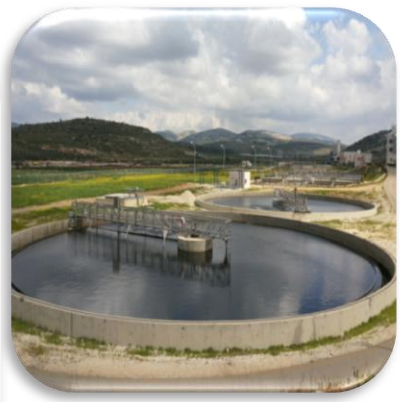
Wastewater Treatment Plant

Nablus West

Annual Report 2022





June 2022

Prepared by

Eng. Yousef Abu Jaffal

Eng. Mohammad Homeidan

Ms. Rola Abu Salama

Mr. Sameh Bitar

Eng.Yazan Odeh

TABLE OF CONTENTS

1. ABBREVIATIONS 4

2. INTRODUCTION 5

3. BACKGROUND 6

3.1 Location of the WWTP Nablus West 6

3.2 WWTP Nablus West 7

4. GENERAL PERFORMANCE 8

5. OPERATION OF WASTEWATER TREATMENT PLANT FACILITIES 9

5.1 Stone trap 9

5.2 Screens and grit/grease removal 9

5.3 Two Primary sedimentation tanks with total volume (1,728 m^3) 9

5.4 Two Aeration tanks with total volume (18,000 m^3) 9

5.4.1 Nitrification and de- nitrification 10

5.5 Two Final sedimentation tanks with total volume (7,718 m^3) 10

6. OPERATION OF SLUDGE FACILITIES 11

6.1 Two Belt thickeners 11

6.2 Primary thickener tank (548 m^3) 11

6.3 Anaerobic digester (3,650 m^3) 11

6.4 Gas balloon holder (660 m^3) 12

6.5 Gas flare 12

6.6 Sludge drying beds 12

6.7 Belt Filter Presses 12

6.8 Other facilities 13

6.9 Additional improvement works 13

7. SCADA SYSTEM 16

8. PERFORMANCE OF WWTP 16

8.1 Influent flow 16

8.2 Cleaning performance 17

8.3 Power consumption 20

8.4 Gas production 20

8.5 Desulfurization Unit 21

8.6 CHP engine 22

8.7 Nablus CHP electrical figures 22

8.8 Online measurement For Nitrogen and suspended solids in the aeration tanks: 23
9. PREVENTIVE MAINTENANCE 23
10. STAFF TRAINING AND ORGANIZATION STRUCTURE 24
11. Photovoltaic system 24
12. Future Improvements 25
13. Problems & Challenges in 2022 25
14. REUSE PROJECTS 26
14.1 Introduction 26
14.2 Nablus Tertiary treatment 26
14.3 Quality of tertiary treatment systems 27
14.4 Summary of Executed Reuse Pilot Projects 28
14.4.1 Reuse Inside scheme Project 28
14.4.2 Compete Reuse Project 30
14.4.3 Reuse outside scheme (under implementation) 31
14.5 Overview of Big Reuse projects 33
14.5.1 Strategic Reuse Project 2000+ 33
14.6 Results 35
14.7 Summary of all reuse projects of Nablus Plant 36
15. Staff 37
16. Annexes 40
Annex 01: Graphs 41
Annex 02: Performance summary 51
Annex 03: Power consumption 51
Annex 04: Additional lab Tests in WWTP Lab 52

WWTP

1. ABBREVIATIONS

µs/cm: Micro Siemens per centimeter

Al: Aluminum element

AT: Aeration tank

B: Boron element

BOD: Biological oxygen demand

Ca: Calcium element

Cd: Cadmium element

cfu: colony fecal unit

CH_4: Methane

Cl: Chloride

Cn: Cyanide element

C^o: Carbon monoxide

C^o: Celsius degree

CO_2: Carbon Dioxide

COD: Chemical oxygen demand

Cr: Chrome element

Cu: Cupper element

DO: Dissolved oxygen

FC: Fecal coliform

Fe: Ferric element

GIZ: Gesellschaft für International Zusammenarbeit

Hg: Mercury element

JV: Joint venture

KfW : Kreditanstalt für Wiederaufbau

kg/d: Kilogram per day

Km: Kilometer

KPR: Kinetics- Passavant Reodiger

kWh: Kilowatt hour

Li/HEC: Consultant Lahmeyer and Hijjawi Engineering Center

m^3: Cubic meter

MBAS: Methylene blue active substance

MCC: Motorized control centre

Mg: Magnesium element

MLSS: Mixed liquor concentration

Mn: Manganese element

MoA: Ministry of Agriculture

Na: Sodium element

NH_4-N: Ammonium as nitrogen

NM Nablus Municipality

NO_3-N: Nitrate as nitrogen

Pb: Lead element

PE: Population equivalent

PLC: Programmable Logic Controller

PO_4-P: Phosphate as phosphorous

SAR: Sodium adsorption ration

SCADA: Supervisory Control and Data Acquisition

Se: Selenium element

SO_4: Sulphate compound

TDS: Total dissolved solids

TN: Total nitrogen

TSS: Total suspended solids

UV: Ultra violet

WSSD: Water supply and sanitation department

WWTP: Wastewater treatment plant

WUA: Water user association

Zn: Zink element

Ni: Nickel element

2. INTRODUCTION

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

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

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

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

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

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

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

3. BACKGROUND

3.1 Location of the WWTP Nablus West

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

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

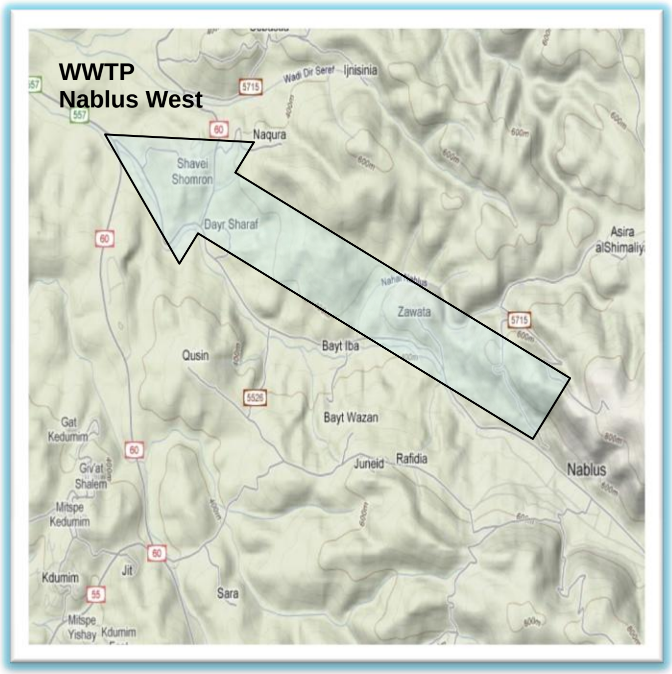


Figure (2): Direction of slope

Figure (3): Overview of WWTP Nablus West

3.2 WWTP Nablus West

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

Figure (4): WWTP Nablus West

4. GENERAL PERFORMANCE

Around four millions five hundred and ninety five six thousand (4,595,600 m^3) cubic meters of wastewater were treated in the year 2022, with an electrical consumption of tow millions nine hundred and sixty six (2,966,000 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 9 mg/l and TSS was 6 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.

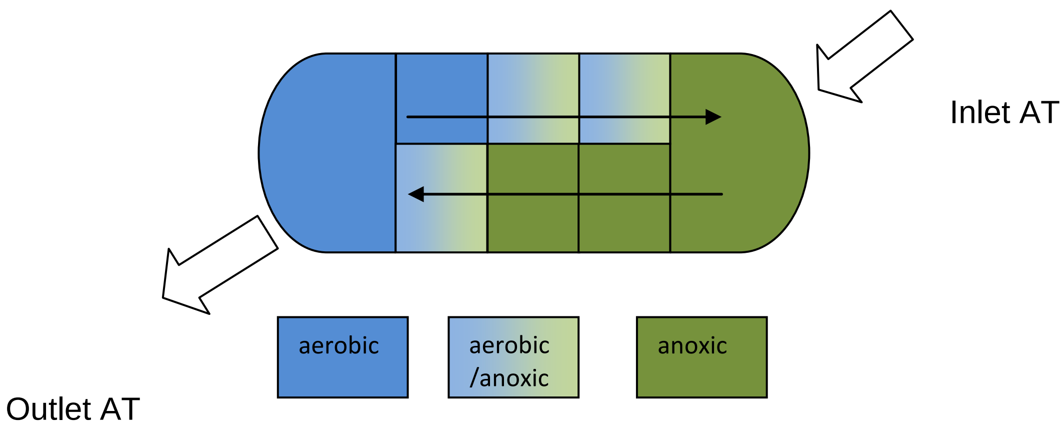


Figure (5): Aeration tank with implemented de-nitrification zone

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 22%. 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.

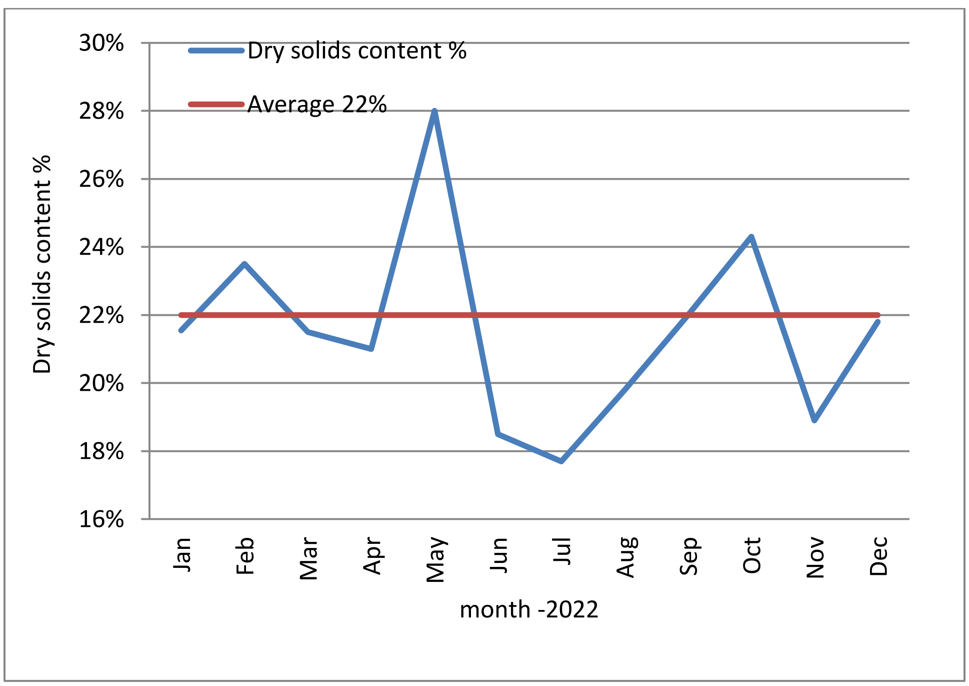


Figure (7): Dry solids content after mechanical dewatering.

6.8 Other facilities

Other equipments 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.

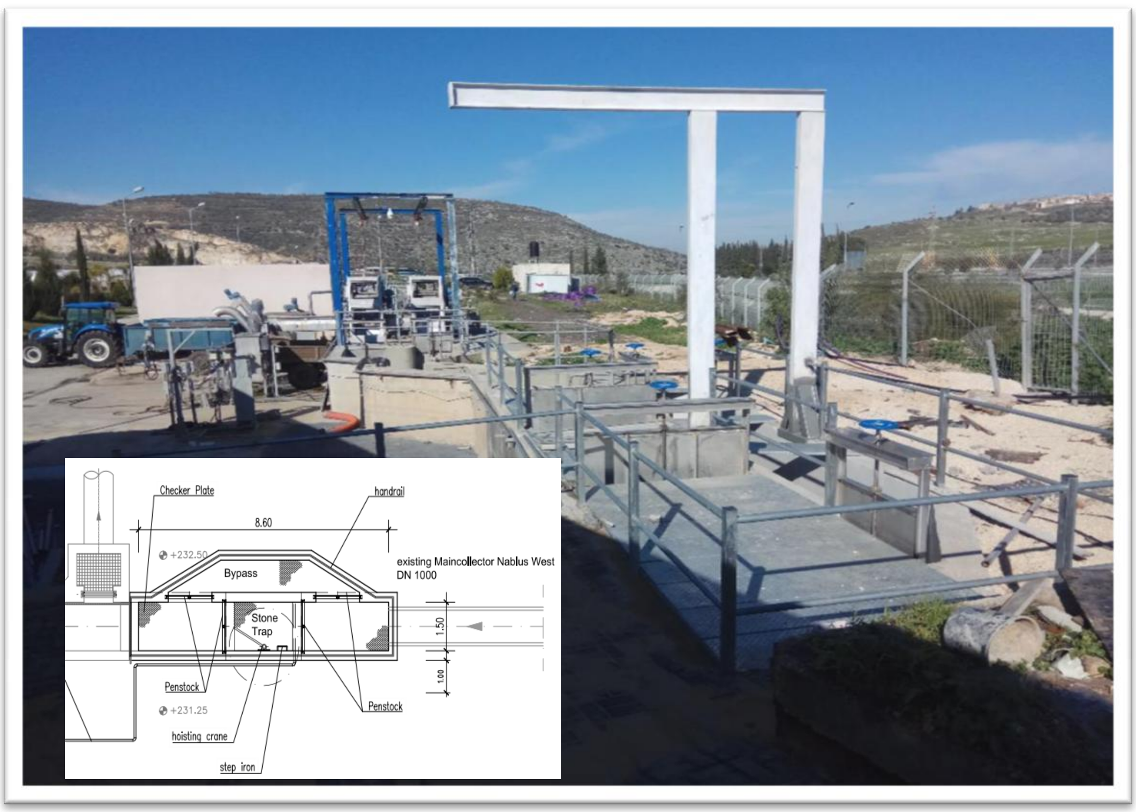


Figure (8): Stone trap at the inlet of WWTP

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 (new structure design is being implemented)

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

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 (13): Nablus WWTP SCADA system

8. PERFORMANCE OF WWTP

8.1 Influent flow

The performance of WWTP Nablus West during 2022 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 2022 to December 2022 were analyzed.

Figure (15) 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 2022 was approximately 12,591 m³/day. The amount of incoming wastewater will increase gradually over the next years.

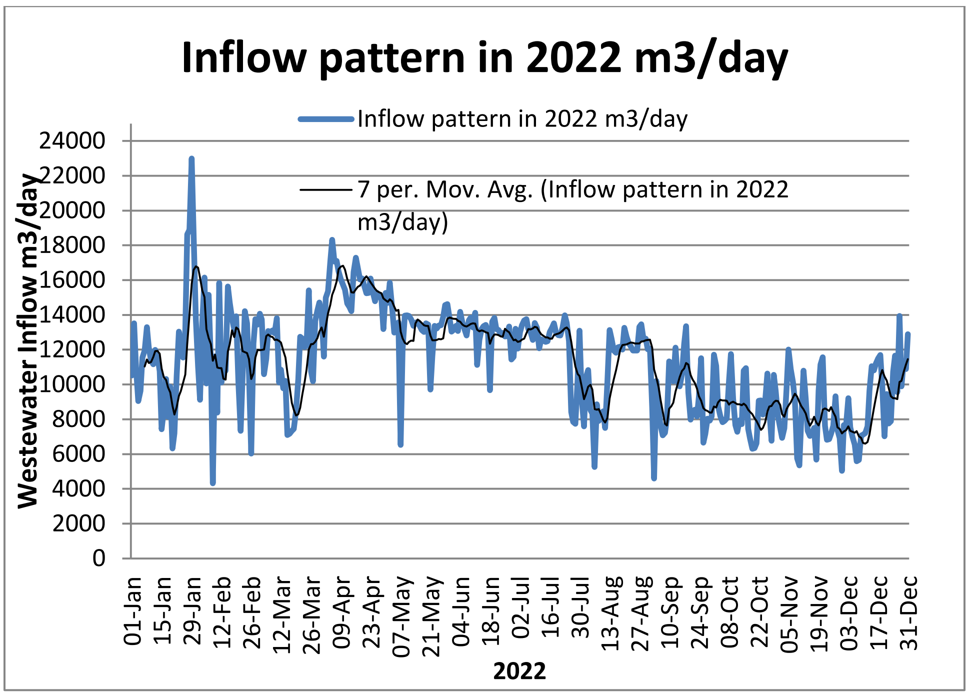


Figure (14): Hydrograph of the daily treated wastewater inflow

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 10,402 kg/d and the total COD load over the year of 2022 was 3,796,900 kg/year. The COD load at the effluent in the same period was 591 kg/year. The cleaning performance is approximately 94%.

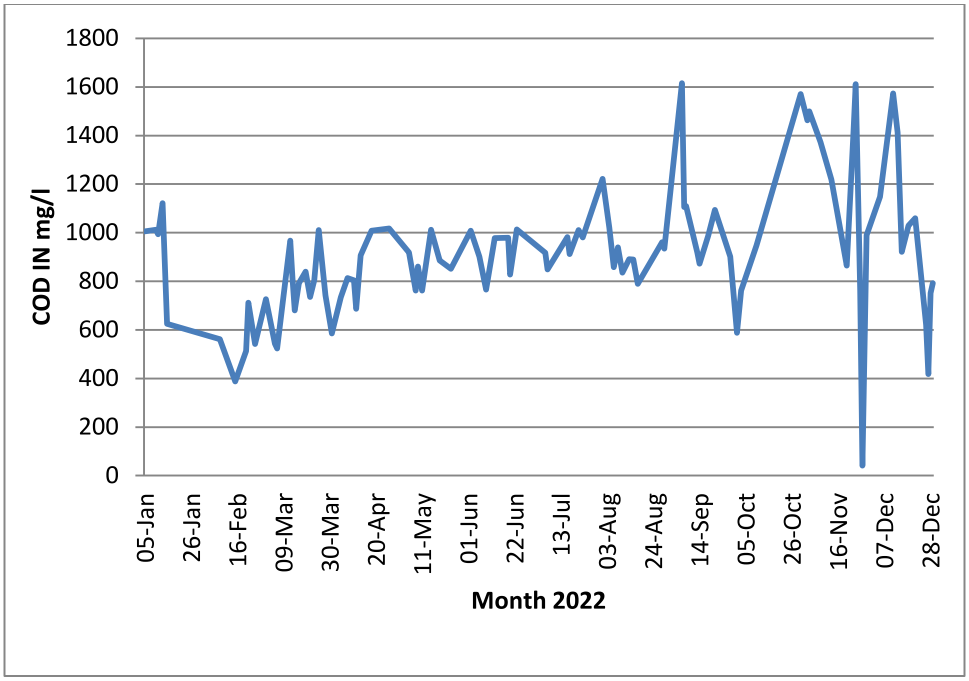


Figure (15): Influent concentration of COD

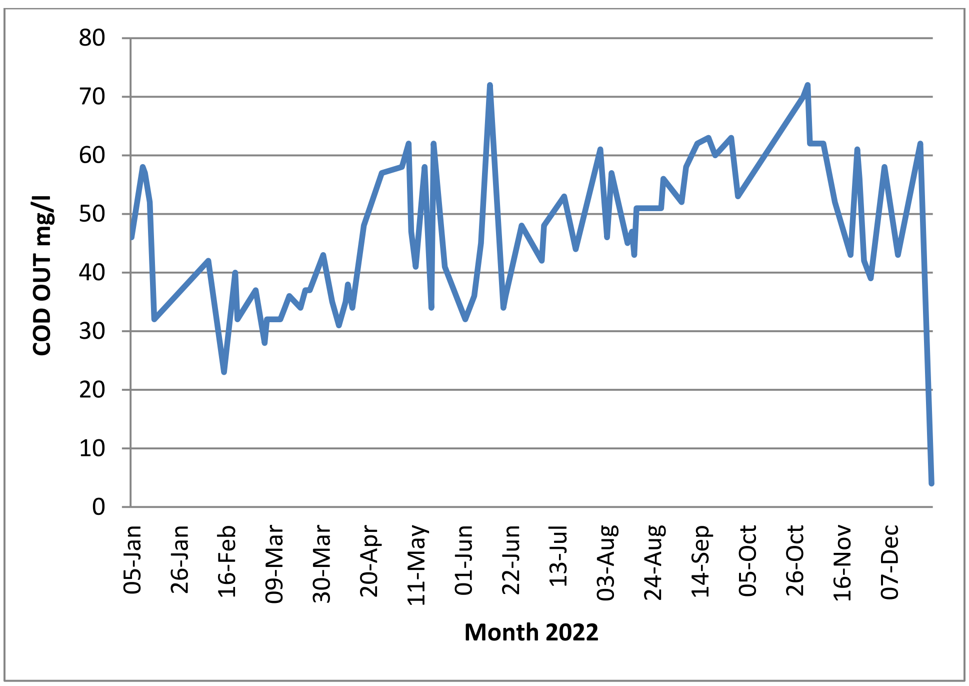


Figure (16): out fluent concentration of COD

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 4,089 kg/d. The reduction of suspended solids was in average approximately 98%.

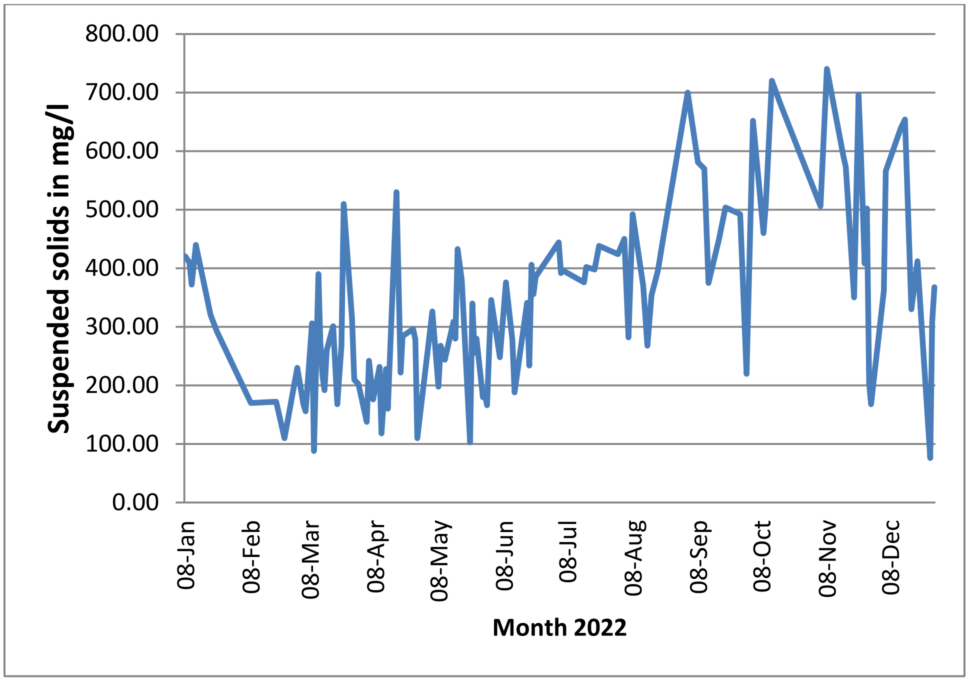


Figure (17): Suspended solids of the inlet of the treatment plant

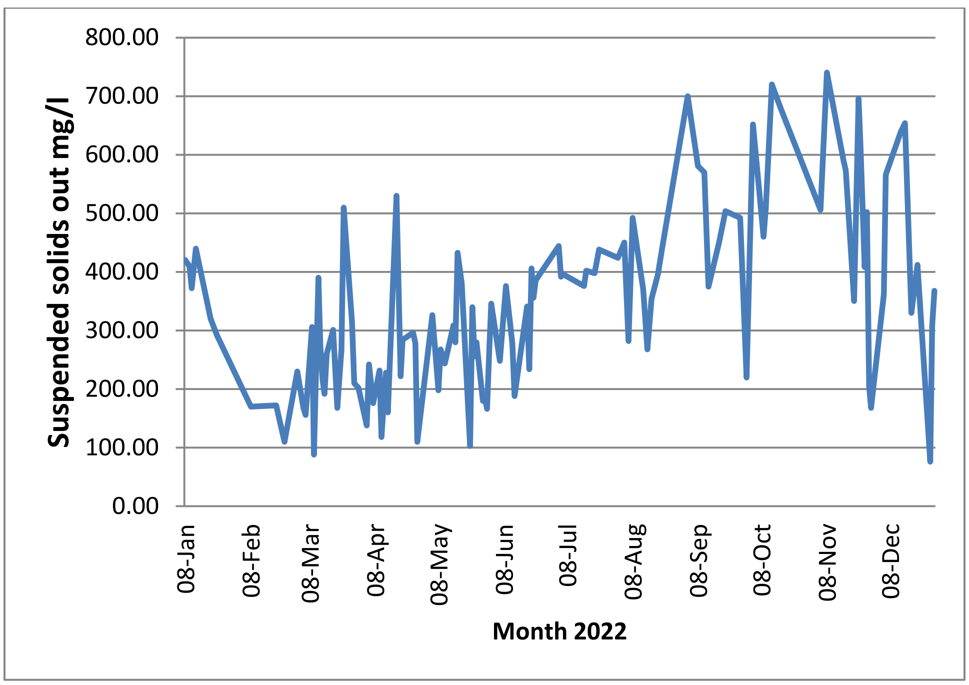


Figure (18): Suspended solids of the outlet of the treatment plant

8.3 Power consumption

Optimization of operation was one of the most important challenges in municipal WWTPs. The specific power consumption of similar WWTP is about below 0.85 kWh per m^3 of treated wastewater, and below 0.8 kWh of kg COD removed, however in Nablus WWTP the values were 0.66 kwh/m^3 and 0.76 kg/COD removed respectively. Deviations from this value can be attributed to the circumstances of daily plant operation.

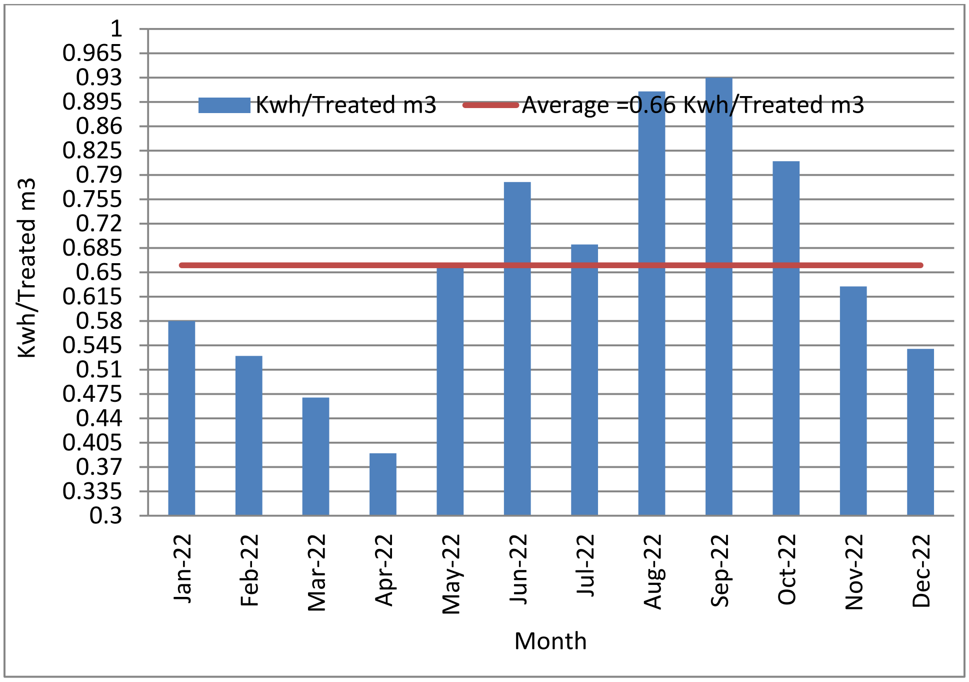


Figure (19): Monthly values of power consumption per treated m^3 of wastewater

8.4 Gas production

The average gas production in 2022 was 1,426 nm^3/d, and was fed to CHP to produce the electrical and thermal power, part of the produced thermal power was used for heating up the digester.

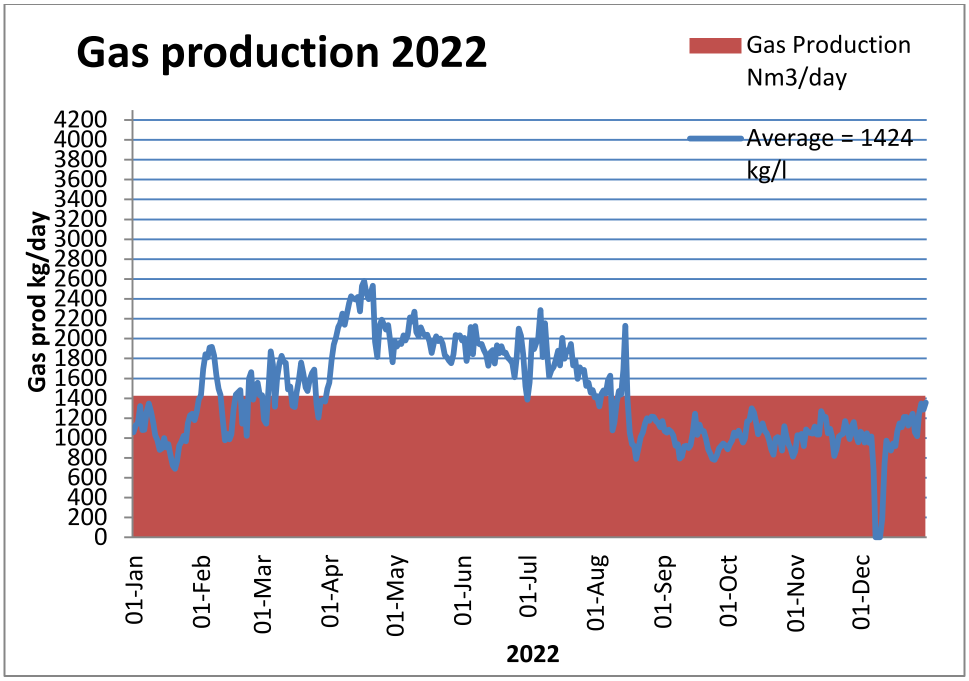


Figure (20): Gas production of the digester

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 (21): Nablus West desulfurization unit

8.6 CHP engine

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

Figure (22): Nablus West CHP engine.

8.7 Nablus CHP electrical figures

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

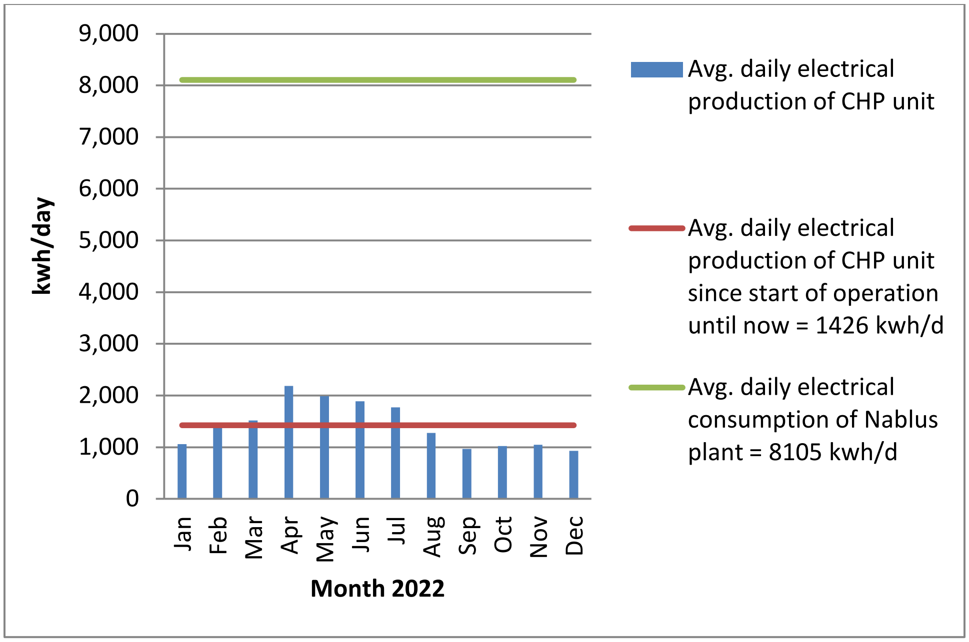


Figure (23): Electrical consumption of plant with comparison of CHP electrical production

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

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

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

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

9. PREVENTIVE MAINTENANCE

From the beginning of the plant operation maintenance works and plans had been conducted in accordance with the periodic and routine works of machines manuals.

These works could be classified as preventive maintenance. Preventive maintenance was done by Nablus WWTP staff.

It is worthy to mention that maintenance operations were done in 2021 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 training.

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 2022 was 171,900 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 (24): 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 2022

- Unavailability of spare parts in local market and the problems of international supply chains after Corona pandemic.
- Keep the staff of the WWTP.
- Unavailability of local maintenance companies for the CHP.
- 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. REUSE PROJECTS

14.1 Introduction

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

14.2 Nablus Tertiary treatment

1- Three different tertiary treatment systems have been installed in Nablus plant for supplying tertiary water for reuse pilot projects. The First system was funded by KfW which consists of sand filtration units and UV disinfection. This system has a capacity of 10 m^3/hr and serving 40 donums as educational pilot reuse project inside the plant.

2- The second system was funded by USAID through compete project which consists of gravel filtration units and chlorination for disinfection . This system has a capacity of 60 m^3/hr and Pumping the tertiary treated water to the reservoir with capacity 750 m3 and then distribute the water by gravity to the farmer's land (140 donums) outside the plant south area of the treatment plant.

3- The Third one funded by KfW which consists of Disc filter units and UV disinfection. This system has a capacity of 100 m^3/hr and serving 86 donums as another pilot reuse project outside the plant North area between the main street and the treatment plant.

14.3 Quality of tertiary treatment systems

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

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

Co ppm	BDL	BDL	0.05	0.05	0.05	0.05	
B ppm	0.15	0.065	0.7	0.7	0.7	0.7	
Ag ppm	BDL	1					Birzeit Lab, ICP
E. coli (Colony/100ml)	Absent	Absent	100	1000	1000	1000	Birzeit Lab, Iso method
Nematodes (eggs/L)	Absent	Absent	1>=	1>=	1>=	1>=	Birzeit Lab, StMe

BDL = below detection limit

14.4 Summary of Executed Reuse Pilot Projects

14.4.1 Reuse Inside scheme Project

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

Figure (1): Planted lands inside Nablus plant (reuse inside scheme)

Table (2): Type of crops which have been planted in Reuse inside Scheme pilot project

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

Figure (2): Fruit trees (reuse inside scheme)

14.4.2 Compete Reuse Project

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

WWTP

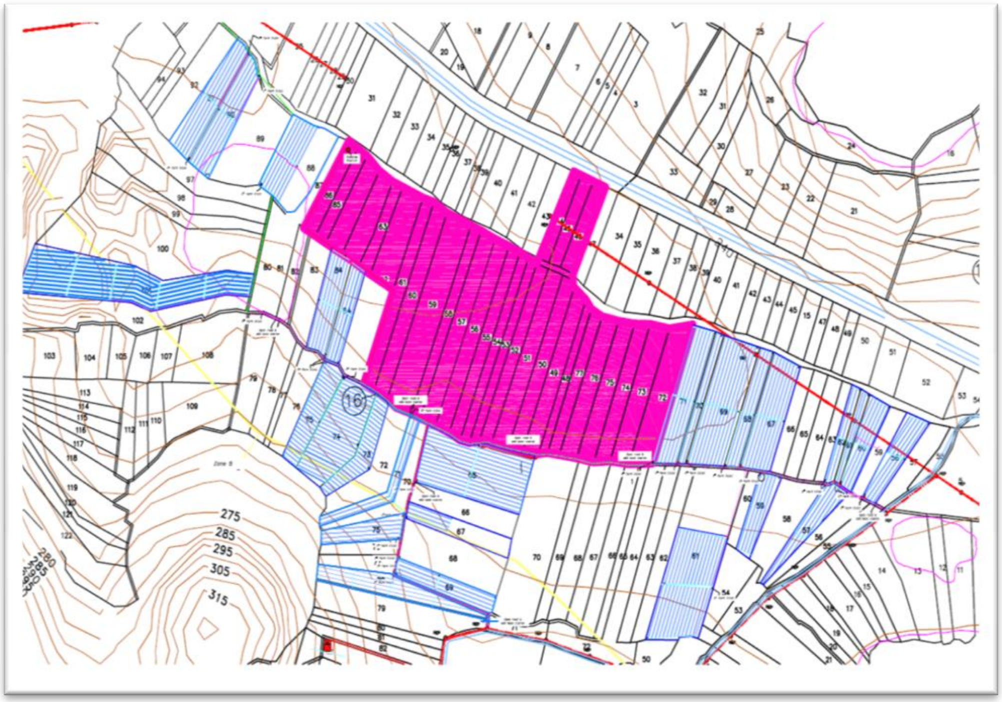


Figure (3): Trees planted in USAID (Compete project) depicted in blue color

Table (3): Type of Trees which have been planted in Compete Reuse pilot project

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

14.4.3 Reuse outside scheme (under implementation)

- 87 Donum, outside the plant

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

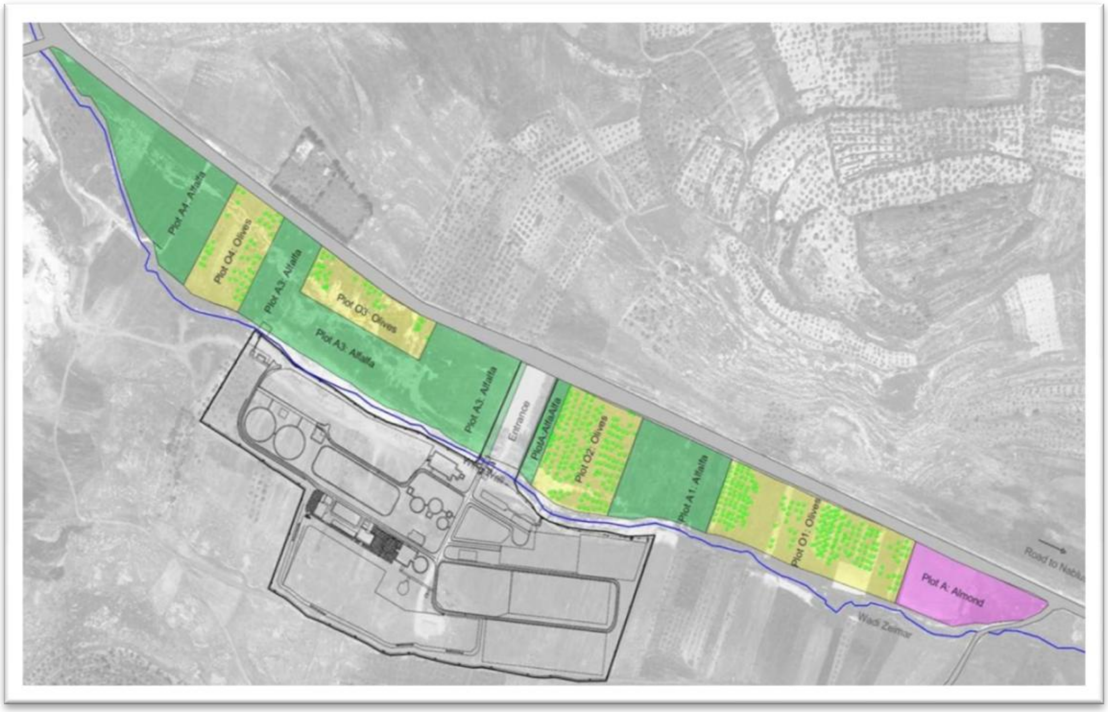


Figure (4): Intended planting lands in Reuse outside scheme.

Table (4): Type of Trees which have been planted in Reuse outside scheme project

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

14.5 Overview of Big Reuse projects

14.5.1 Strategic Reuse Project 2000+

The Wastewater Reuse Project Nablus (WRPN), implemented by NablusMunicipality (NM) as Project Executing Agency (PEA), is a German Financial Cooperation

project funded by the KfW Development Bank on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) with an in-kind and financial contribution of the beneficiary farmers of the Wadi Shaeer reuse irrigation scheme.

The reuse irrigation scheme includes the villages of Burqa, Deir Sharaf, Rameen and Sabastyia west of the city of Nablus and comprises 2,641 dunum (264 ha) of land parcels that are currently cultivated with cultivated with rain-fed crops (olive orchards) or are uncultivated. The overall objective of the project is to make best use of the available treated wastewater (reclaimed water) from the NW-WWTP for agricultural production.

The Financing and Project Agreement between the Palestinian Authority represented by the Ministry of Finance and Planning, and between Nablus Municipality (Project Execution Agency) and KfW was signed on 16 July 2018.

The consulting services to support NM in the implementation of works along and accompanying measures under the project were awarded the Joint Venture (JV) GFA Consulting Group GmbH (GFA, Lead Consultant) and Fichtner Water & Transportation GmbH(FWT) Project implementation started in January 2019, the project implementation period was extended until sept June 2023.

The purpose of this project is to make “best use” of the available reclaimed water from the Nablus-West WWTP with the clear target to:

Maximize cropping, available cropping areas, and financial benefits to each of the stakeholders who are directly involved;

Maximize use of the available reclaimed water and thereby reduce the quantities of treated effluent that are currently flowing across the Green Line into Israel and thus costs to be borne by the Palestinian Authorities;

Create employment opportunities additional income for the local population;

Recover the cost of wastewater treatment.

The project consists of the following (construction) components:

1. Filtration system to eliminate suspended solids;

2. UV Disinfection system for the treated wastewater;

3. Storage tank for treated effluent at the treatment plant;

4. Pumping station to pump the water from the treatment plant to the balancing tank;

5. Trunk line from the pumping station to the tank;

7. Main distribution pipelines from the tank to the minor distribution pipelines;

8. Minor distribution pipelines connecting the main distribution pipelines with the land parcels;

9. Irrigation systems inside and seedling of fruit trees each land parcel;

10. Fittings and accessories for connection of the pipelines;

11. Capacity building and training to farmers, WUA and other stakeholders in different subjects including farming, environment, financial, and technical.

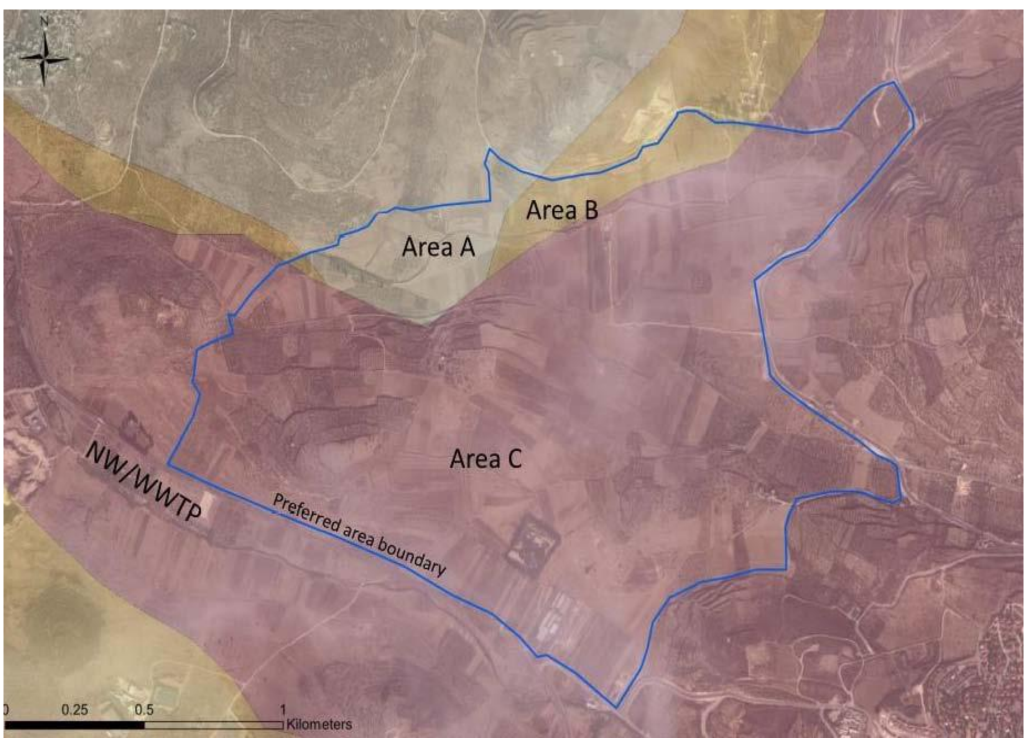


Figure (5): Objected lands in the strategic reuse project 2000+

Figure (6): Irrigation reservoir reuse project 2000+

14.6 Results

The growth status of the plants which have been planted inside the Nablus WWTP was monitored. Table (4) shows the assessment of agricultural experts for the growth status of the different plants types. Also figure (21) shows the growth of olive trees in two different pictures which have been captured within duration of less than one year.

Table (5): Results from reuse pilot project inside scheme

Crop and planting date	Growth status
Almond Tree	Very Good
Pistachio	Good
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

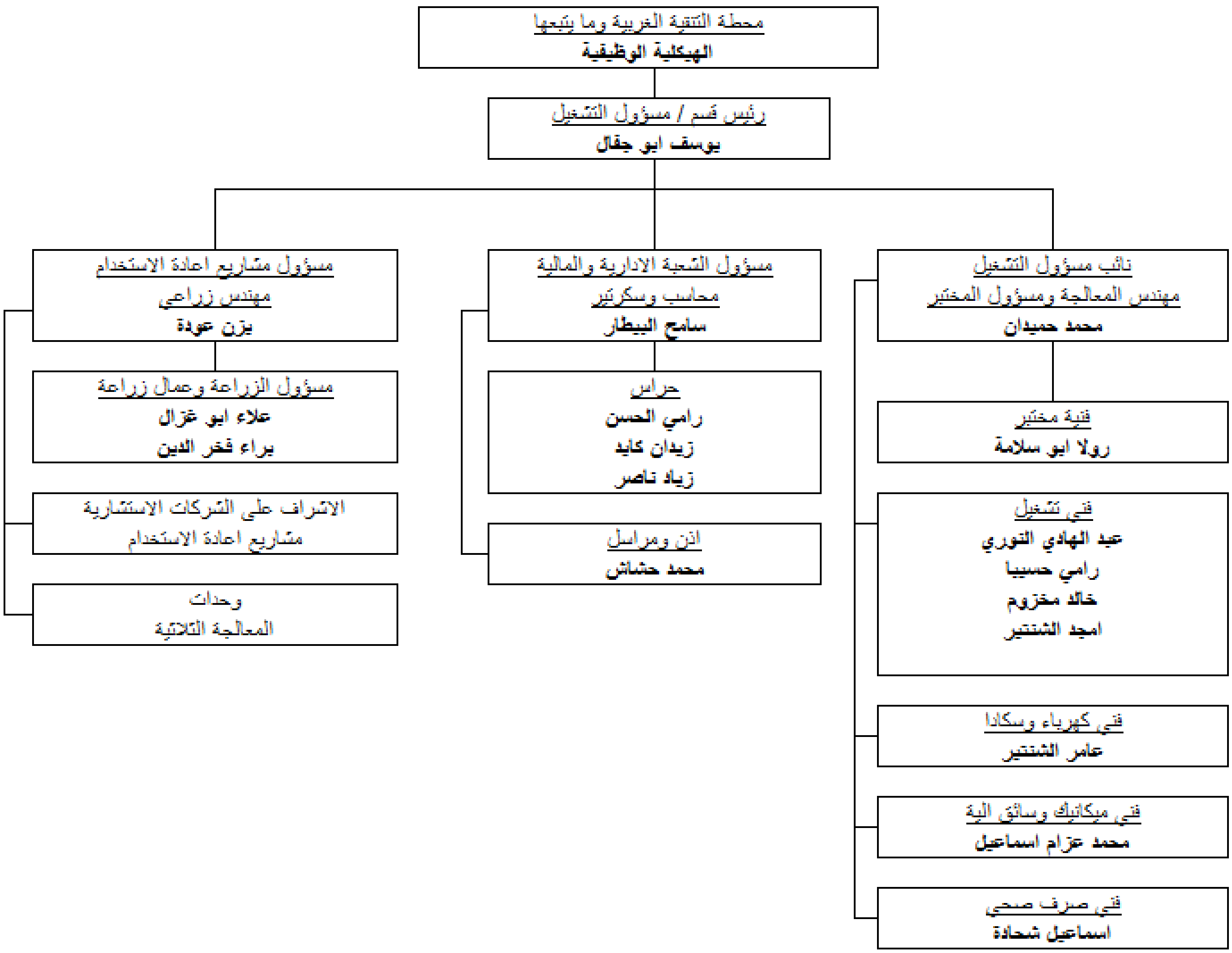
14.7 Summary of all reuse projects of Nablus Plant

This section is summarizing reuse projects of Nablus plant.

Table (6): Summary of Nablus Plant reuse projects

No	Reuse Projects	responsibilities	Area (Donum)	Quantity of TWW (m^3) \Year	Date of Taking Over
1	Reuse Inside WWTP scheme (Pilot)	Nablus Municipality	40	35,000	Jan-2017
2	Compete Project (Pilot)	Dairsharaf cooperative association	140	80,000	June-2017
3	Reuse outside WWTP scheme	WUA	120	115,000	April-2020
4	Strategic reuse project 2000+	WUA	2000	1000000	June - 2023

15. Staff



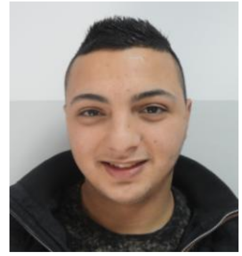
محطة التنقية الغربية وما يتبعها
الهيكلية الوظيفية
رئيس قسم / مسؤول التشغيل
يوسف ابو جقال
مسؤول مشاريع اعادة الاستخدام
مهندس زراعي
يزن عودة
مسؤول الشعبة الادارية والمالية
محاسب وسكرتير
سامح البيطار
نائب مسؤول التشغيل
مهندس المعالجة ومسؤول المختبر
محمد حميدان
مسؤول الزراعة وعمال زراعة
علاء ابو غزال
براء فخر الدين
حراس
رامي الحسن
زيدان كايد
زياد ناصر
فنية مختبر
رولا ابو سلامة
الاشراف على الشركات الاستشارية
مشاريع اعادة الاستخدام
اذن ومراسل
محمد حشاش
فني تشغيل
عبد الهادي النوري
رامي حسيبا
خالد مخزوم
امجد الشنتير
وحدات
المعالجة الثلاثية
فني كهرباء وسكادا
عامر الشنتير
فني ميكانيك وسائق الية
محمد عزام اسماعيل
فني صرف صحي
اسماعيل شحادة

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

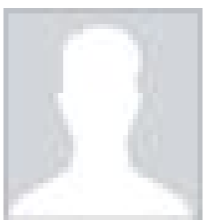
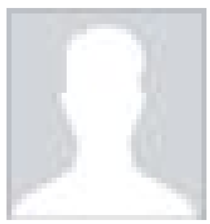
Operators

			
Khaled Makhzom	Amjad Shanteer	Rami Hasiba	Abdel hadi Norie

<table>
<tr><td colspan="2"><u>Electro mechanic Technicians</u>

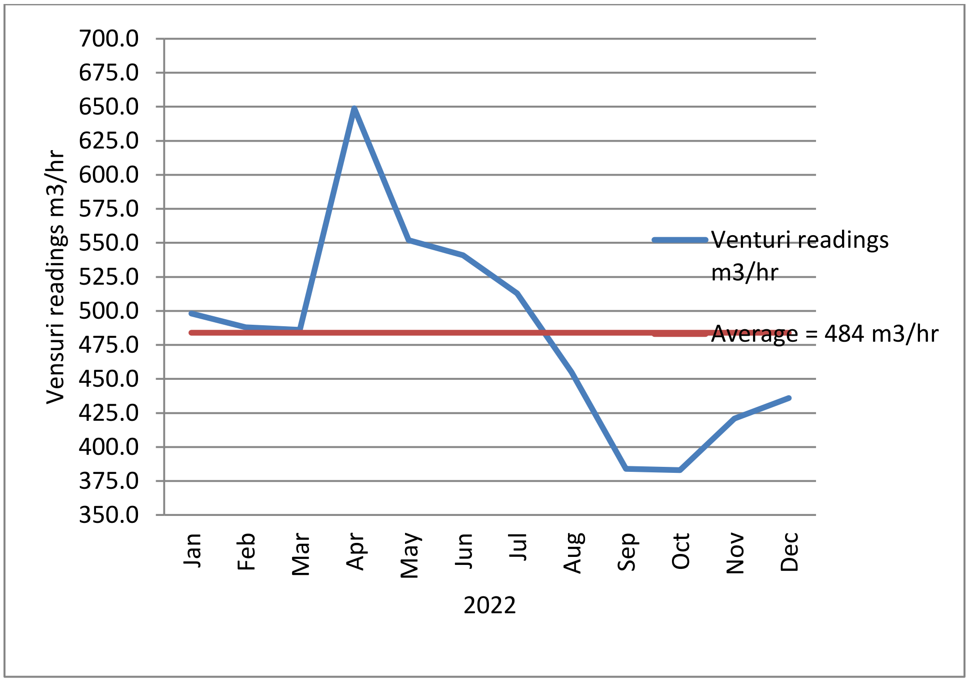
Mohammad Azam</td><td><u>office boy</u>

Mohammad Hashash</td></tr>
<tr><td>Labor

Ismail Shehadeh</td><td colspan="2"><u>Agriculture</u>

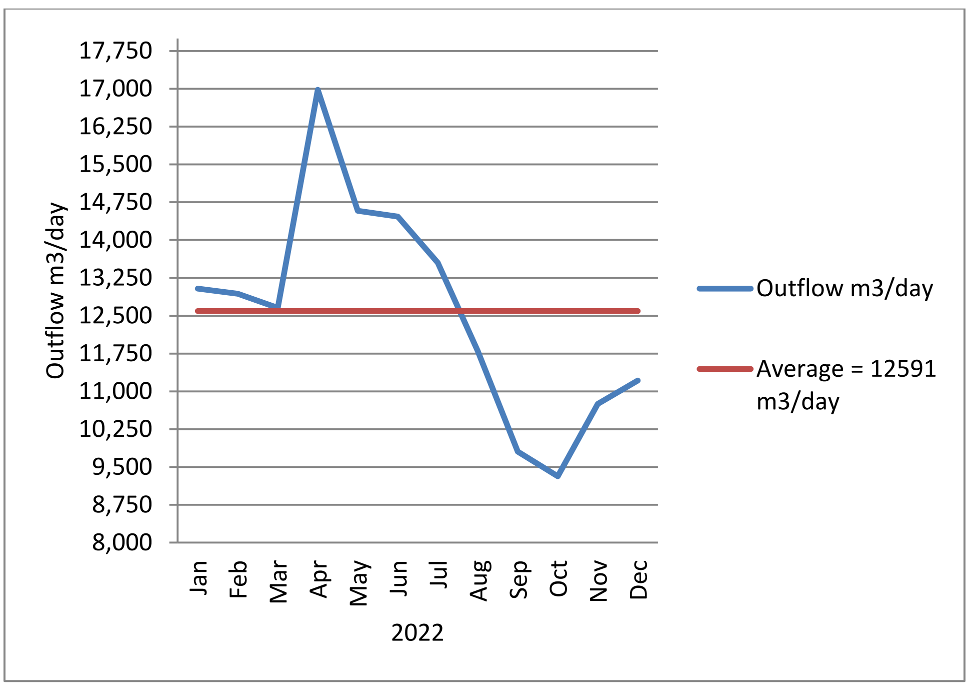
Ala'a Abu Gazal</td></tr>
<tr><td colspan="3"><u>Guards</u></td></tr>
<tr><td>
Rami Hasan</td><td>
Zeidan Kayed</td><td>
Zeiad Nasser</td></tr>
</table>

16. Annexes

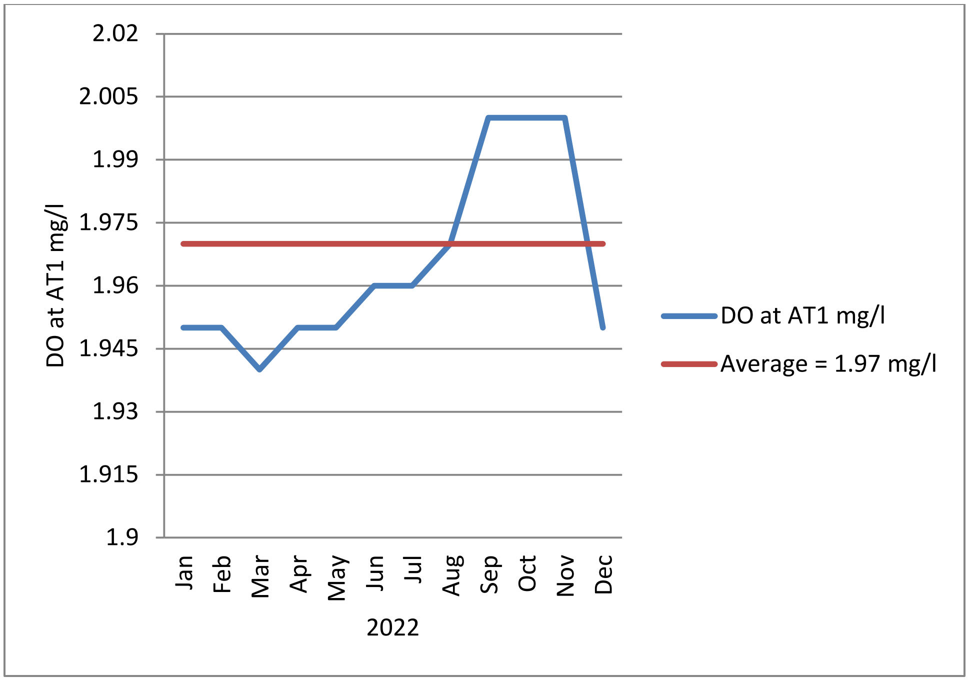
Annex 01: Graphs



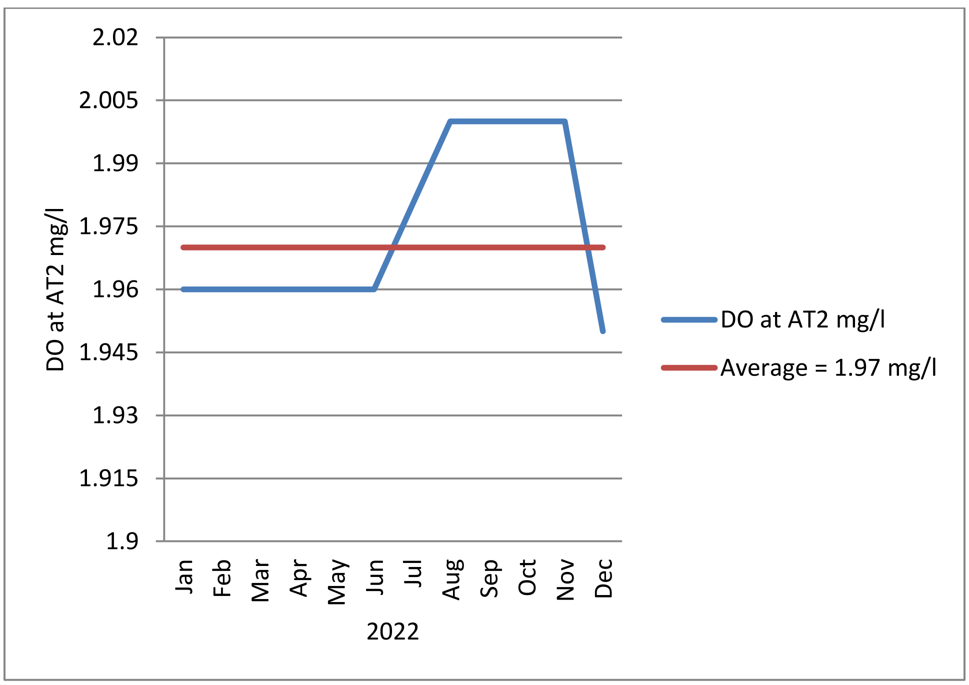
Graph 1: Average wastewater effluent



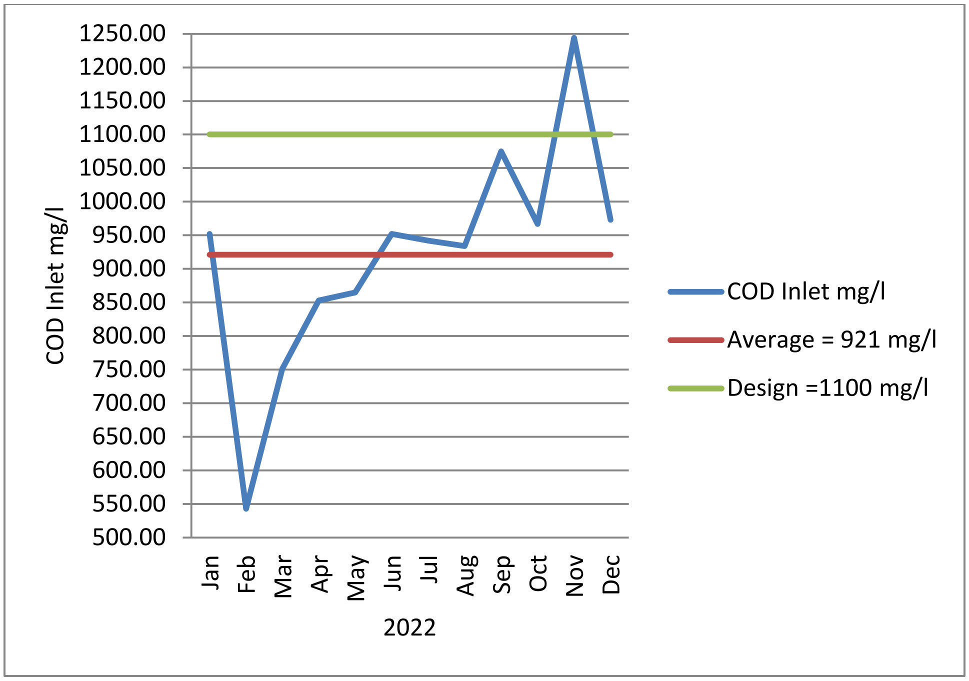
Graph 2: Average treated wastewater effluent



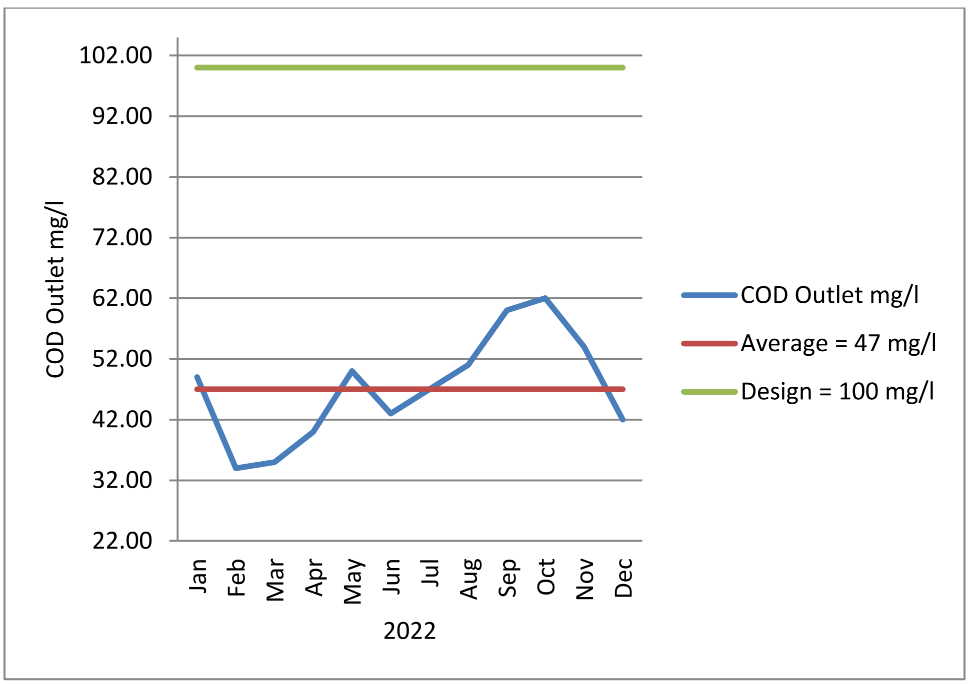
Graph 3: Monthly dissolved oxygen concentration pattern in the aeration tank no. (1)



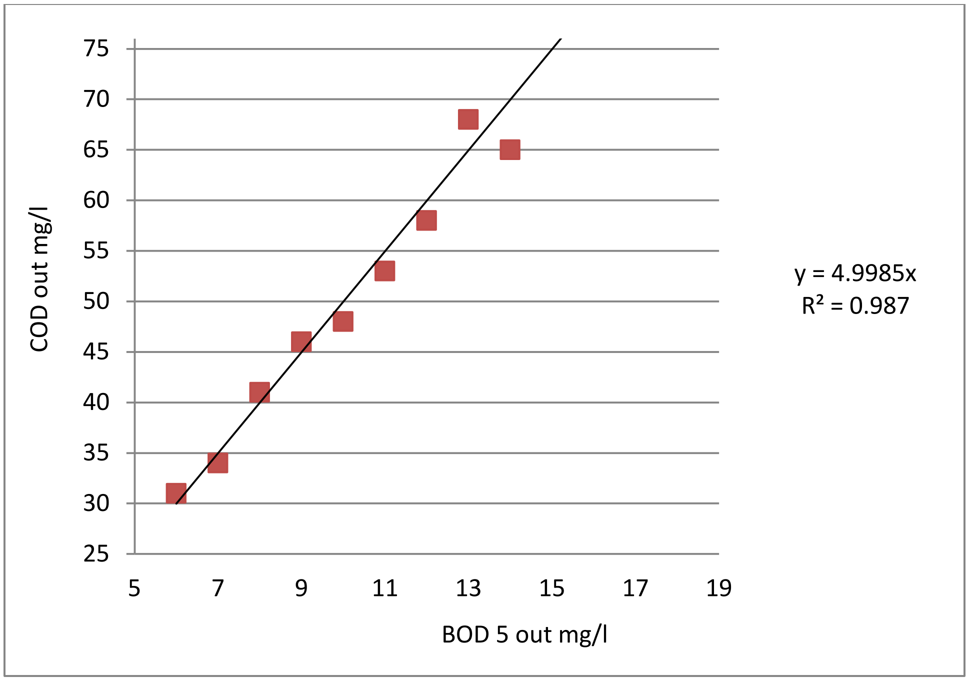
Graph 4: Monthly dissolved oxygen concentration pattern in tank no. (2)



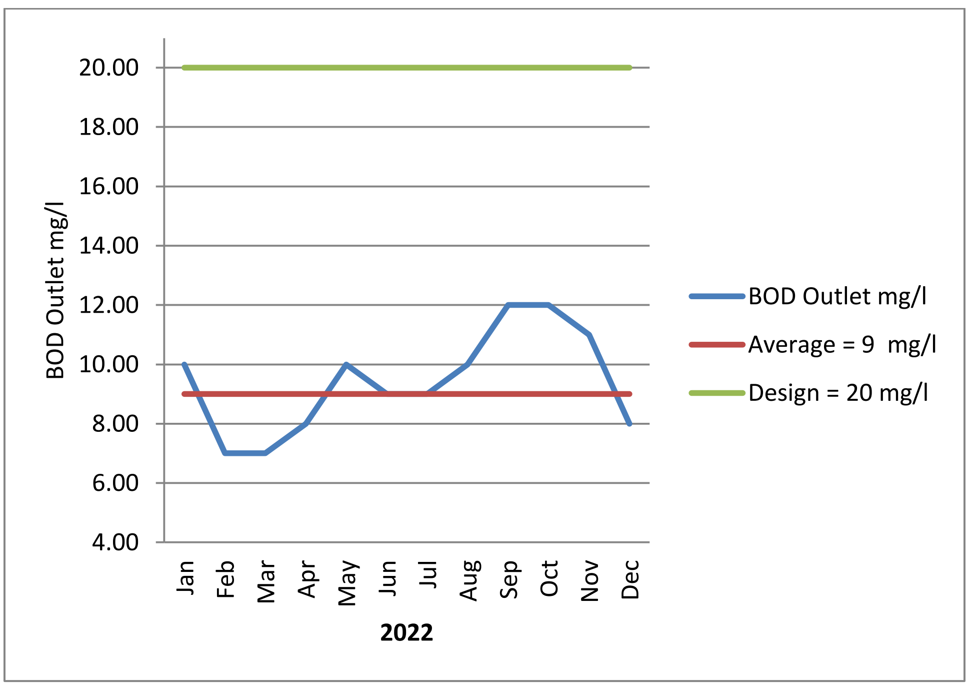
Graph 5: The COD concentration in the influent of WWTP



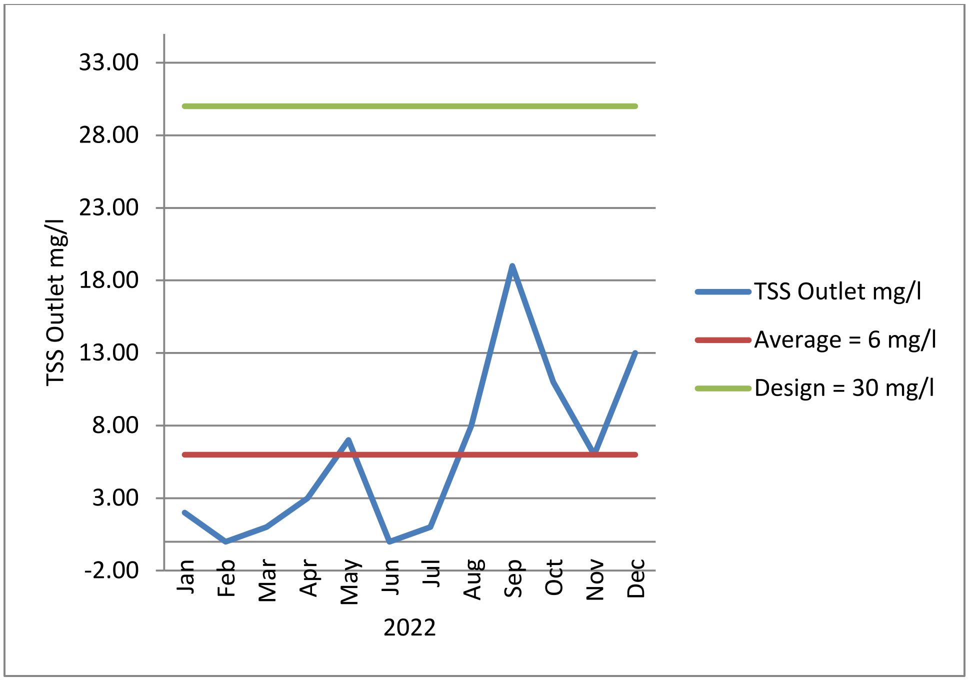
Graph 6: The COD concentration in the effluent of the treated waste water



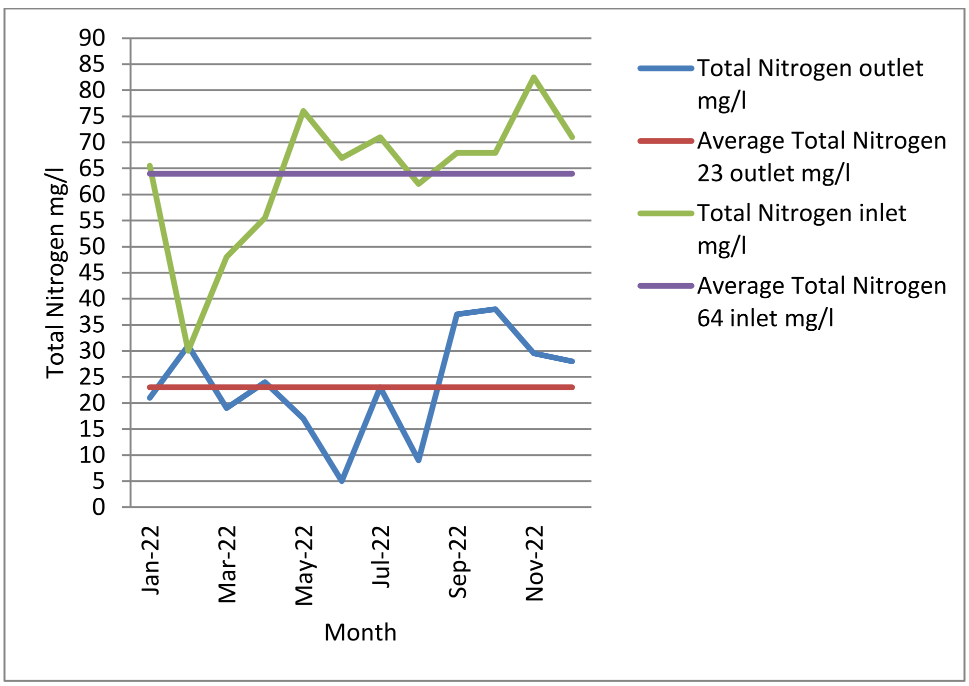
Graph 7: The correlation between COD_{out} and BOD_{5eff}



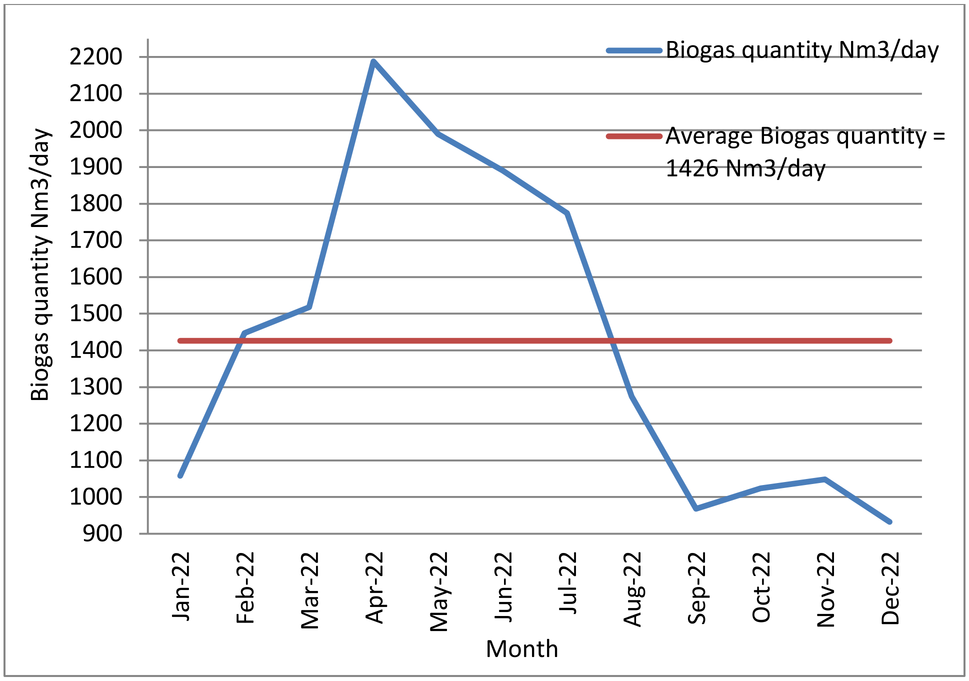
Graph 8: The BOD_5 concentration in the effluent of the treated wastewater



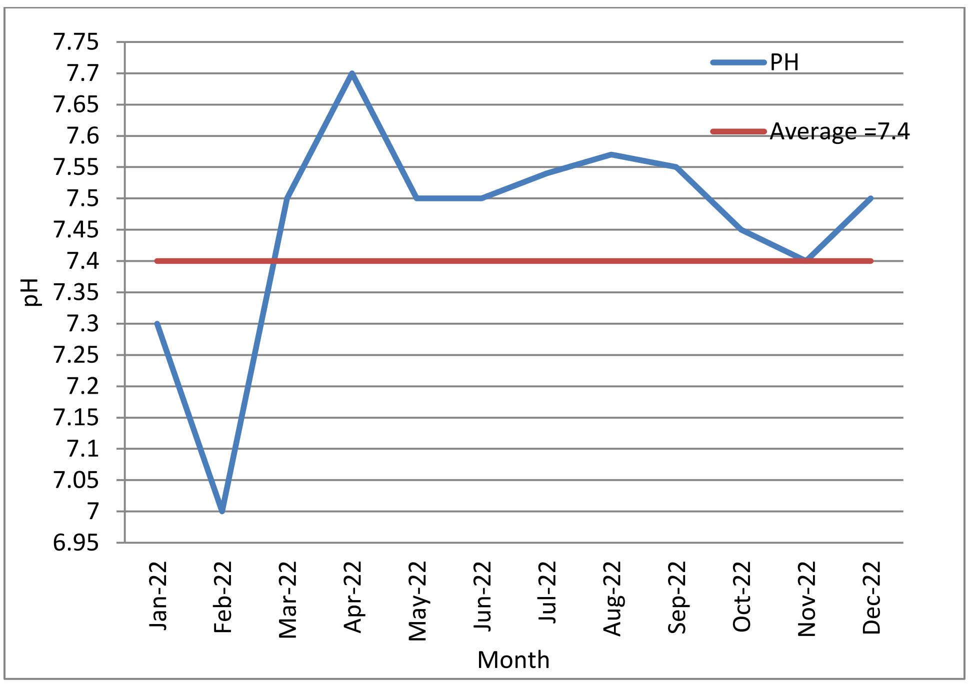
Graph 9: TSS concentration of the treated wastewater (TSS)



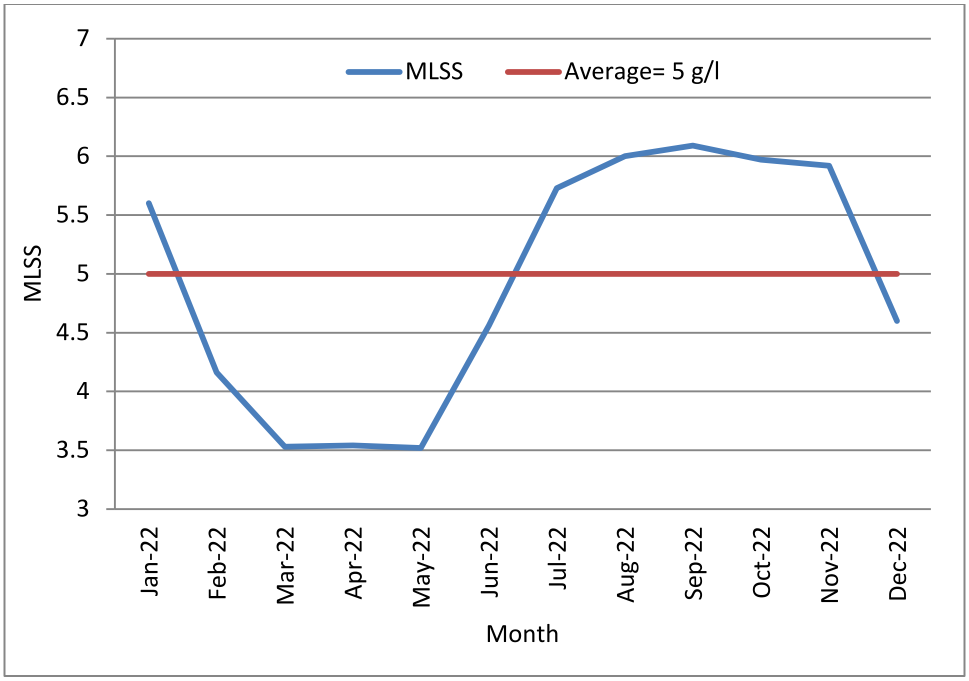
Graph 10: Total Nitrogen for influent and effluent (TN)



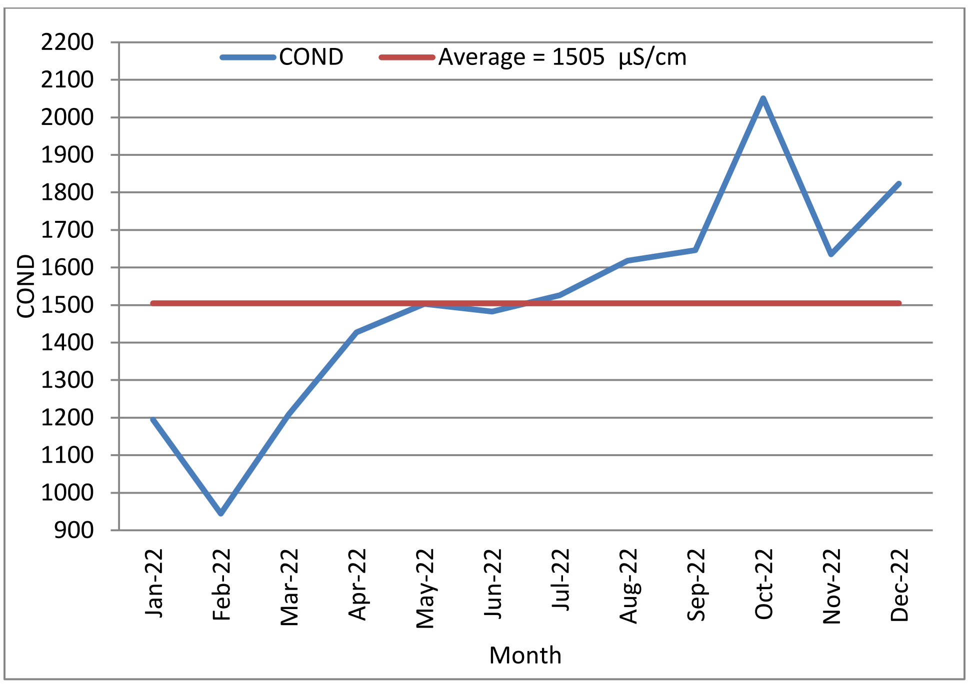
Graph 11: The average produced quantities of biogas



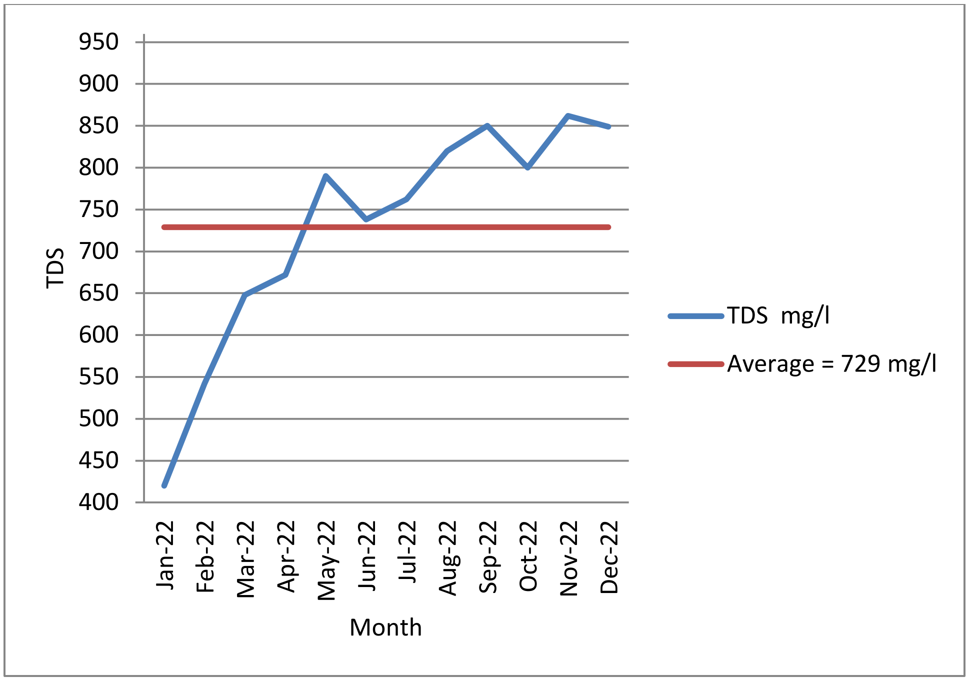
Graph 12: Average pH of the inlet wastewater



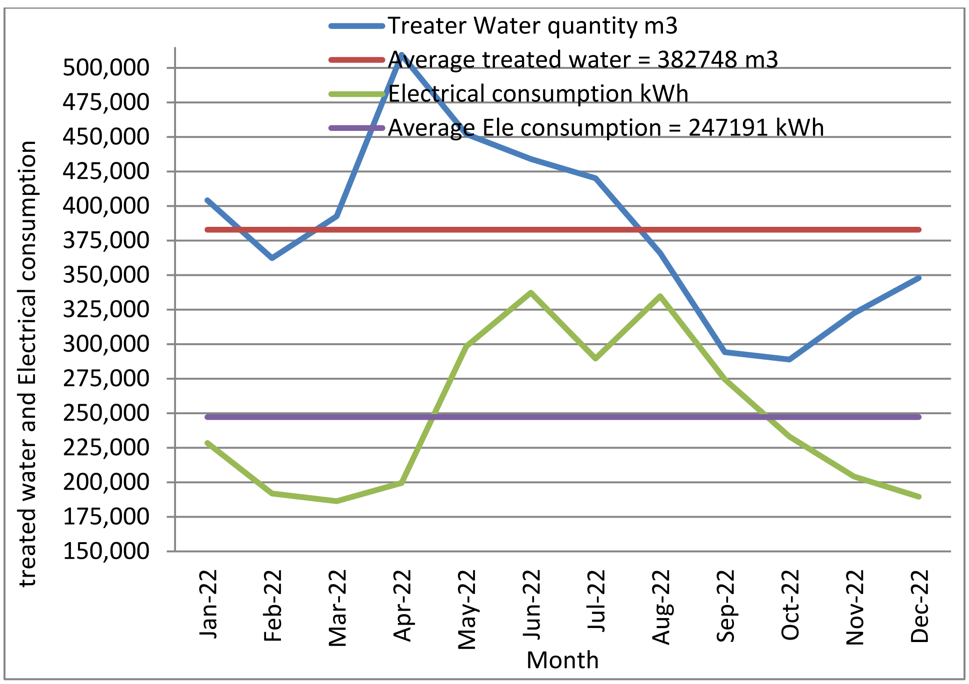
Graph 13: Mixed liquor suspended solids concentration (MLSS) in aeration tanks



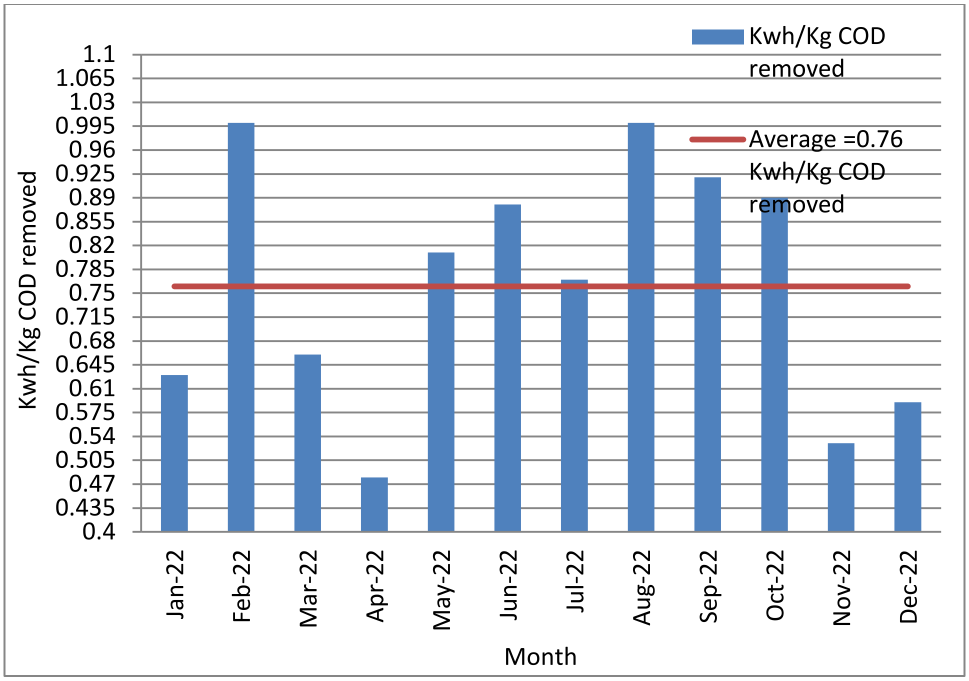
Graph 14: Conductivity of the inlet flow



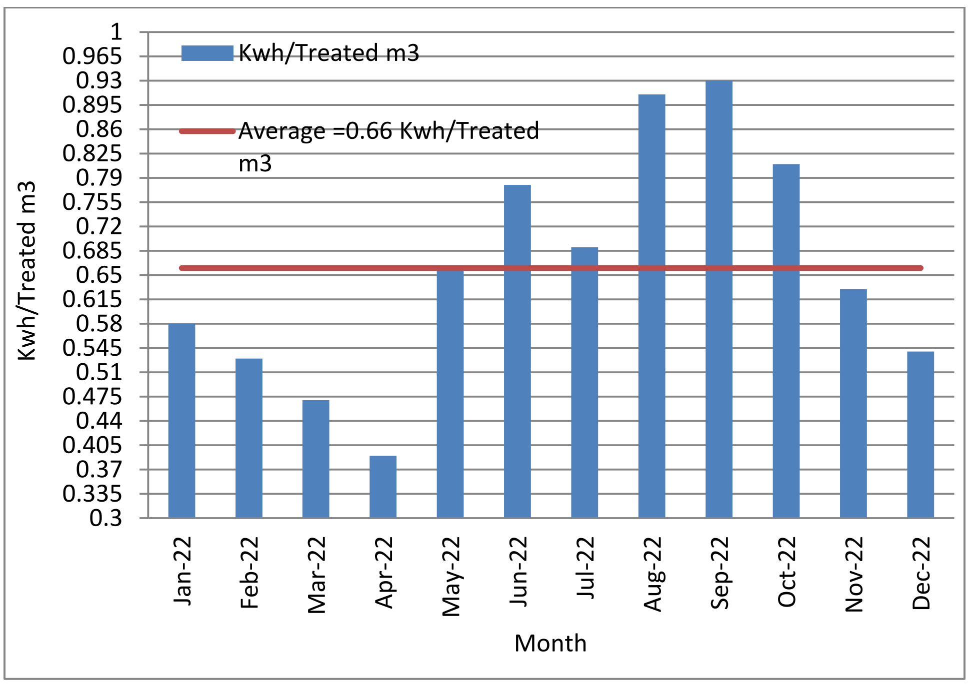
Graph 15: Total dissolved solids in the effluent



Graph 16: Average monthly treated wastewater and power consumption

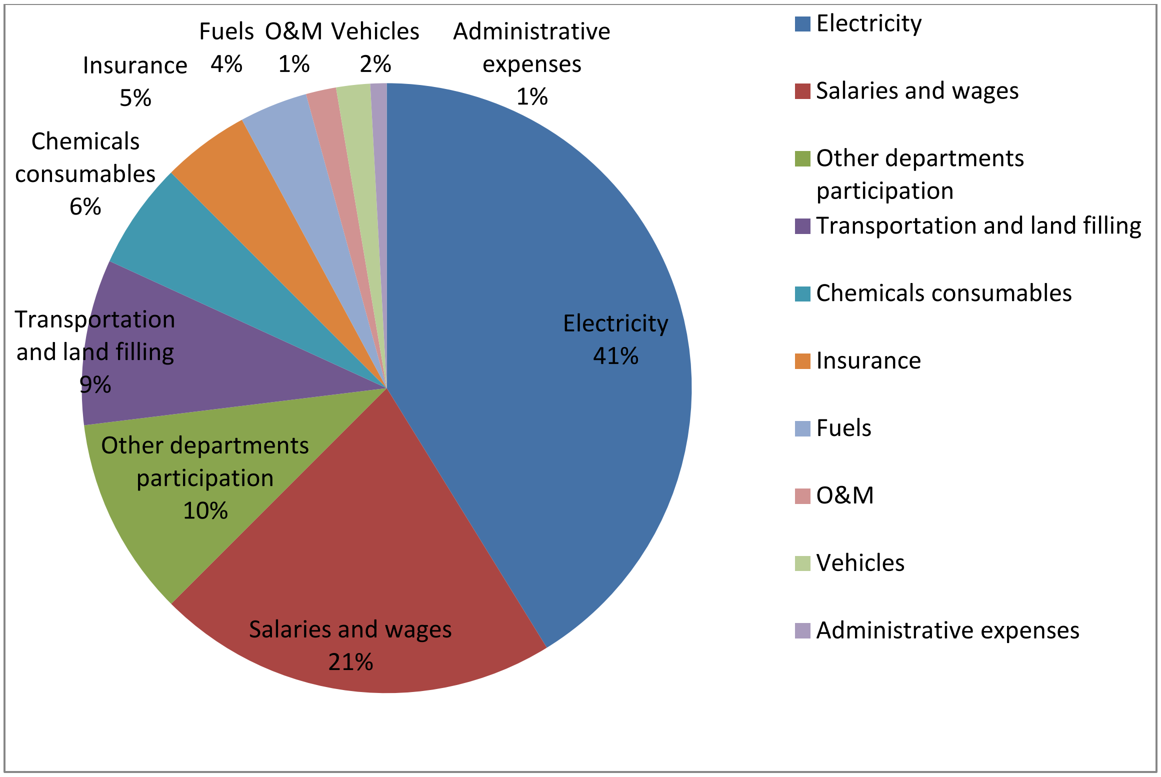


Graph 17: Power requirement kWh/kg COD treated



Graph 18: Power requirement kWh/m^3 treated

WWTP



Graph 19: Expenditures breakdown 2022

Annex 02: Performance summary

Parameters	Design value	Treatment % efficiency	Average	Month - 2022											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average inlet flow m^3/d	14000	-----	12591	13035	12933	12659	16982	14578	14467	13550	11799	9805	9314	10750	11218
Inlet COD mg/L	1100	-----	921	952	543	751	853	865	952	942	934	1075	967	1244	973
Outlet COD mg/L	100	95%	47	49	34	35	40	50	43	47	51	60	62	54	42
Outlet BOD_5 mg/L	20	98%	9.4	10	7	7	8	10	9	9	10	12	12	11	8
Inlet BOD_5 mg/L	550		459	476	272	375	426	432	462	471	467	538	483	622	486
Sludge age (days)	13.7	-----	15	15	15	16	16	15	15	16	15	15	15	16	15
MLSS g/L	3	-----	5	5.6	4.16	3.53	3.54	3.52	4.56	5.73	6	6.09	5.97	5.92	4.6
TSS_{inlet} mg/L	500		362	376	151	250	232	263	312	407	386	525	540	487	413
TSS_{outlet} mg/L	30	98%	6	2	0	1	3	7	0	1	8	19	11	6	13
kWh/kg COD	0.8	-----	0.76	0.63	1	0.66	0.48	0.81	0.88	0.77	1	0.92	0.89	0.53	0.59

Annex 03: Power consumption

Month	Avg	2022											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Treated wastewater quantity m^3	382,748	404,086	362,132	392,442	509,470	451,917	434,007	420,048	365,764	294,140	288,731	322,469	347,769
Total electrical consumption kWhr	247,191	196,580	141,700	133,743	111,296	206,550	236,649	212,450	269,620	259,330	220,993	195,150	182,789
PV electrical production kWhr		6,800	10,000	17,240	15,863	21,283	26,814	12,630	18,410	15,070	12,090	9,000	6,700
production CHP electrical kWhr		25,000	40,000	35,200	72,171	70,412	73,819	64,445	46,500	under maintenanc e	under maintenanc e	under maintenanc e	under maintenanc e
kWhr per m^3	0.65	0.57	0.53	0.47	0.39	0.66	0.78	0.69	0.91	0.93	0.81	0.63	0.54

Annex 04: Additional lab Tests in WWTP Lab

/ Test	Values	Average	2022											
			Dec	Nov	Oct	Sep	Aug	Jul	Jun	May	Apr	Mar	Feb	Jan
COD out mg/l	Average	47.3	42.00	54.00	62.00	60.00	51.00	47.00	43.00	50.00	40.00	35.00	34.00	49.00
	Max	59.6	62.00	72.00	70.00	63.00	61.00	53.00	72.00	62.00	57.00	43.00	42.00	58.00
	Min	31.9	4.00	39.00	53.00	52.00	43.00	42.00	32.00	34.00	31.00	28.00	23.00	2.00
BOD out mg/l	Average	9.4	8.00	11.00	12.00	12.00	10.00	9.00	9.00	10.00	8.00	7.00	7.00	10.00
	Max	11.8	12.00	14.00	14.00	13.00	12.00	10.00	14.50	12.00	11.00	8.60	8.50	11.50
	Min	6.8	0.80	8.00	11.00	10.00	8.00	8.00	6.50	7.00	6.00	5.60	4.50	6.00
NH4-N out mg/l	Average	16.2	15.00	27.00	30.00	34.00	17.00	19.85	3.90	18.30	24.00	4.30	0.20	1.00
	Max	20.5	24.00	29.60	36.00	36.00	27.00	21.30	4.50	27.60	29.00	8.60	0.30	2.00
	Min	11.3	4.00	25.40	24.00	32.00	8.00	18.40	3.30	2.60	17.00	0.60	0.10	0.00
NO3-N out mg/l	Average	7.0	0.60	2.00	0.70	0.45	0.40	0.80	0.30	7.25	0.25	22.90	29.90	18.00
	Max	8.8	0.60	2.80	0.70	0.50	0.50	0.80	0.30	13.70	0.30	28.90	31.80	25.00
	Min	5.1	0.60	1.40	0.70	0.40	0.30	0.80	0.30	0.80	0.20	16.90	28.00	11.00
TN out mg/l	Average	23.5	28.00	29.50	38.00	37.00	9.00	23.00	5.00	17.00	24.00	19.00	31.00	21.00
	Max	24.9	34.00	31.00	38.00	37.00	9.00	23.00	5.00	17.00	28.00	19.00	31.00	27.00
	Min	21.8	20.00	28.00	38.00	37.00	9.00	23.00	5.00	17.00	20.00	19.00	31.00	15.00
PO4-P out mg/l	Average	3.9	3.13	NA	NA	5.22	5.96	2.56	1.84	2.62	5.82	4.96	4.00	2.92
	Max	3.9	3.13	NA	NA	5.22	5.96	2.56	1.84	2.62	5.82	4.96	4.00	2.92
	Min	3.9	3.13	NA	NA	5.22	5.96	2.56	1.84	2.62	5.82	4.96	4.00	2.92
TSS out mg/l	Average	5.9	13.00	6.00	11.00	19.00	8.00	1.00	0.00	7.00	3.00	1.00	0.00	2.00
	Max	13.3	30.00	16.00	18.00	36.00	16.00	4.00	4.00	12.00	12.00	6.00	0.00	6.00
	Min	1.4	0.00	2.00	4.00	8.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	1.00
MLSS mg/l	Average	4.9	4.60	5.92	5.97	6.09	6.00	5.73	4.56	3.52	3.54	3.53	4.16	5.60
	Max	6.0	7.25	7.05	6.90	6.99	7.00	6.48	5.61	4.27	4.23	4.62	4.88	6.60
	Min	3.8	2.67	3.28	5.20	5.13	5.00	5.05	3.25	2.92	2.85	2.63	3.50	4.70