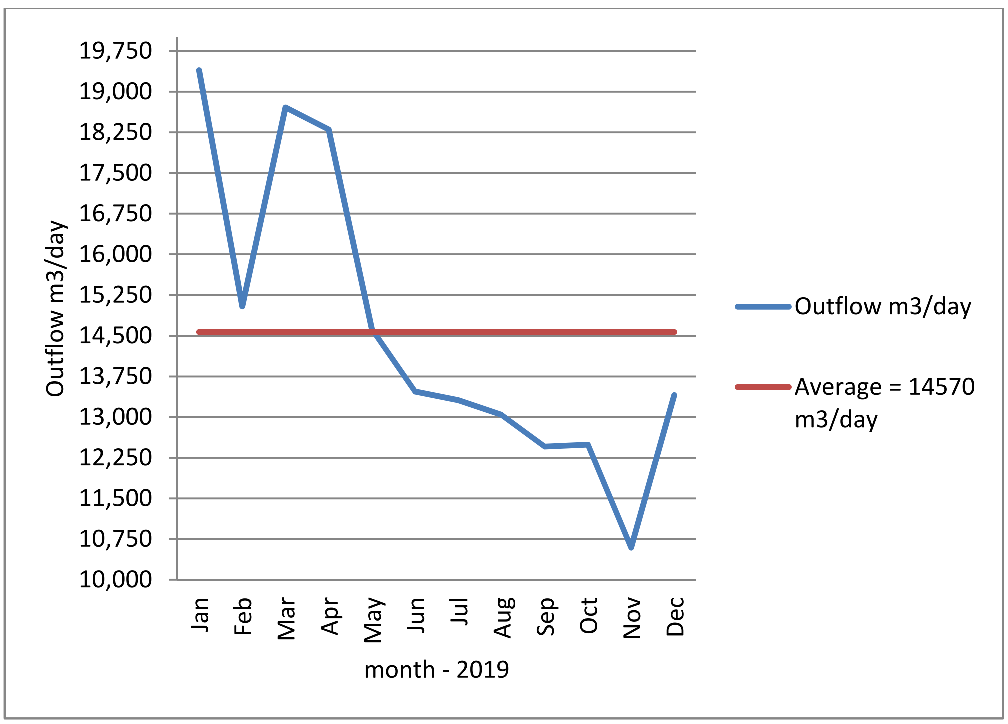
Guards		
 Rami Hasan	 Zeidan Kayed	 Zeiad Nasser

15. Annexes

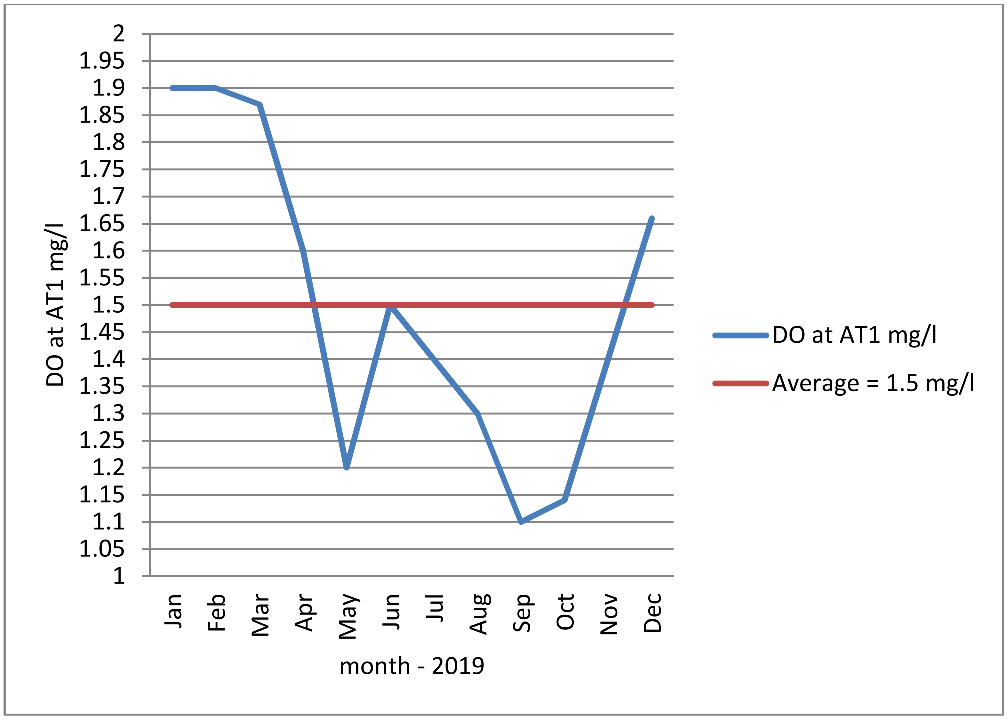
Annex 01: Graphs



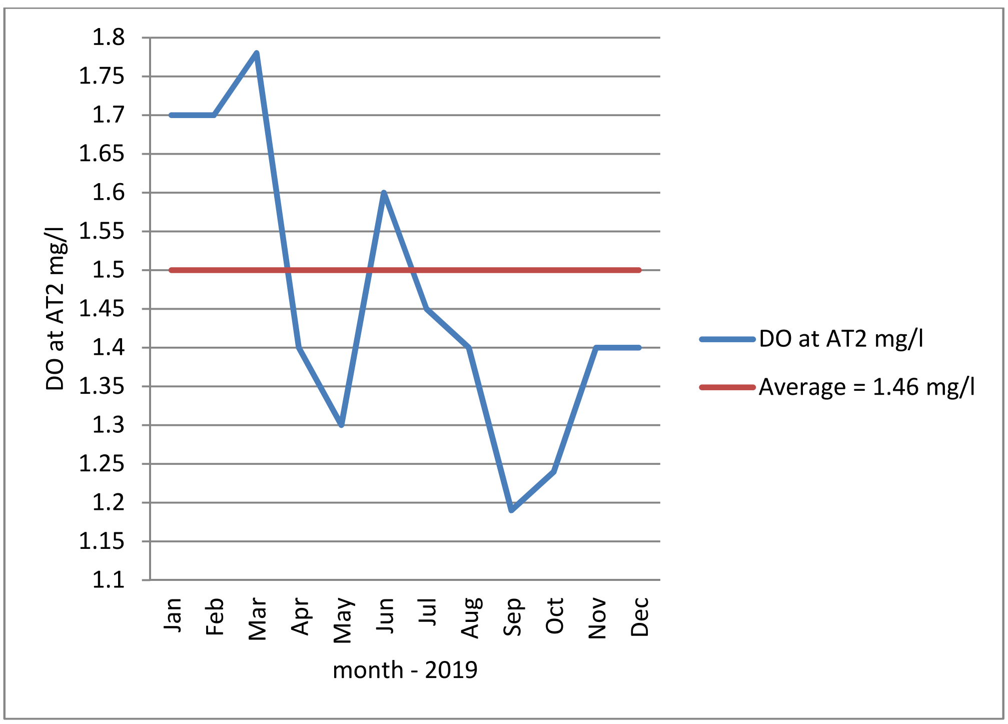
Graph 1: Average wastewater effluent



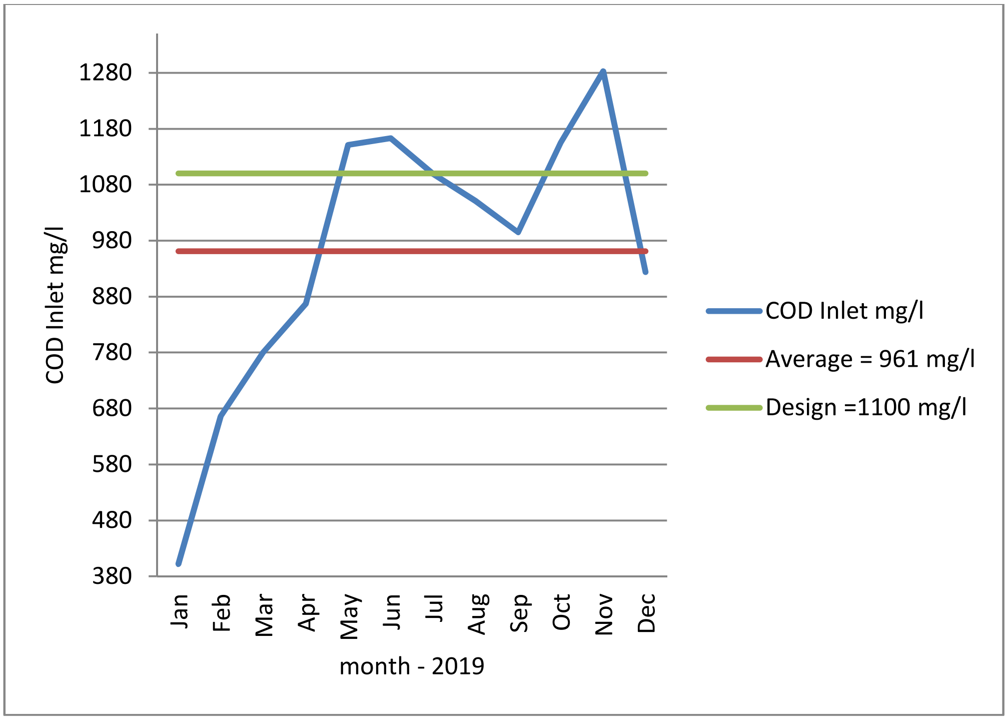
Graph 2: Average treated wastewater effluent



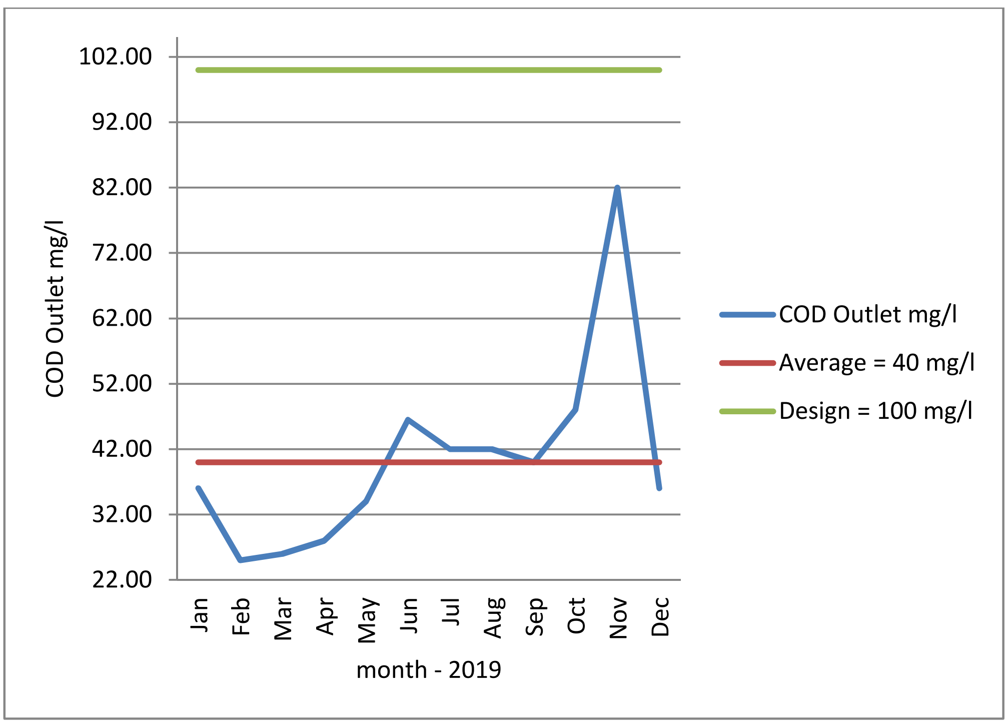
Graph 3: Monthly dissolved oxygen concentration pattern in the aeration tank no. (1)



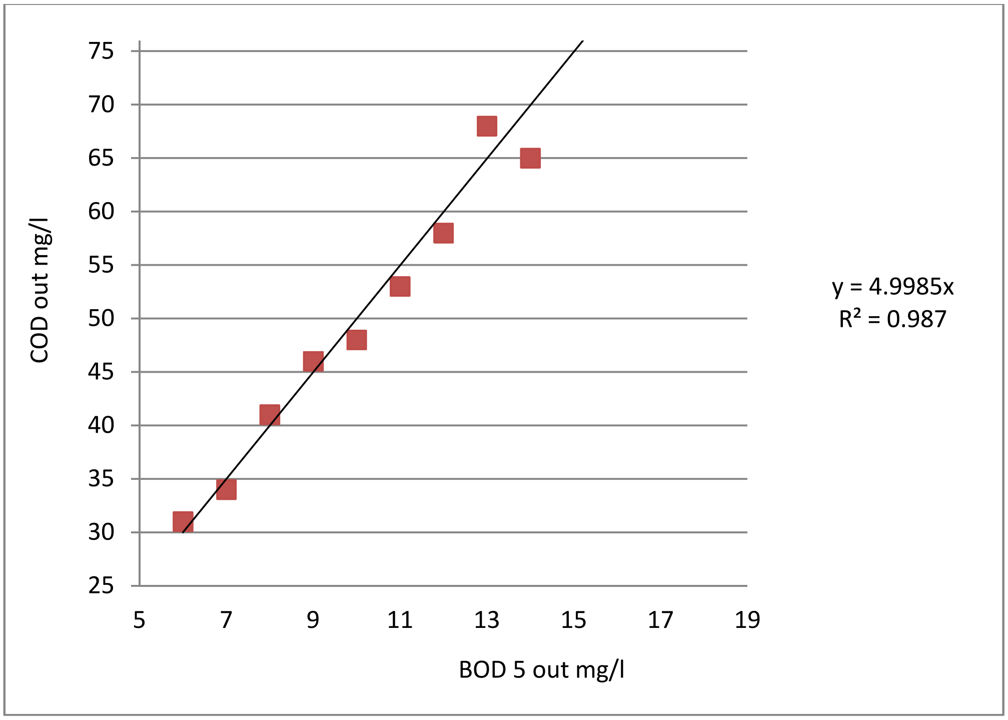
Graph 4: Monthly dissolved oxygen concentration pattern in tank no. (2)



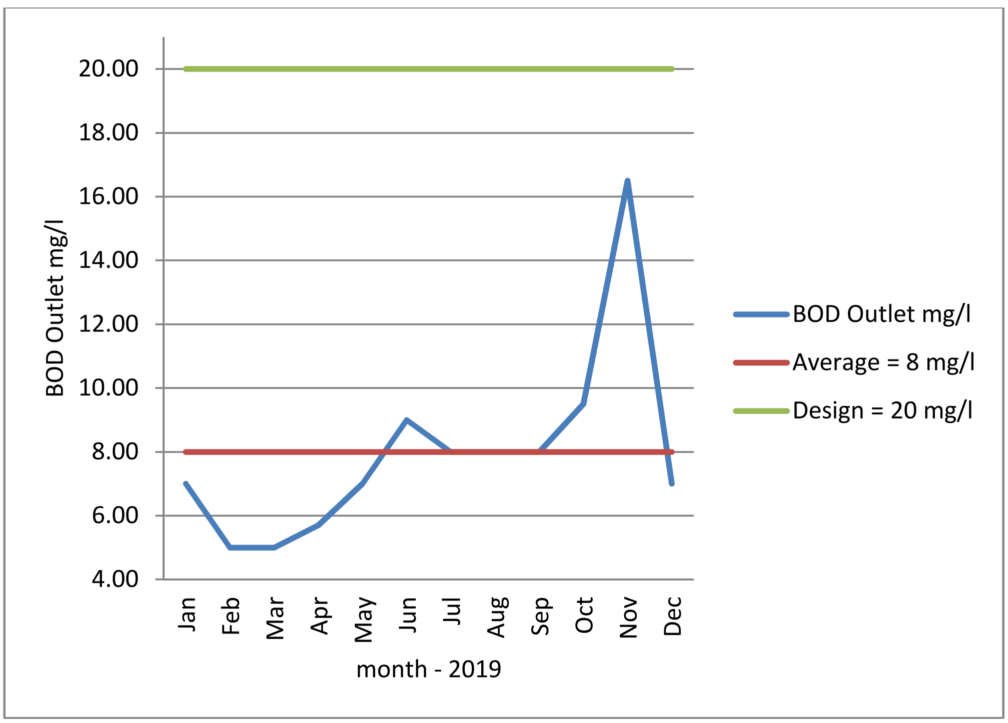
Graph 5: The COD concentration in the influent of WWTP



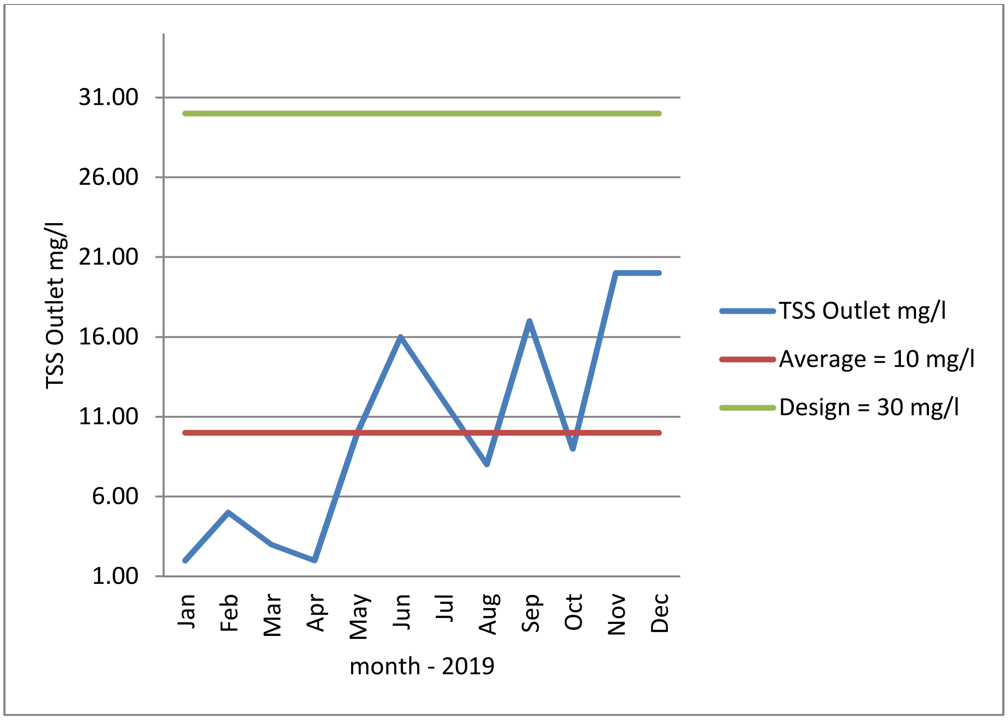
Graph 6: The COD concentration in the effluent of the treated waste water



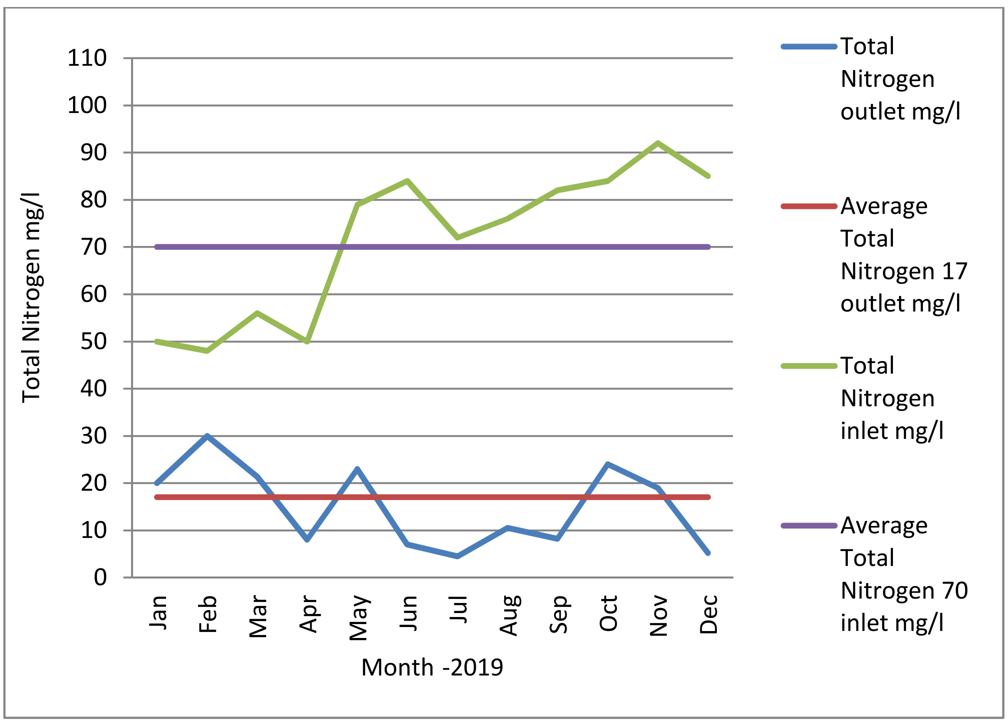
Graph 7: The correlation between COD_{out} and BOD_{5eff}



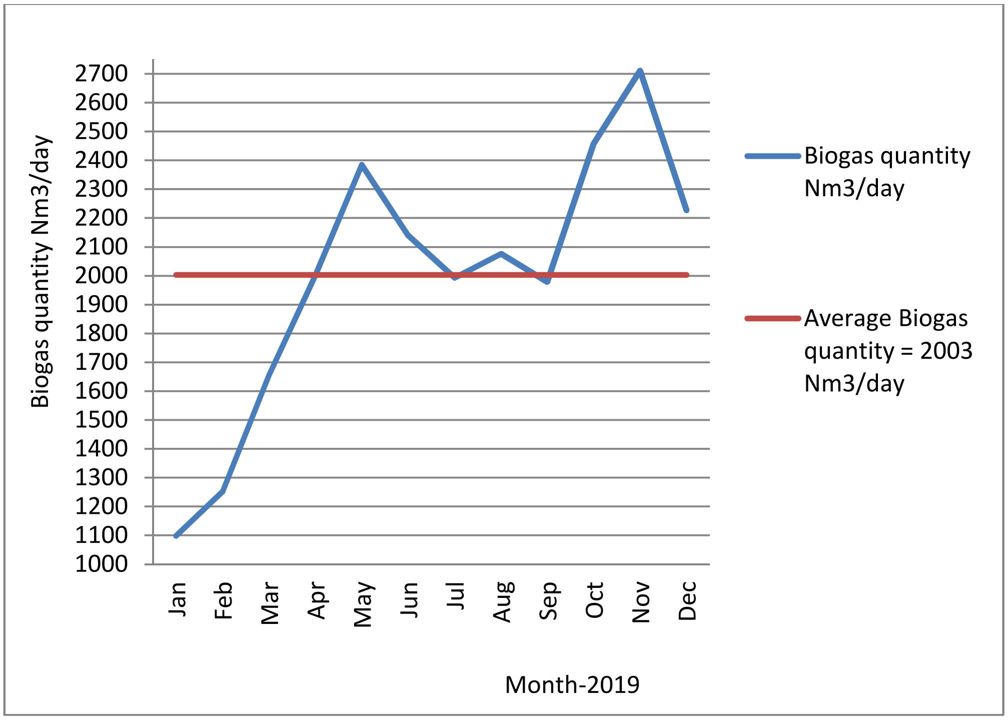
Graph 8: The BOD_5 concentration in the effluent of the treated wastewater



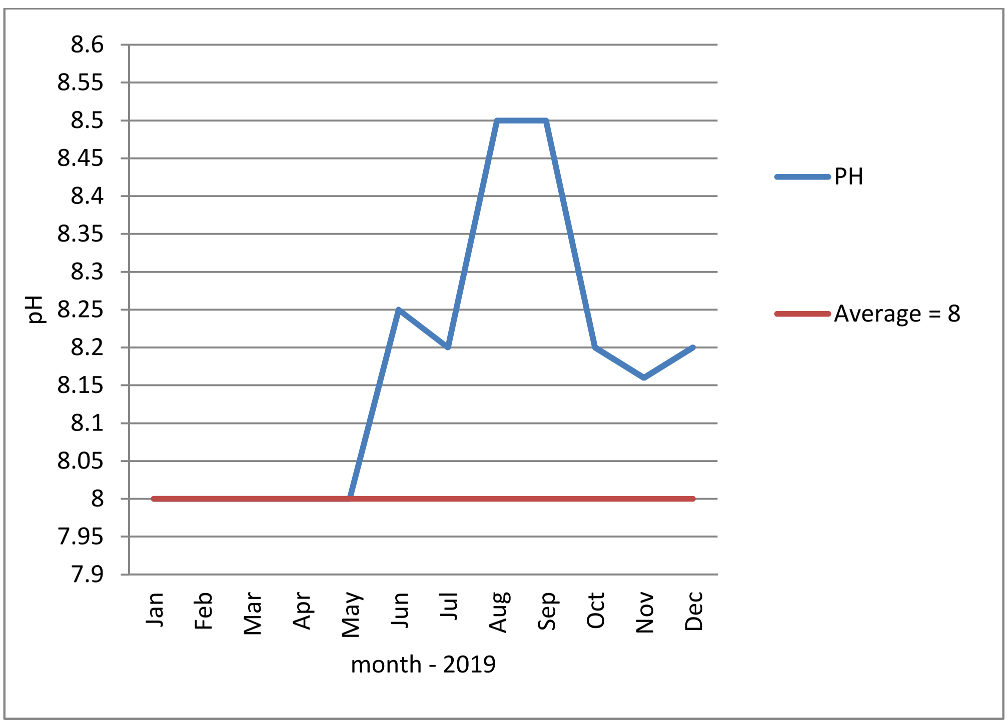
Graph 9: TSS concentration of the treated wastewater (TSS)



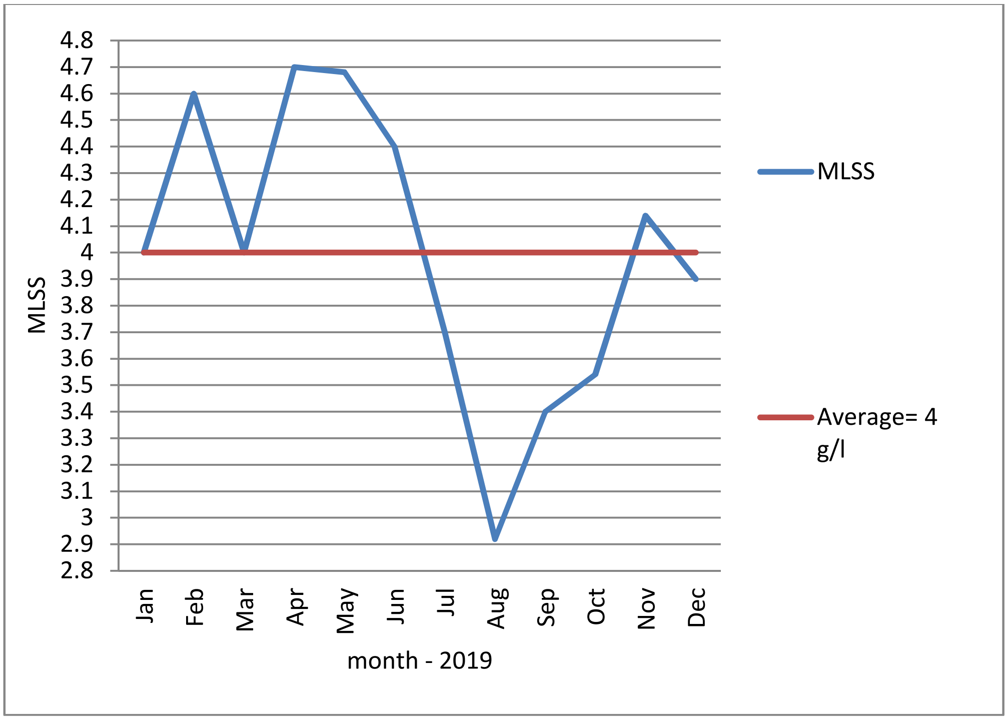
Graph 10: Total Nitrogen for influent and effluent (TN)



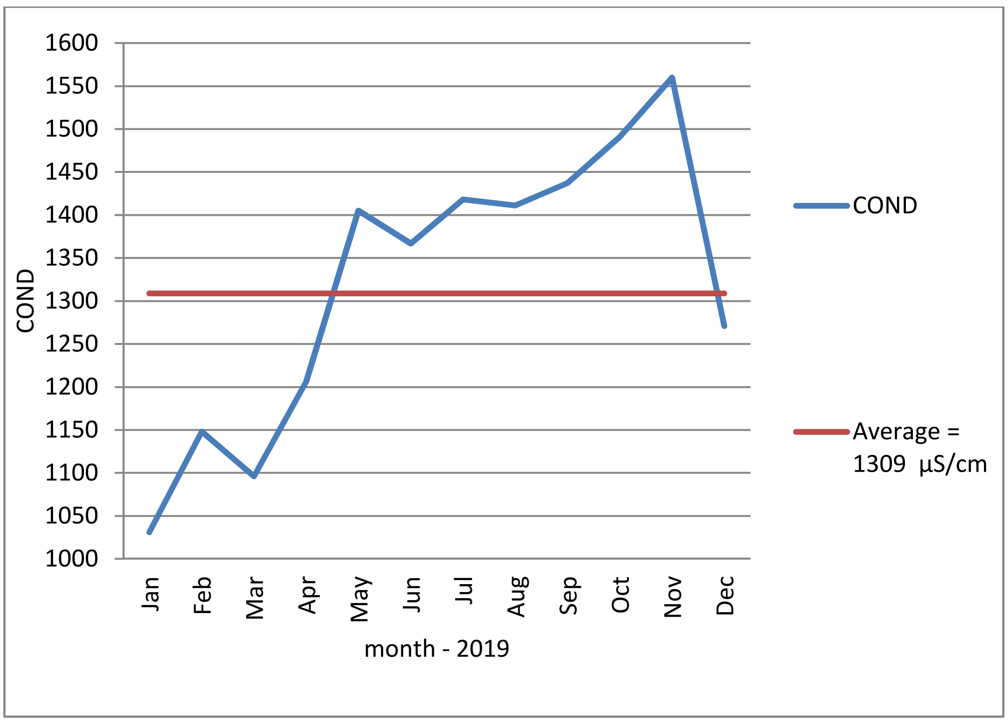
Graph 11: The average produced quantities of biogas



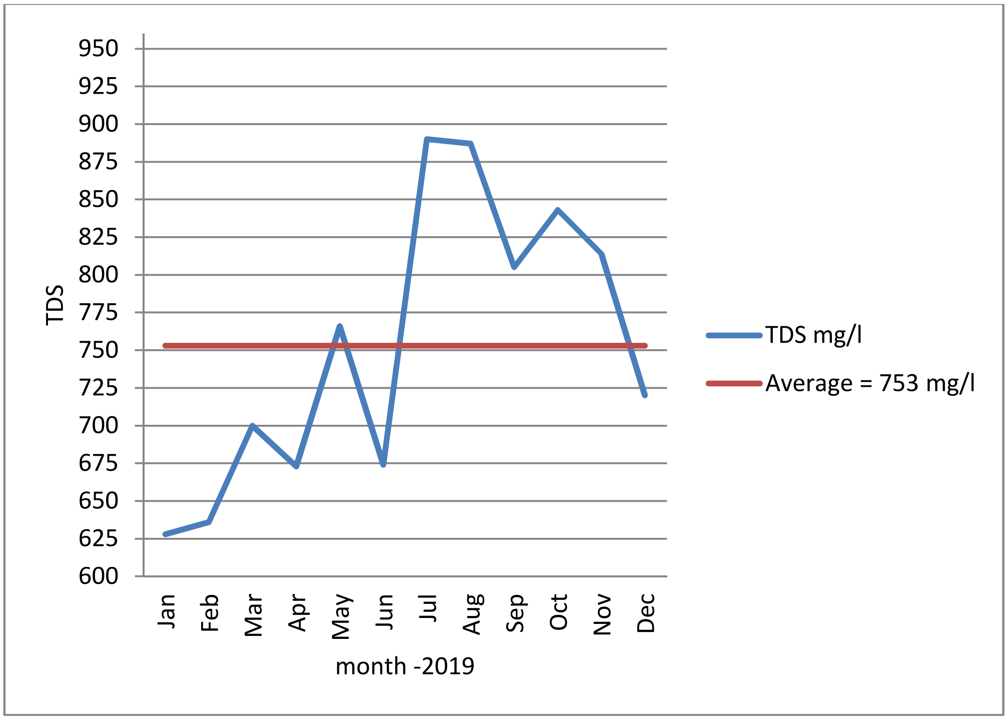
Graph 12: Average pH of the inlet wastewater



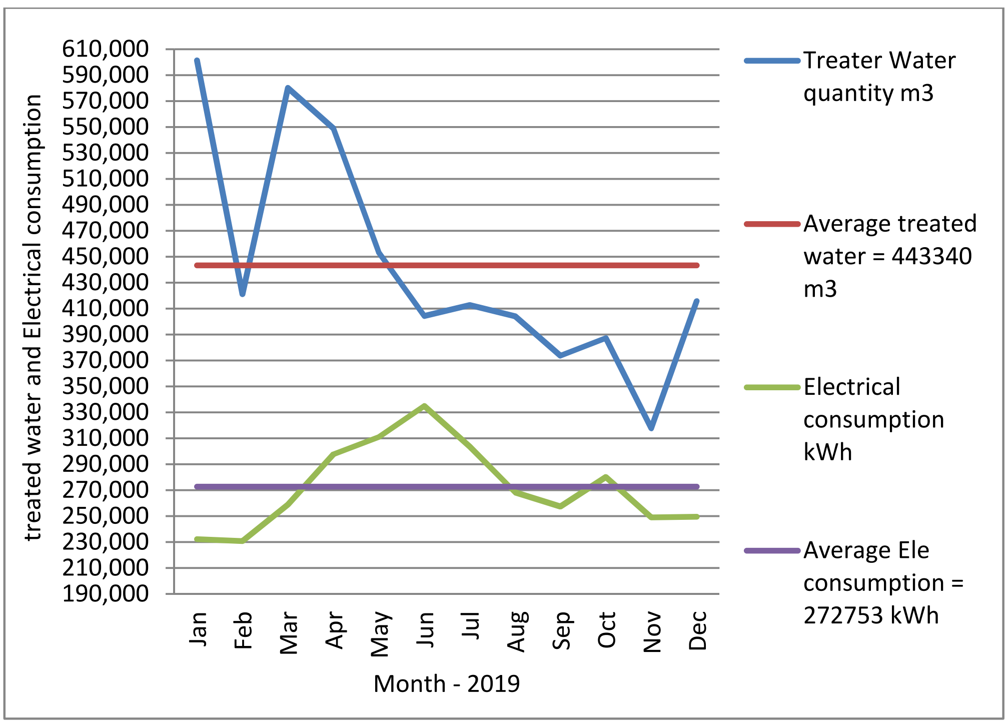
Graph 13: Mixed liquor suspended solids concentration (MLSS) in aeration tanks



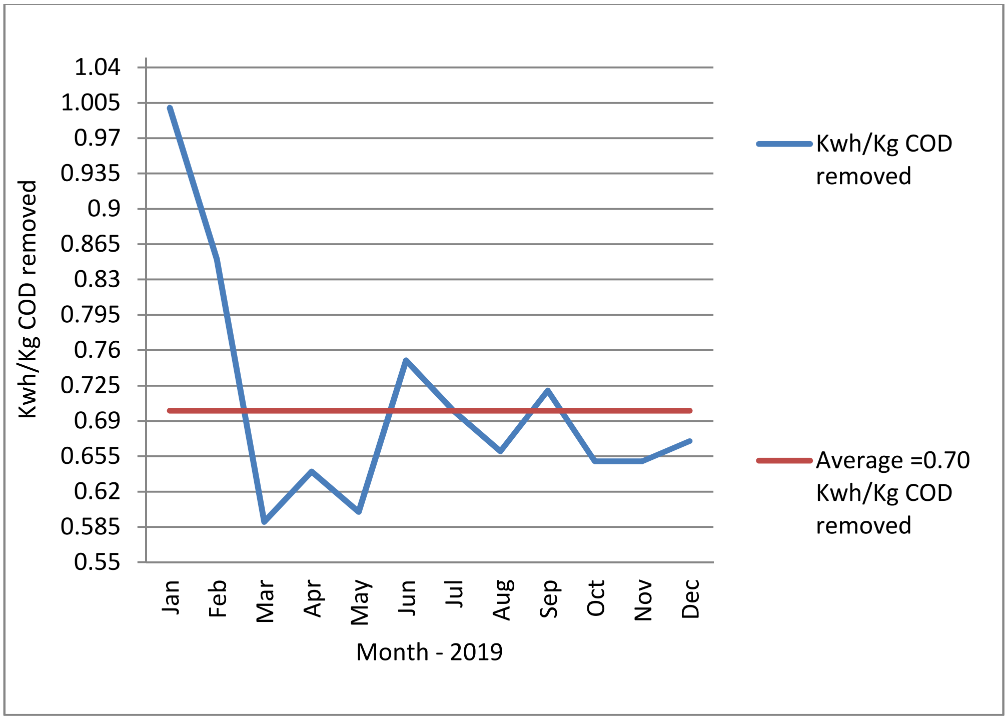
Graph 14: Conductivity of the inlet flow



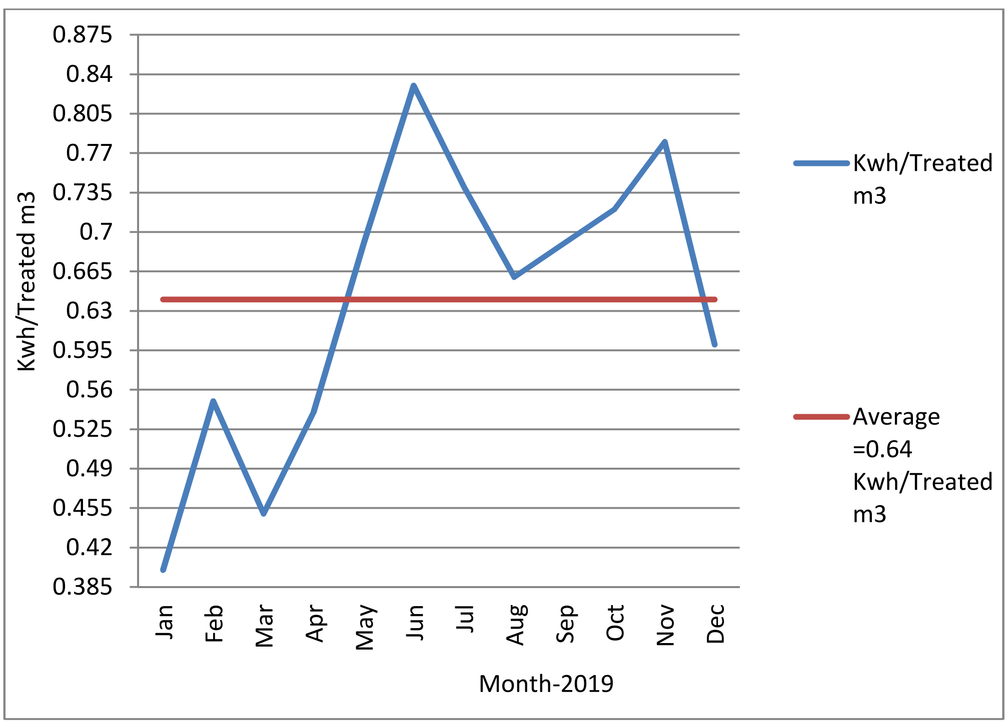
Graph 15: Total dissolved solids in the effluent



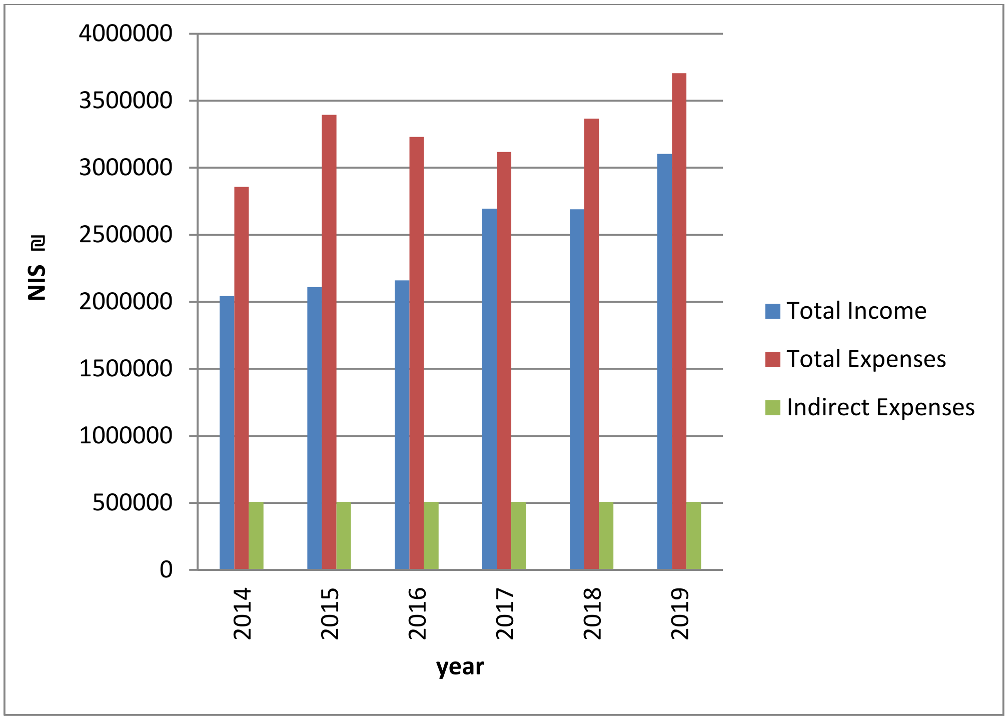
Graph 16: Average monthly treated wastewater and power consumption



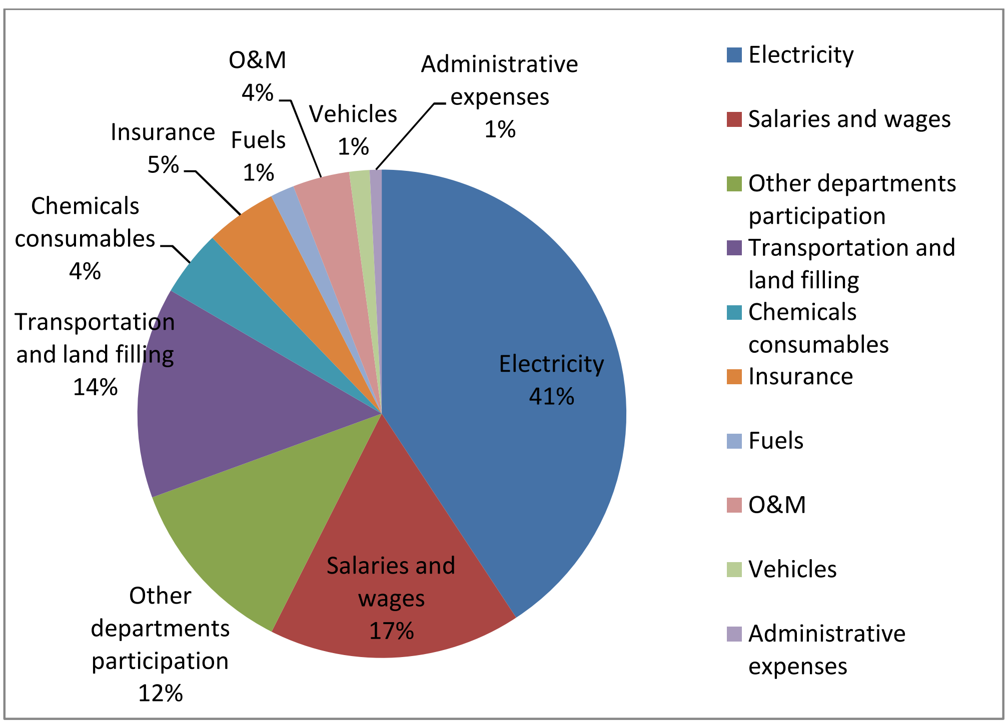
Graph 17: Power requirement kWh/kg COD treated



Graph 18: Power requirement kWh/m^3 treated



Graph 19: Expenditures versus collection



Graph 20: Expenditures breakdown 2019

Annex 02: Performance summary

Parameters	Design value 2020	Treatment % efficiency	Average	Month - 2019											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average inlet flow m^3/d	14000	-----	14570	19395	15040	18712	18303	14621	13474	13310	13038	12454	12492	10591	13409
Inlet COD mg/L	1100	-----	961	402	666	780	867	1151	1163	1099	1051	995	1155	1283	924
Outlet COD mg/L	100	96%	40	36	25	26	28	34	46.5	42	42	40	48	82	36
Outlet BOD_5 mg/L	20	98%	8	7	5	5	5.7	7	9	8	8	8	9.5	16.5	7
Inlet BOD_5 mg/L	550		476	148	332	390	434	575	582	550	525	498	578	641	462
Sludge age (days)	13.7	-----	18	15	20	19	23	24	18	14	18	15	18	16.5	20
MLSS g/L	3	-----	4	4	4.6	4	4.7	4.68	4.4	3.7	2.92	3.4	3.54	4.14	3.99
TSS_{inlet} mg/L	500		439	201	301	407	419	500	515	484	518	448	496	584	394
TSS_{outlet} mg/L	30	98%	10	2	5	3	2	10	16	12	8	17	9	20	20
kWh/kg COD	0.8	-----	0.71	1	0.85	0.59	0.64	0.6	0.75	0.7	0.66	0.72	0.65	0.65	0.67

Annex 03: Power consumption

Month	Avg	2019											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated wastewater quantity m^3	443,340	601,232	421,126	580,084	549,103	453,242	404,234	412,602	404,171	373,627	387,262	317,716	415,675
Total electrical consumption kWhr		190,709	182,507	147,150	149,700	137,370	160,386	145,962	133,144	122,497	119,164	105,323	140,188
PV electrical production kWhr	272,753	15,482	10,523	14,143	18,000	21,500	21,361	23,130	20,190	14,511	13,417	10,520	8,345
production CHP electrical kWhr		26,023	37,637	97,620	130,000	152,000	153,118	134,558	114,860	120,462	147,440	133,099	100,999
kWhr per m^3	0.64	0.39	0.55	0.45	0.54	0.69	0.83	0.74	0.66	0.69	0.72	0.78	0.60

Annex 04: Additional lab Tests in WWTP Lab

/ Test	Values	Average	2019											
			Dec	Nov	Oct	Sep	Aug	Jul	Jun	May	Apr	Mar	Feb	Jan
COD out mg/l	Average	40.5	36.00	82.00	48.00	40.00	42.00	42.00	47.00	34.00	28.00	26.00	25.00	36.00
	Max	47.8	36.00	84.00	49.00	54.00	51.00	62.00	68.00	37.00	32.00	30.00	32.00	38.00
	Min	35.8	35.00	80.00	46.00	36.00	35.00	32.00	30.00	32.00	25.00	23.00	21.00	34.00
BOD out mg/l	Average	8.0	7.00	16.50	9.50	8.00	8.00	8.00	9.00	7.00	5.70	5.00	5.00	7.00
	Max	9.5	7.20	17.00	9.80	11.00	10.00	12.00	14.00	7.40	6.40	6.00	6.00	7.00
	Min	7.1	7.00	16.00	9.20	7.00	7.00	6.00	6.00	6.40	5.00	4.60	4.00	7.00
NH4-N out mg/l	Average	1.4	0.60	7.80	0.70	0.60	0.00	0.25	0.15	4.80	0.65	0.20	0.50	0.00
	Max	2.1	0.60	14.40	0.70	0.60	0.00	0.30	0.20	6.90	0.90	0.20	0.50	0.00
	Min	0.6	0.60	1.20	0.70	0.60	0.00	0.20	0.10	2.70	0.40	0.20	0.50	0.00
NO3-N out mg/l	Average	9.1	5.00	12.50	0.00	6.25	7.75	7.50	2.70	14.75	12.00	12.80	28.20	0.00
	Max	11.1	5.00	12.90	0.00	7.10	7.80	14.00	2.70	15.60	18.00	22.40	28.20	0.00
	Min	7.3	5.00	12.10	0.00	5.40	7.70	3.50	2.70	13.90	4.00	5.20	28.20	0.00
TN out mg/l	Average	14.5	5.20	19.00	24.00	8.25	10.50	4.50	7.00	23.00	8.00	14.50	30.00	20.00
	Max	16.0	5.20	19.00	24.00	8.50	11.00	5.00	10.00	27.00	8.00	24.00	30.00	20.00
	Min	12.7	5.20	19.00	24.00	8.00	10.00	4.00	4.00	18.00	8.00	2.00	30.00	20.00
PO4-P out mg/l	Average	4.2	4.45	5.45	3.41	3.58	2.00	1.76	4.60	4.90	8.40	9.10	3.30	0.00
	Max	4.3	4.45	5.45	3.41	3.58	2.00	1.76	4.60	4.90	8.40	9.10	3.60	0.00
	Min	4.2	4.45	5.45	3.41	3.58	2.00	1.76	4.60	4.90	8.40	9.10	3.00	0.00
TSS out mg/l	Average	10.4	20.00	20.00	9.00	17.00	8.00	12.00	16.00	10.00	3.00	3.00	5.00	2.00
	Max	17.2	20.00	20.00	10.00	36.00	16.00	42.00	32.00	14.00	3.00	5.00	6.00	2.00
	Min	6.4	20.00	20.00	8.00	8.00	4.00	2.00	2.00	4.00	3.00	2.00	2.00	2.00
MLSS mg/l	Average	4.0	3.90	4.14	3.54	3.40	2.92	3.70	4.40	4.68	4.70	4.00	4.60	4.00
	Max	4.6	4.30	4.71	4.26	3.90	3.36	4.50	5.00	5.35	5.30	4.00	5.40	5.00
	Min	3.4	3.50	3.40	3.11	2.80	2.55	3.00	3.60	4.19	4.00	4.00	3.80	3.00