State of Palestine
Nablus Municipality

دولـــة فلسطين
بلديــة نابلس

Wastewater Treatment Plant

Nablus West

Operation Report

of Year 2014

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1 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. The allocated fund reached to **32.00** 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 intersection. The wastewater is collected from Nablus West and five villages namely Zawata, Beit Eba, Beit Wazan, Deir Sharaf and Qusin in the future by gravity.

Nablus West catchment area presently has a population of about 130.000. 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 Zeimar
- Protect the surface and ground 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 taking over certificate to the contractor the JV of Kinetics- Passavant Reodiger (KPR) on September 23^{th,} 2013.

Operation assistance 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 is expected to be completed in November 2015.

2 General Overview

Three Millions Four Hundred Eighty Thousands and Three Hundred Eighty One 3, 480,381 cubic meters of wastewater were treated in the year 2014, with an electrical consumption of two millions two hundred sixty nine thousands and nine hundred ninety four 2,269,994 kW/hr. During last year, in general the average lab results were in line with the agreed standards. The average concentration of BOD_5 was 22 mg/l and TSS was 30 mg/l. By these results, the treatment efficiency in terms of BOD_5 and TSS were 95.5% and 93% respectively.

3 Yearly Data

3.1 WWTP inflow

The average inflow in 2014 was 290,032 m3/month. These readings were measured at the inlet channel of the plant by a venture meter. Figure (1) explains the daily pattern readings from the plant in a certain day of December 2014

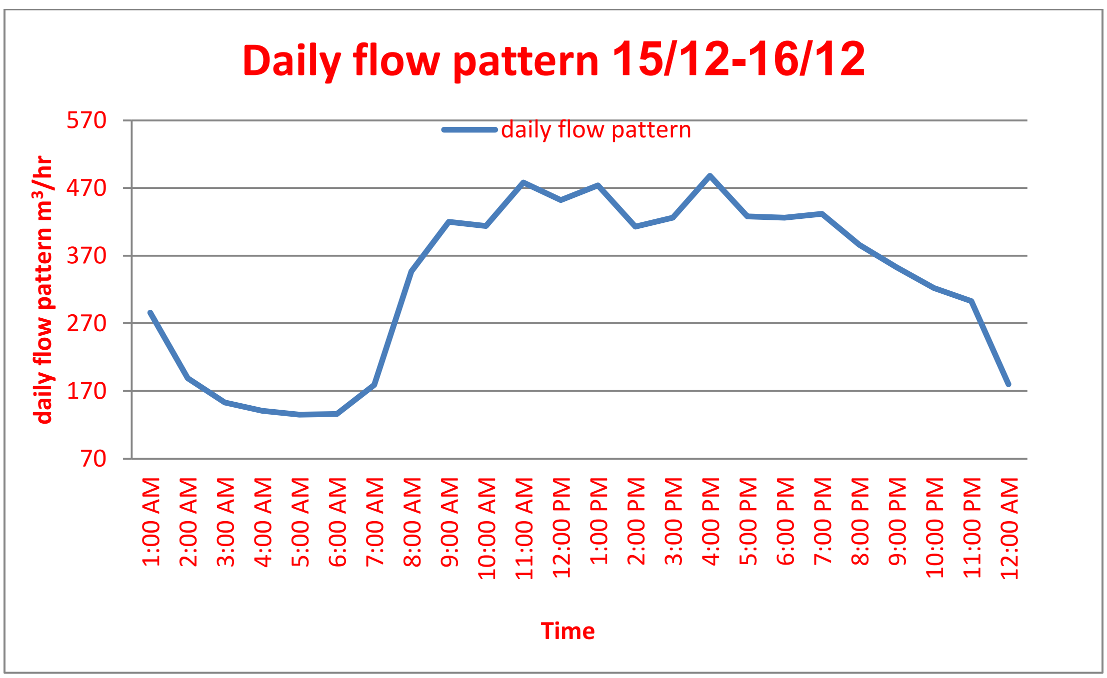

Figure (1): The daily flow pattern in 15/12-16-12

Figure (2) explains the average wastewater influent in m^3/hr in 2014 months taken from SCADA reports.

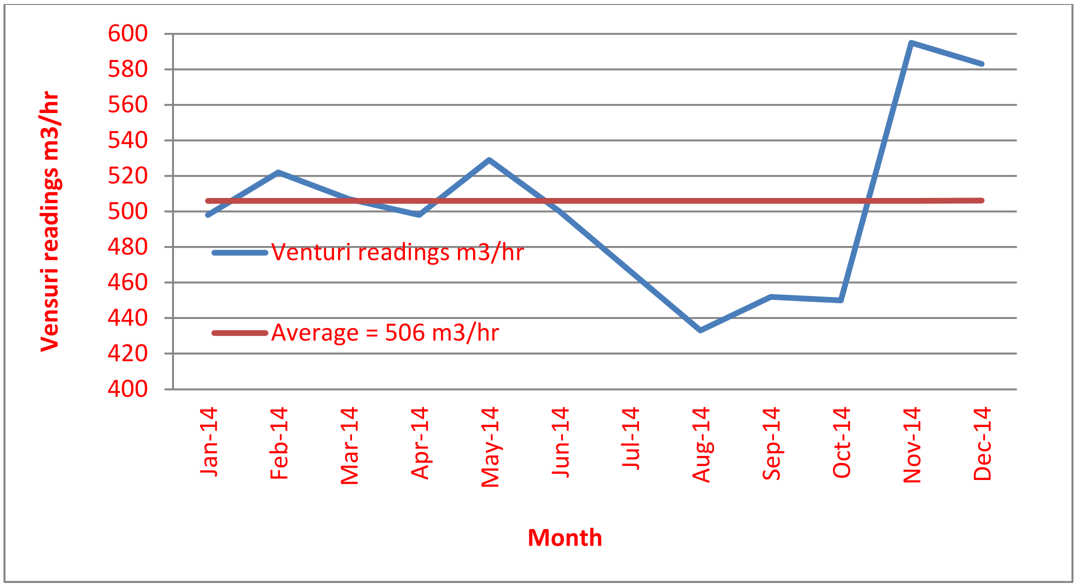

Figure (2): Average wastewater influent in (Jan – Dec) 2014

Figure (3) explains the average wastewater outflow in m^3/day in 2014 months taken from SCADA reports.

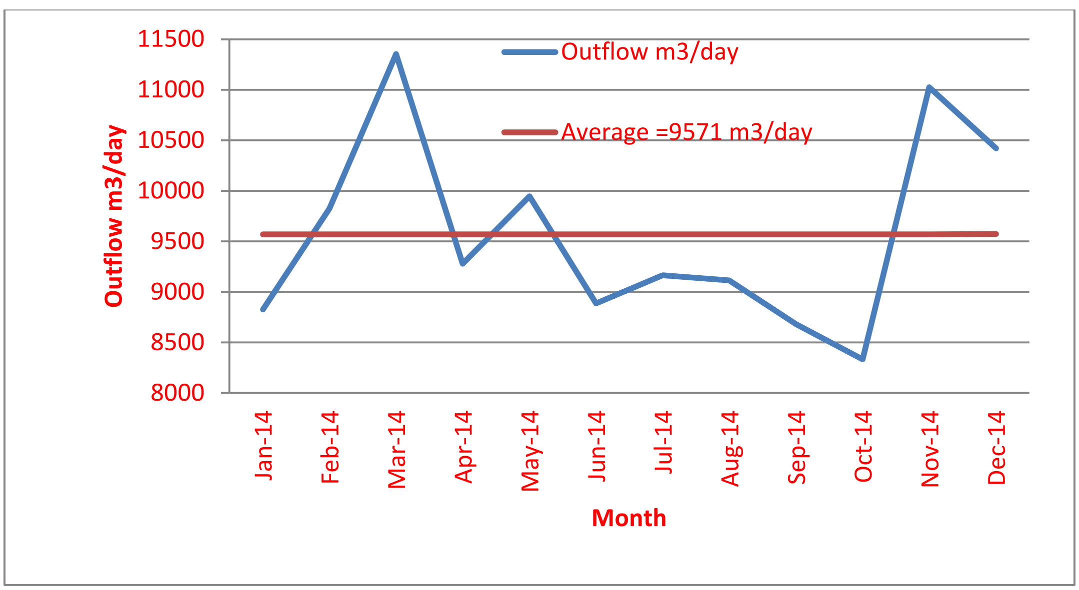

Figure (3): The average treated effluent (Jan – Dec) 2014

3.2 Dissolved oxygen in the aeration tank

Figure (4) explores the dissolved oxygen concentration in aeration tank no. (1)

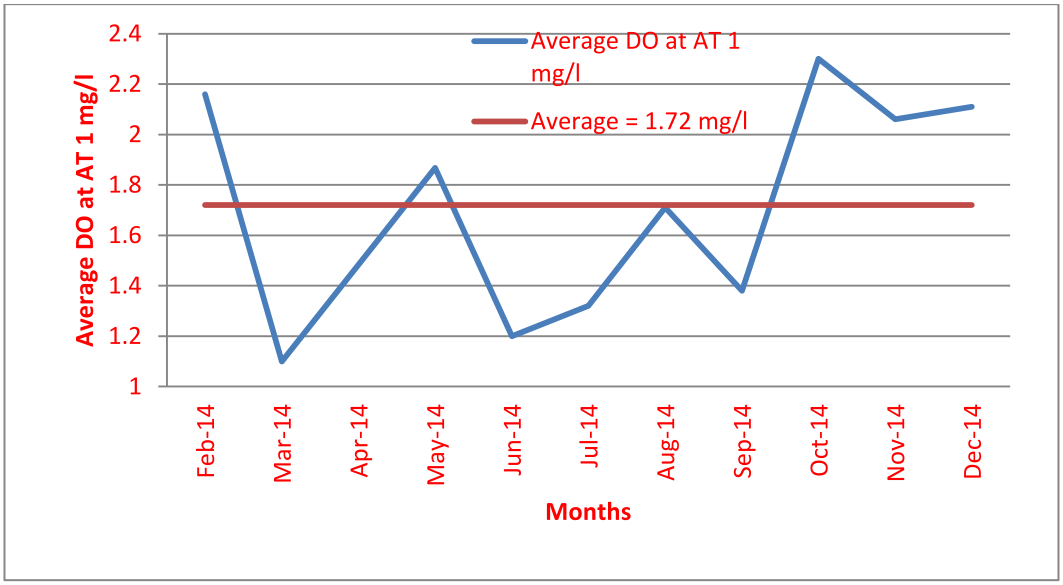

Figure (4): Daily dissolved oxygen concentration pattern in the aeration tank no. (1)

3.3 Dissolved oxygen in aeration tank

Figure (5) explores the dissolved oxygen concentration in aeration tank no. (2). This tank was put again into operation in 23/11/2014 to tackle high hydraulic load of water during winter season.

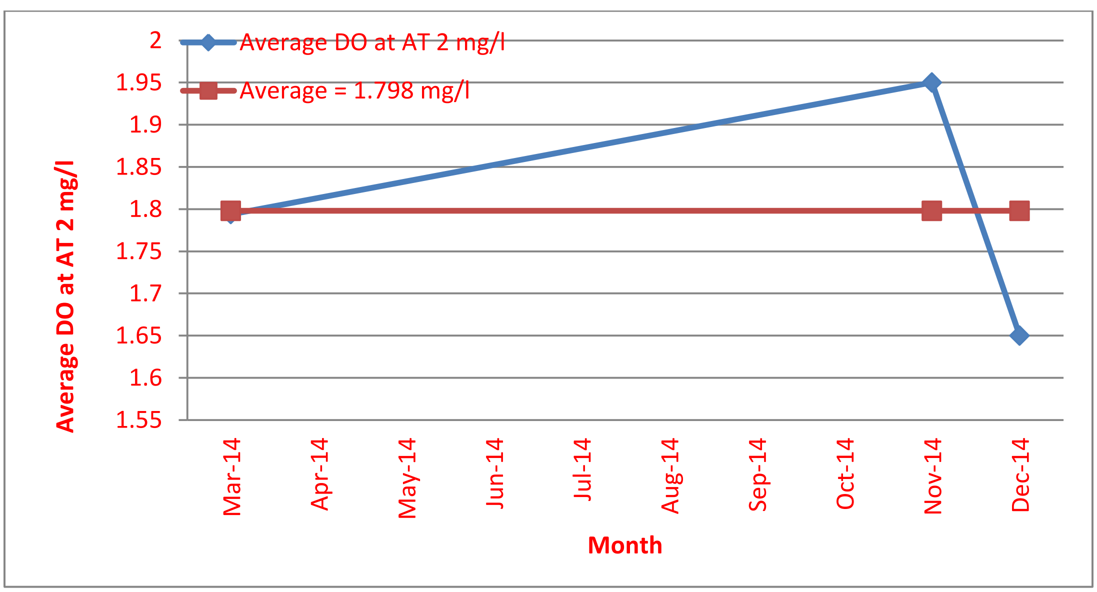

Figure (5): Daily dissolved oxygen concentration pattern in tank no. (2)

4 Quality Control/WWTP Lab Tests

Figure (6) depicts the average influent concentration of COD_{in} in 2014.

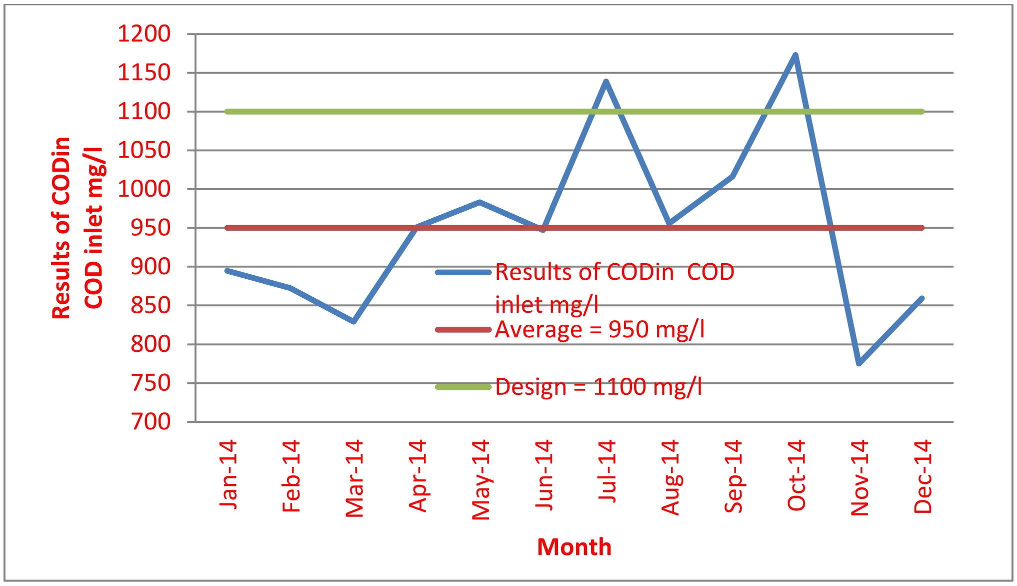

Figure (6): The COD concentration in the influent of WWTP in 2014

Figure (7) shows the average concentration of COD_{out} which is treated in the plant during 2014.

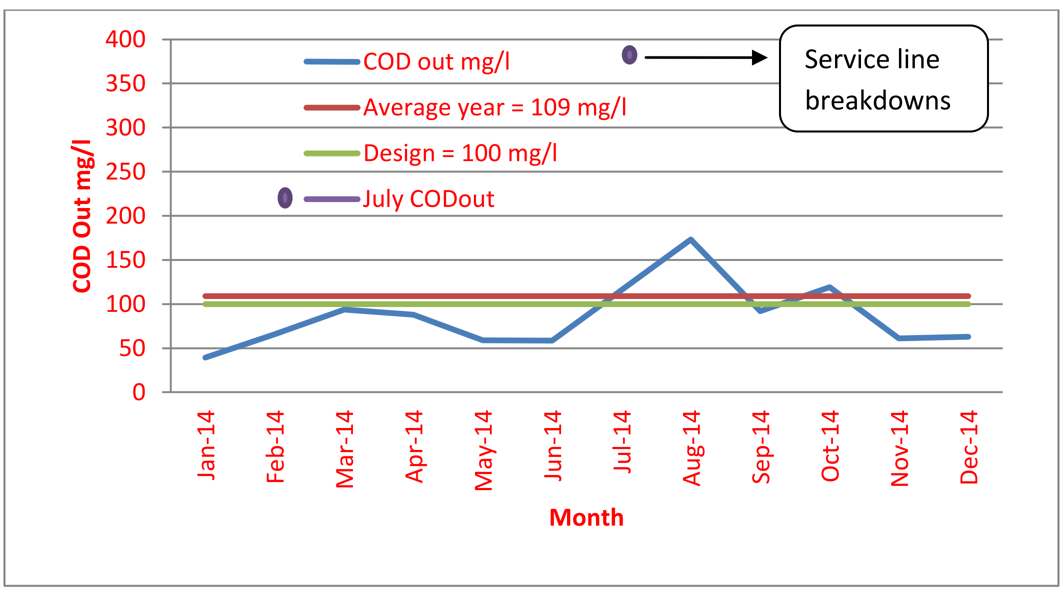

Figure (7): The COD concentration in the effluent of the treated waste water in 2014

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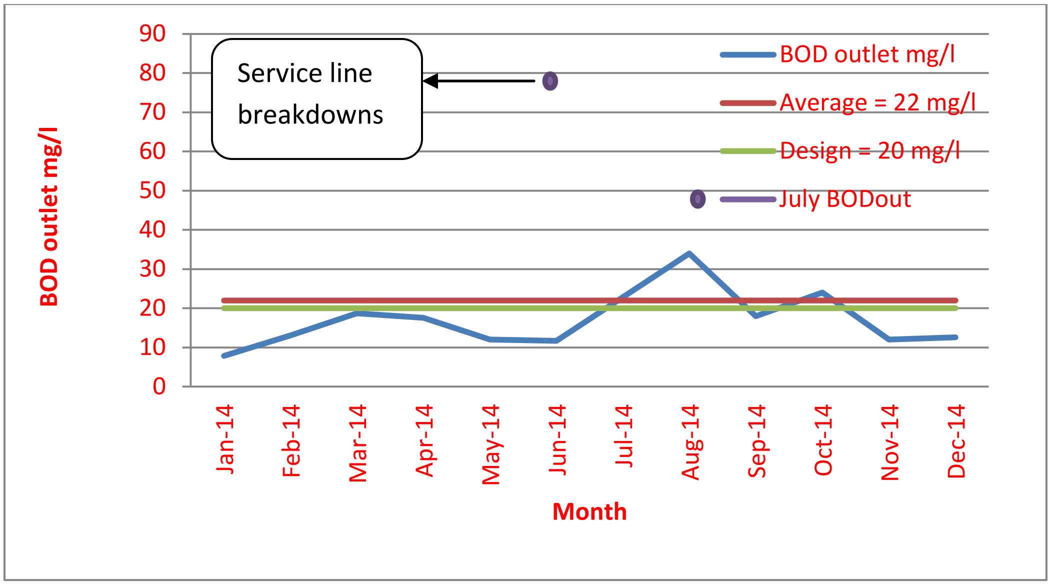

Figure (8): The BOD_5 concentration in the effluent of the treated wastewater in 2014

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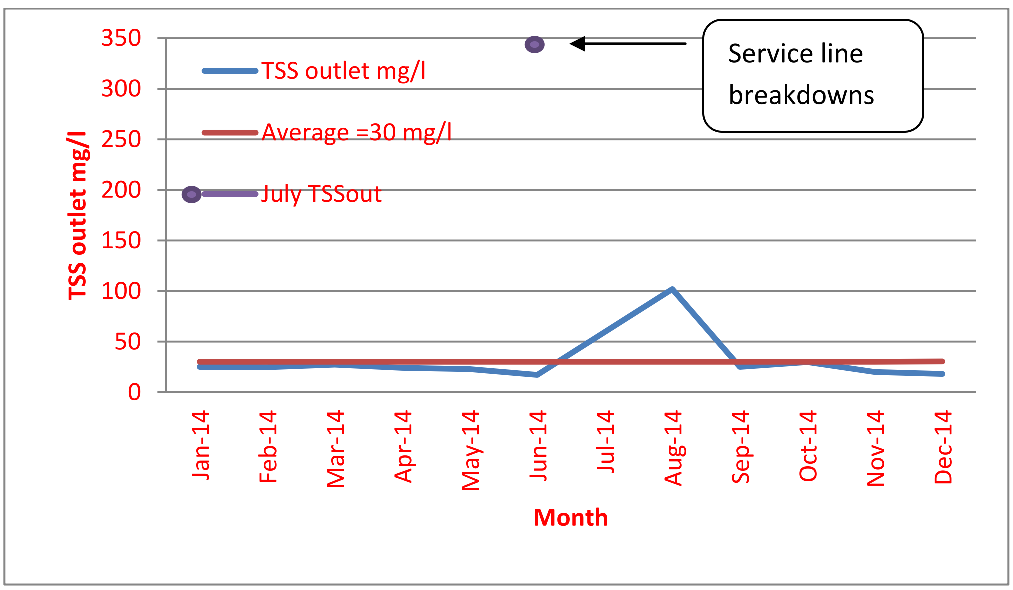

Figure (9): TSS concentration of the treated wastewater (TSS) in 2014

Figure (10) shows the correlation between the COD and BOD_5 for the treated water (2014). The ratio of COD out /BOD_5 out was equal to 5.

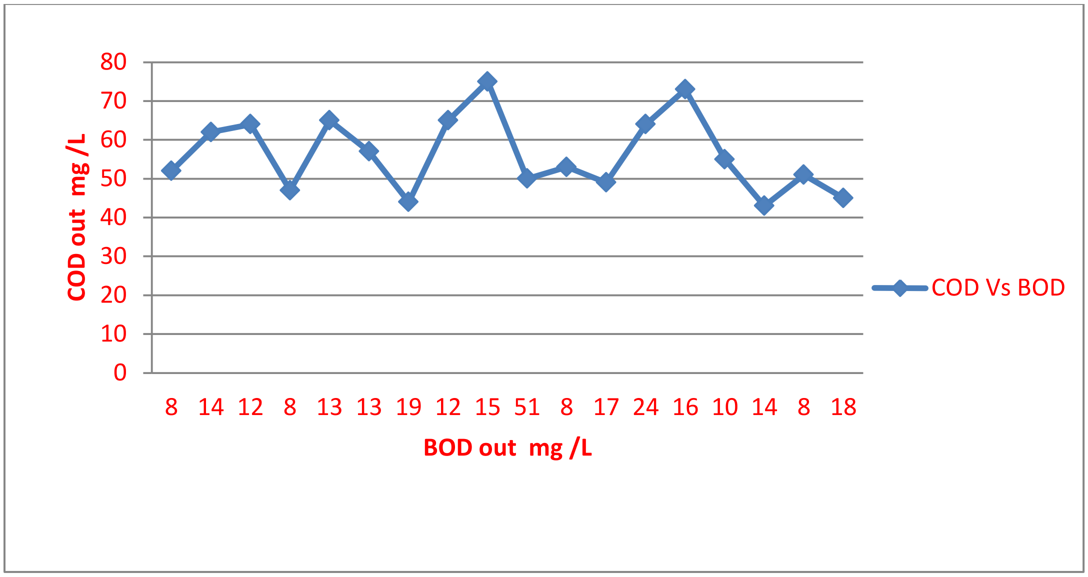

Figure (10): The Correlation between COD_{out} and BOD_{out} 2014

Figure (11) shows the average produced quantities of biogas from the anaerobic during the interval of 5/2014 to12/2014.

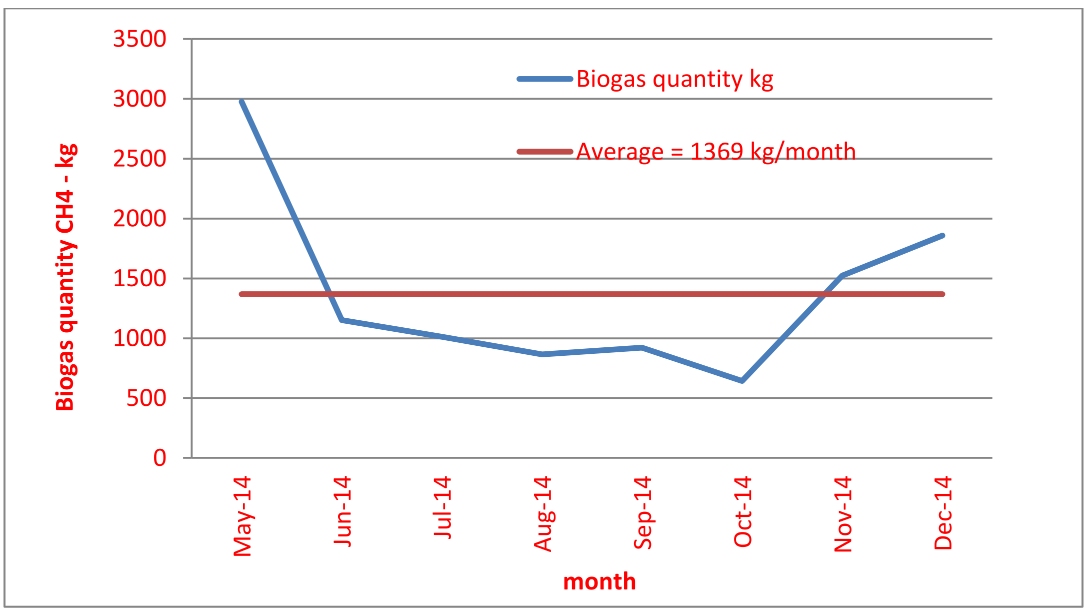

Figure (11): The average produced quantities of CH4 biogas in 2014

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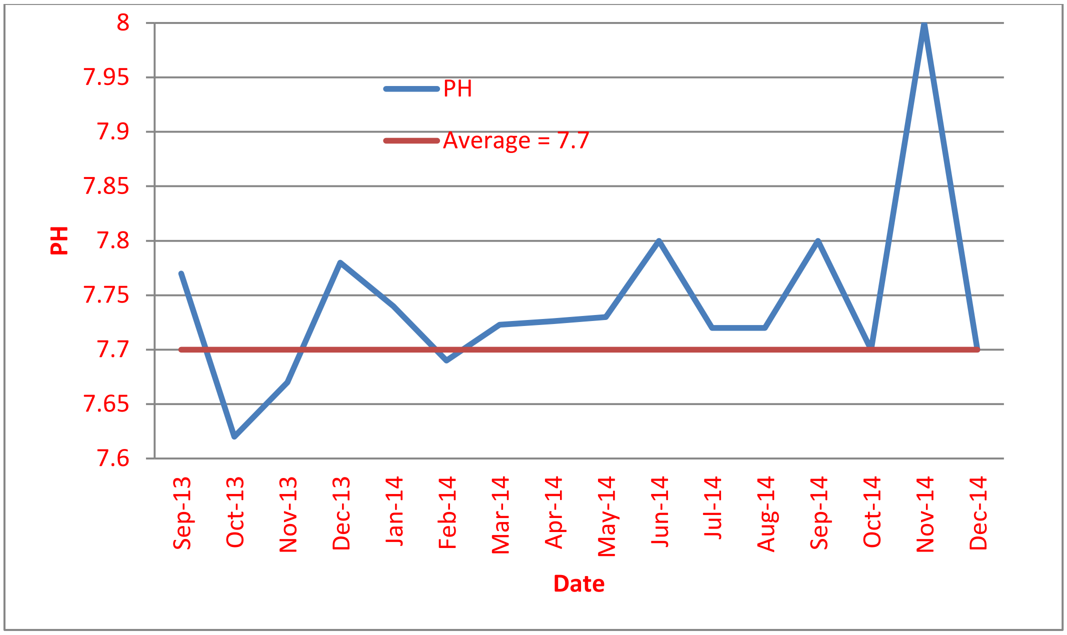

Figure (12): Average pH measurements of the inlet wastewater

Figure (13) shows the average (MLSS) mixed liquor suspended concentrations in the aeration tanks during 9/2013 to12/2014.

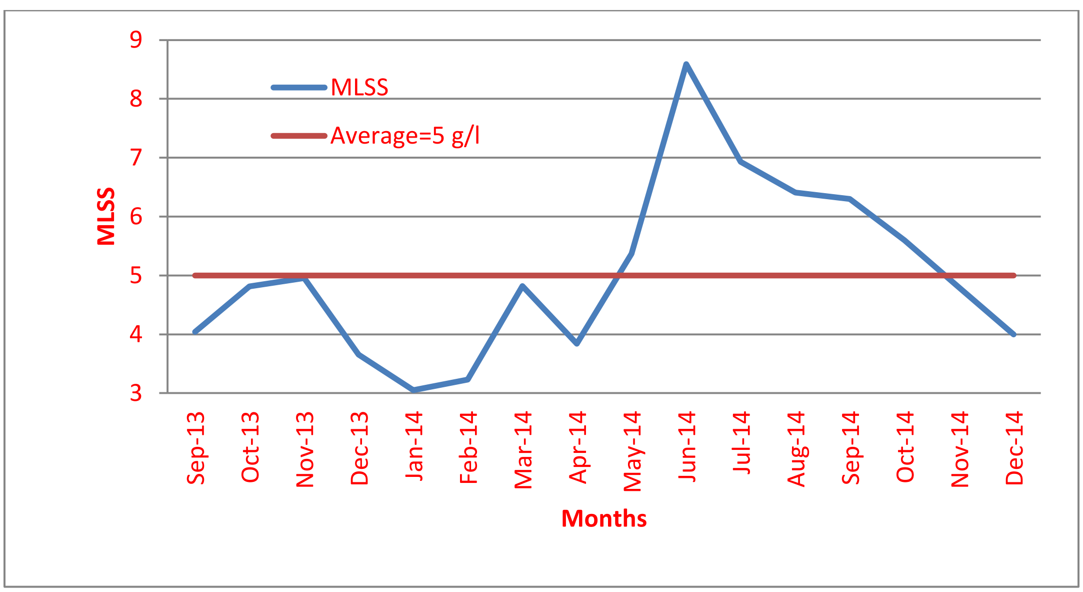

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Figure (14) shows the average treated wastewater and power consumption during 1/2014 to 12/2014.

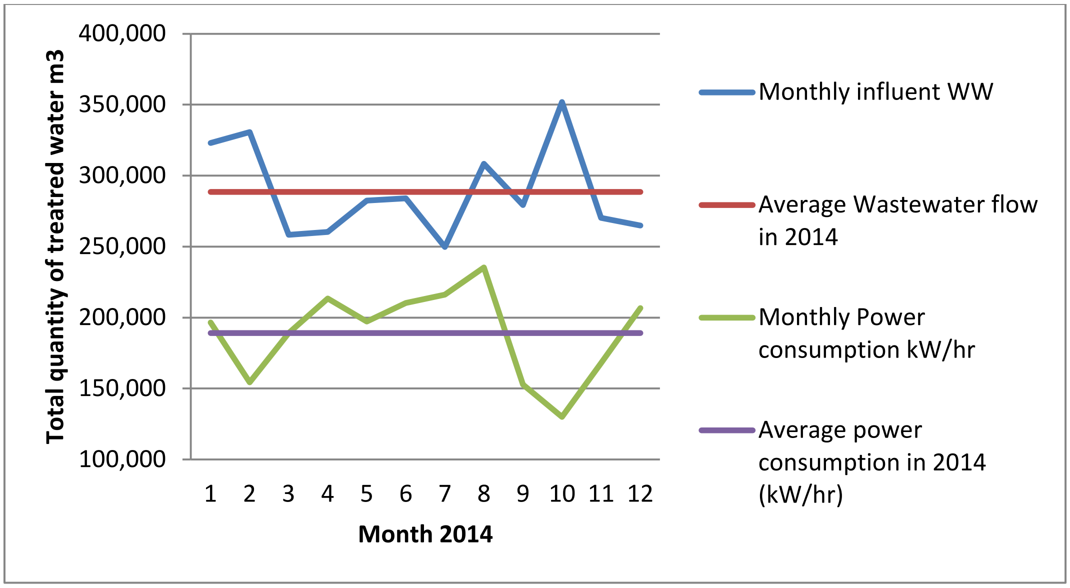

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Figure (15) shows the average conductivity measurements in the inlet flow from 9/2013 to12/2014.

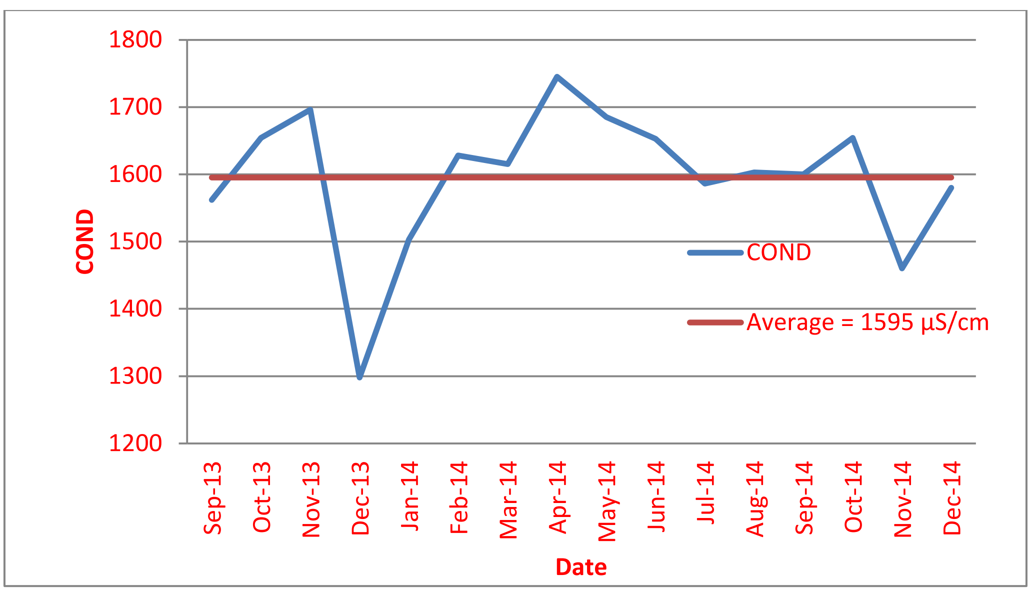

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Figure (16) shows the results of total dissolved solids in the effluent of the plant from 11/2013 to12/2014

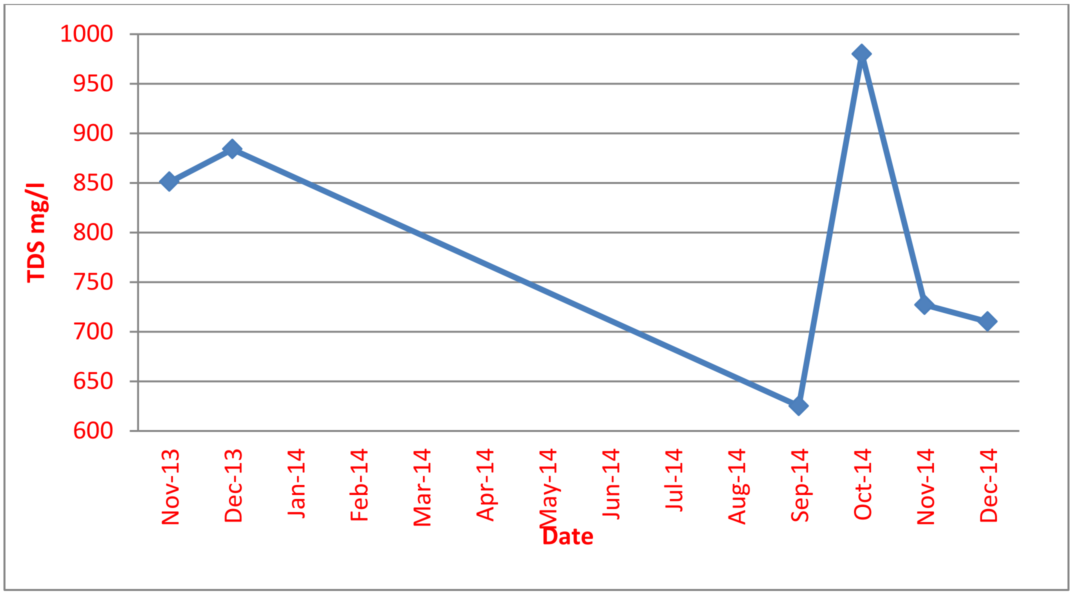


Figure (16): Total dissolved solids in the effluent during 2014

Figure (17) shows the power requirement in terms of kWh/kg COD treated in 2014.

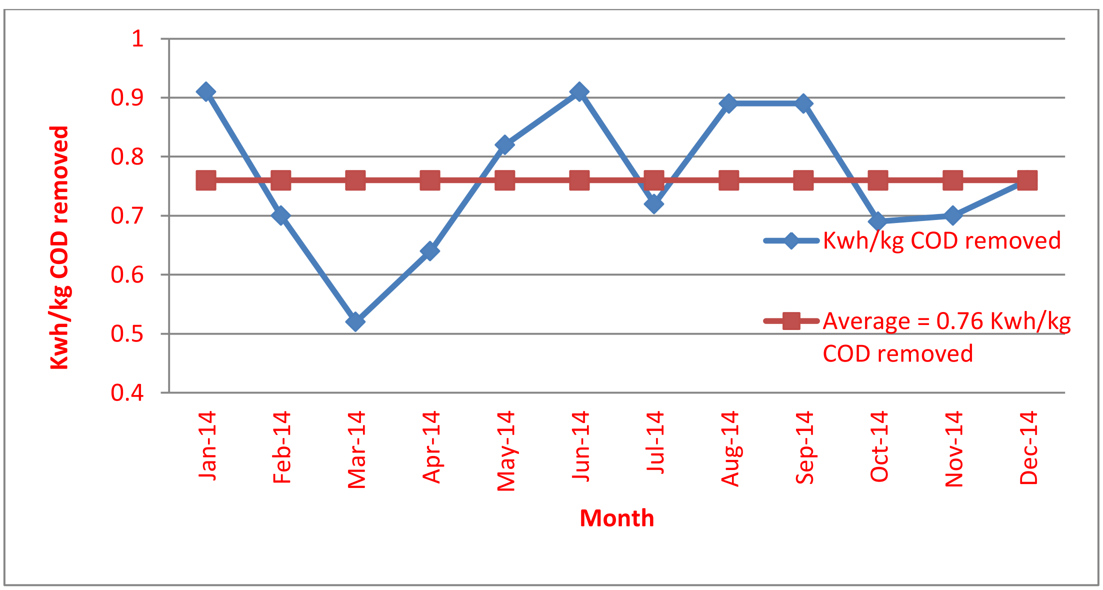


Figure (17): Power requirement kWh/kg COD treated

Figure (18) shows power requirement in terms of kWh/m^3 treated in 2014.

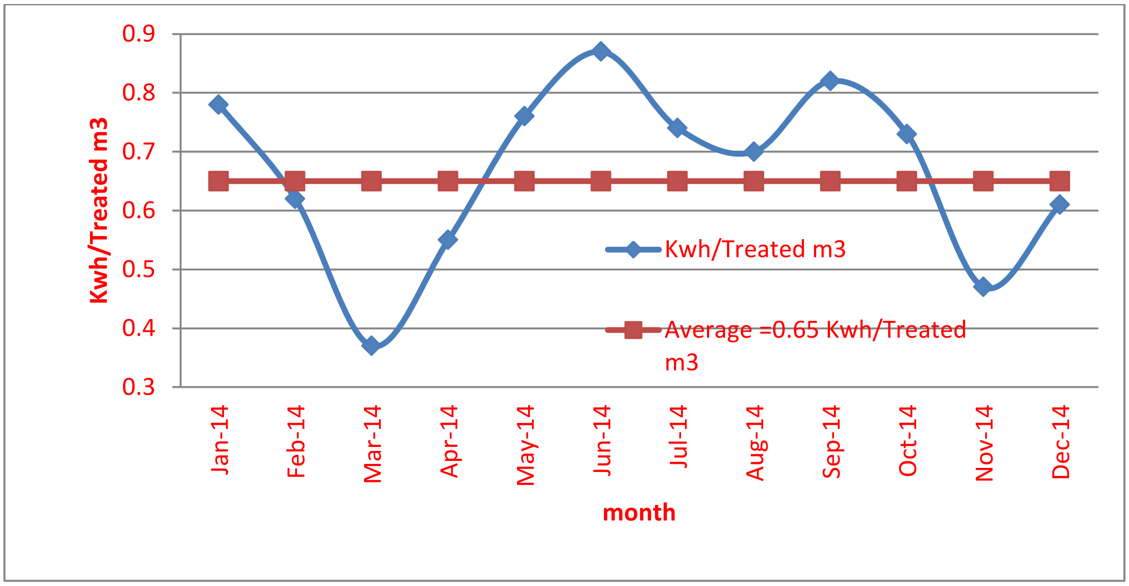


Figure (18): Power requirement kWh/ m^3 treated

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 save 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 for sanitary disposal.

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

In this unit, around 80% 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.

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.

5.4 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 Mechanical Sludge Thickening Machines

The excess sludge was withdrawn via pumps to the mechanical thickening machines 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. pH and temperature 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.

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 the summer time, the digested sludge was pumped to the drying beds for drying via natural evaporation. There were 11 beds with total area of 11.5 donums. After drying, the sludge was transported to the sludge storage yard for disposal in Zahret Al –Fenjan near Jenin.

6.7 Two Mechanical Dewatering Machines

During winter time these machines 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 19.

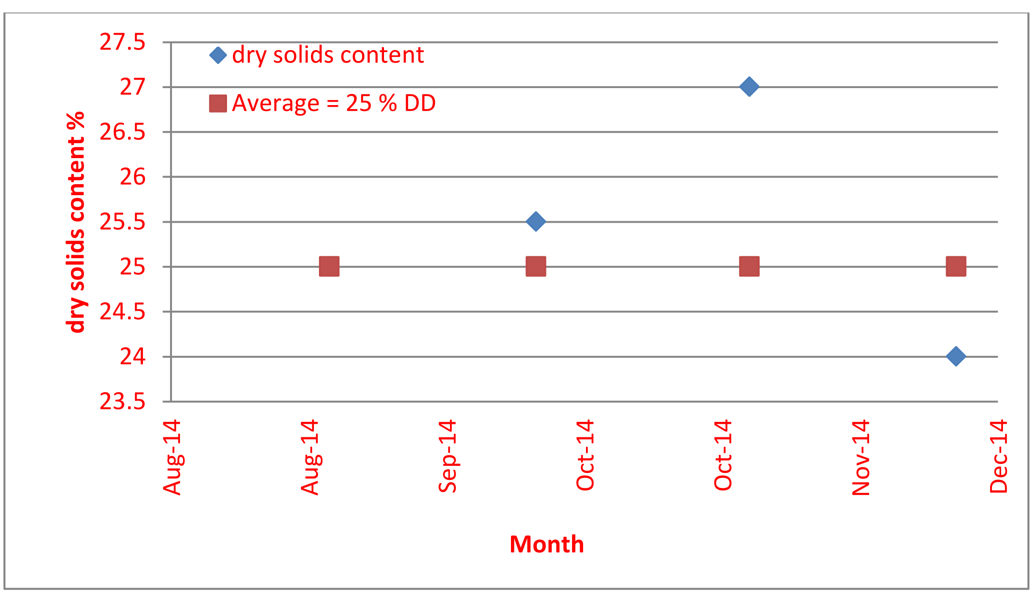


Figure (19): Dry solids content after Mechanical dewatering.

7 SCADA

All facilities of the WWTP were monitored and operated via advanced SCADA system from the SCADA center located in the administration building of the WWTP.

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 for two years etc.

9 Preventive Maintenance

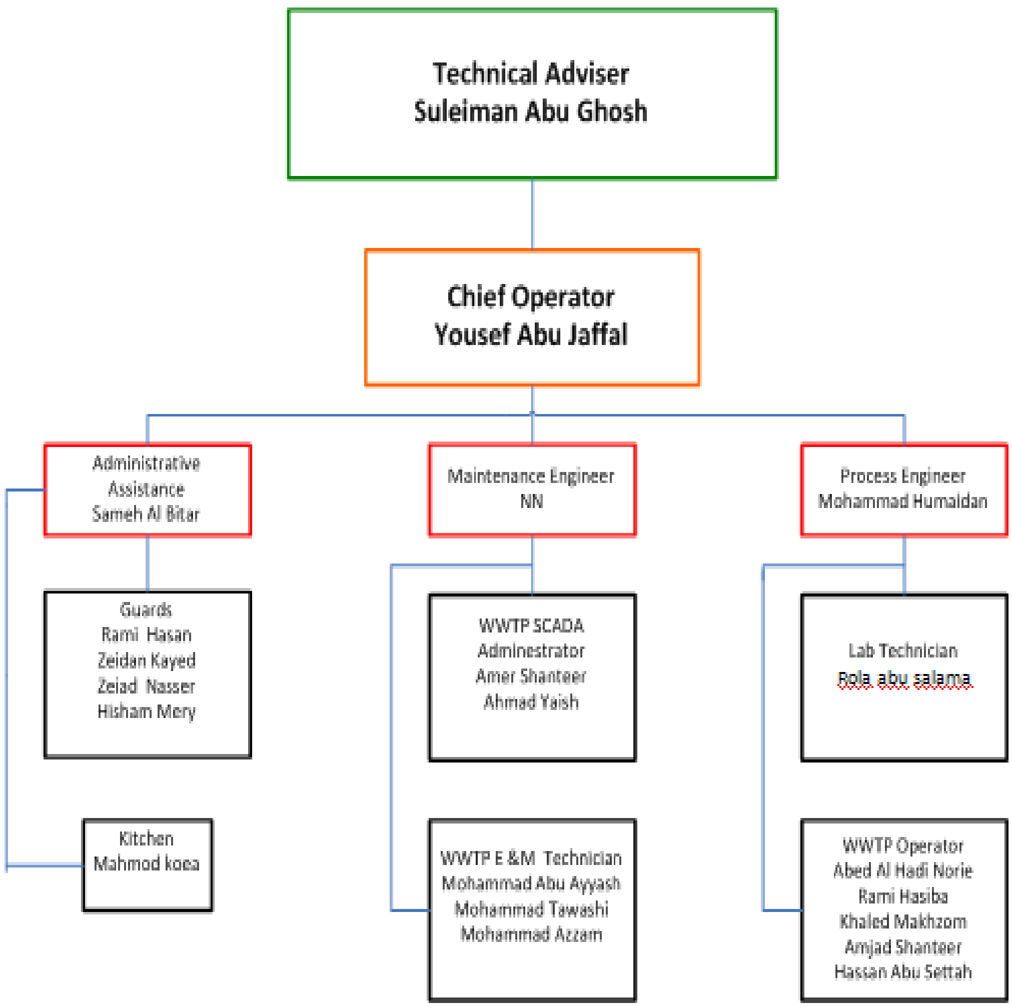
From the beginning of the plant operations maintenance works and plans have been conducted in accordance with the periodic and routine works of machines manuals. These works can be classified as preventive maintenance and failure ones. Preventive maintenance was conducted under supervision of operational assistance German experts.

10 Staff Training and Organization Structure

Training was essential for the sustainability of the project. Nablus West WWTP staff has been trained by German experts in many fields of plant operations such as:

- Practical and theoretical off job training in Hamburg-Germany
- Practical and theoretical on the job training for all units of NWWTP.
- Trouble shooting in emergency cases and under normal operation.

Waste Water Treatment Plant Nablus- West Organization Structure



11 Tests in the WWTP

11.1 Results of Lab Tests

For period from 01/01/2014 to 31/12/2014, testing results were as follow:

Parameters	Design value 2020	Treatment efficiency %	Average	Present value / Month											
			2014	1	2	3	4	5	6	7	8	9	10	11	12
Average incoming waste water m^3/d	14000	-----	9571	8828	9826	11317	9279	9946	8887	9165	9114	8681	8333	11025	10420
Inlet chemical oxygen demand COD_{in} mg/L	1100	-----	950	895	872	829	951	983	947	1139	956	1016	1173	775	859
Outlet chemical oxygen demand COD_{out} mg/L	100	%88.5	109	39.5	65.9	93.9	88	59	58.4	395	173	92	119	61	63
Outlet biochemical oxygen demand BOD_5 mg/L	20	%95.5	22	12.6	12	24	18	34	79	11.7	12	17.6	18.7	13.1	7.9
Inlet Biochemical oxygen demand BOD_5 mg/L	550	-----	493	590	436		475	491	474	569	478	508	587	382	430
Sludge age (day)	13.7	-----	27	58	81	20	11	14	21	21	22	22	26	16	15
MLSS g/L (AT)	3	-----	5	3.00	3.00	2.40	2.00	5.37	7.90	6.40	6.40	6.17	5.60	4.80	3.80
NH4-N in	-----	-----	66	66	86	65	65	61	49	54	Na	93	na	56	64
NH4-N out	-----	-----	33	1	24	54	56	3	31	50	Na	63	na	43	5
TSS_{inlet} mg/L	500	-----	436	379	356	356	470	451	478	484	424	452	562	404	412
TSS_{outlet} mg/L	30	%93	30	25.00	24.80	27.00	24.00	23.00	17.20	00.0	102.00	25.00	29.80	20.00	18.00
Electrical consumption/$kgCOD_{removed}$ kW/kg	0.8	-----	0.76	0.91	0.70	0.52	0.64	0.82	0.91	0.72	0.89	0.89	0.69	0.70	0.76

11.2 Power Consumption

The following table shows the monthly power consumption and treated quantities of wastewater

Month / 2014	Average	Dec.	Nov.	Oct.	Sept	August	July	June	May	April	March	Feb	Jan
Avg. monthly treated water	**290,032**	323,014	330,740	258,331	260,443	282,533	284,104	266,610	308,327	279,177	351,916	270,341	264,845
Power consumption kW/hr	**189,166**	196,652	154,362	189,057	213,369	197,193	210,365	216,232	235,323	152,729	130,075	167,919	206,718
kWh /Treated m3	0.65	0.61	0.47	0.73	0.82	0.7	0.74	0.87	0.76	0.55	0.37	0.62	0.78

11.3 Additional lab results in 2014

Test / 2014	values	Average	Dec.	Nov.	Oct.	Septem	August	July	June	May	April	March	Feb	Jan
COD out mg/l	**Average**	**109**	63	61	119	92	173	395	58.4	59	88	93.9	65.9	39.5
	Max	**347**	86	97	170	171	330	1760	814	176	160	179	171	54
	Min	**40**	37	25	59	45	71	73	27	30	18	60	15	22
BOD out mg/l	**Average**	**22**	12.6	12	24	18	34	79	11.7	12	17.6	18.7	13.1	7.9
	Max	**54**	17.2	19.4	34	34	66	299	34	35	32	27	34.2	10.8
	Min	**8**	7.4	5	11.8	9	14.2	19.2	5.4	6	3.6	12	3	4.4
NH4 out mg/l	**Average**	**30**	____	____	____	____	____	32	____	5.4	56.7	62.7	24.3	0.5
	Max	**35**	____	____	____	____	____	35	____	____	____	____	____	____
	Min	**33**	____	____	____	____	____	29	____	____	35.2	34.7	____	____
TSS out mg/l	**Average**	**30**	18	20	29.8	25	102	0	17.2	23	24.1	27.4	24.8	25.09
	Max	**182**	31	2	66	48	428	1322	32	30	38	50	40	92
	Min	**12**	5	60	6	10	14	8	8	6	7	4	8.3	4
MLSS mg/l	**Average**	**5**	3.8	4.8	5	6.17	6.44	6.4	7.91	5.4	3.75	4.82	3.22	3.05
	Max	**6**	4.6	6.3	7.28	7.62	7.87	9.6	10.5	7.4	4.64	5.96	1	3.51
	Min	**3**	3	3.34	2.5	4.22	5.01	3.2	4	3.1	3.11	3.88	4.59	1.32

12 Testing of Sludge

In 2010, Palestinian standards institute specified a standard for reusing the sludge of treatment plants in Palestine. The sludge reuse standard “Use of treated sludge and sludge disposal” which has a number of 898. This standard identifies the main parameters which have to be tested for the sludge to be reused in agriculture. Sludge reusing was classified into three classes (1st, 2nd, 3rd class).

Class	Allowed application
1st class	Can be used in all different applications of agriculture or disposed in sanitary land filling.
2nd class	Can be used to enhance the soil properties or disposed in sanitary land filling
3rd class	Can be disposed in sanitary land filled only.

The test results show the treated sludge of the WWTP can be classified as First class sludge. Two parameters had been not tested due to the lab disability. Nablus Municipality tested the sludge in Beir Zeit University, the results were as follows:

Elements	1st class	2nd class	3rd class	**NWWTP Sludge**
As (ppm)	41	75	75	Not detected
Cd (ppm)	40	40	85	Not detected
Cr (ppm)	900	900	3000	12.6
Cu (ppm)	1500	3000	4300	61.2
Hg (ppm)	17	57	57	0.828
Mo (ppm)	75	75	75	1
Ni (ppm)	300	400	420	8.3
Se (ppm)	100	100	100	Not detected
Pb (ppm)	300	840	840	3.3
Zn (ppm)	280	400	7500	250
Moisture %	30%	50%	------	49.50%
FC (cfu/g)	1000	2000000	------	38000
Salmonella (cu/g)	3	------	------	Not detected
Helminthes eggs (cu/g)	1	------	------	Not tested
Viruses (cu/4g)	1	------	------	Not Tested

13 External Lab Results by third party

13.1 Results of Master student from Bongorion University

13.1.1 Pharmaceutical residues in the inlet and outlet for NWWTP

Out let sample ppb	Inlet sample ppb	site / PPCPs
4.4	59	Caffeine
0.07	4.6	Carbamazepine

13.1.2 Hormones analysis for the inlet and outlet wastewater for NWWTP

(ppt) Outlet sample	(ppt) Sample inlet	Place / EDCs
0	354.602	Estriol
2.560	79.626	Estrone

The results above show very good removal percentage of the aforementioned hormones.

13.2 Analysis results of the treated wastewater from NWWTP in 21/9/2014 in Khadouri University labs.

Parameter	mg/l	Range mg/l	Notes
Chloride	517		
Cadmium	0.047	0.02-0.3	
Sulfite	95.6	150-900	
Ammonia	75		As nitrogen
Potassium	106	8-50	Over range
Calcium	205		
Magnesium	27	0.5-50	
Copper	0.168	0.1-8	
Nitrate	0.762	5-35	Under measuring rate
Lead	0.07	0.1-2	Under measuring rate
Nitrate	0.445	0.23-13.5	No3-n

Nickel	0.1	0.1-6	Under measuring rate
Water hardness	17.1 dh		
Ammonium	68	2-47	
Boron	0.105	0.05-2.5	
Iron	0.18		
Manganese	0.4		
Barium	6		
TDS	353		
Sulfate	341		
Zinc	0.231	0.2-6	

13.3 Boron results in the treated wastewater 12/11/2014

Sample type	Result
Grape Sample at 9 o'clock am	0.2 mg/l
Composite Sample (24hrs)	0.15 mg/l

13.4 The chloride content in the treated wastewater effluent was measured; the average of the results was 220 mg/l.

14 Appendices