Faculty of Graduate Studies

Reality and Challenges of Water Quality in Palestine: Focus on Regulations and Monitoring of Wastewater Treatment and Reclaimed Water Use

واقع وتحديات جودة المياه في فلسطين: التركيز على انظمة ورقابة معالجة المياه العادمه واستخدام المياه المستصلحه

M.Sc. Thesis in Water and Environmental Sciences

Prepared By: Dalia Jaradat

Registration Number [1115409]

Main Supervisor: Dr. Rashed Al-Sa`ed

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This thesis was prepared under the main supervision of Dr. Rashed Al-Sa'ed and has been approved by all members of the examination committee**.**

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The findings, interpretations and the conclusions expressed in this study do not necessarily express the views of Birzeit University, the views of the individual members of the M.Sc. Committee or the views of their respective employers.

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Abstract

Palestine suffers not only from the shortage of water but also from the poor quality of available resources. More than 95% of groundwater wells, main potable source in Gaza Strip, are reported unfit neither for human consumption nor for agricultural irrigation. Lack of financial resources and the prevailing political environment are among the main reasons behind poor water quality management in Palestine. The institutional building and good governance are crucial for the development and sustainable management of wastewater infrastructures, supported by governmental reform program for the water and sanitation sectors. The reform program in 2014, resulted in a new Water Law (WL), aimed at ensuring good governance within the water and sanitation sectors. The new WL divided the historical functions of the Palestinian Water Authority (PWA) into ministerial and regulatory functions. The PWA functions as a regulatory body for protection and monitoring of water resources, while monitoring of water and sanitation services is the mandate of the Water Sector Regulatory Council, a newly established governmental institution.

The goal of this study focuses on challenges and perspective of water quality management with special emphasis on water law and regulations pertinent to wastewater treatment facilities and reclaimed water use in agriculture. Specific objectives are two folds; first to critically review and analyze the current valid water legislation and quality standards required; second to examine the current practices on water quality monitoring of reclaimed water use in agricultural purposes. For this purpose, Nablus West wastewater treatment plant (Nablus West

WWTP) was taken as a case study, where monthly self-monitoring reports were collected and analyzed.

One major finding of this study is the lack of by-laws regarding monitoring and enforcement mechanisms to ensure sustainable water and wastewater treatment facilities. The by-law on household connection to public sewers is the only endorsed instrument currently valid. The current water and wastewater treatment facilities are barely monitored or controlled, where monitoring mechanism and use of polluter pay principles are non-existing. Local rules and regulations set for monitoring of raw sewage characteristics into sewerage networks and standards on quality of treated water for diverse beneficial uses are not forced or applied.

The study underlines the fact of considering wastewater as an integral part of water resources management, where the construction or rehabilitation of urban sewage works are of high priority. This is reflected by the increased amount of wastewater generated reaching about 180 million cubic meters [MCM] of treated water by 2025. The study shows that the current regulations and standards applied in Palestine are in line with regional and WHO standards and regulations. To elevate the pressure on fresh water, priority of reuse of treated effluents should be directed as a source for irrigation. Treatment of wastewater shall be targeted towards producing an effluent complying with local effluent rules and regulations. The quality of reclaimed water for agricultural purposes shall consider soil characteristics, type of crops, irrigation methods, and quality of other waters if mixed with treated wastewater.

Results analysis of monthly self-monitoring reports on process performance and

effluent quality of Nablus West WWTP revealed a reliable treatment system complying with set local effluent limits for agricultural irrigation, except for microbiological limits. Since no chlorination system installed at Nablus West WWTP, the microbiological quality of the effluent exceeded by far the limits for the lowest quality standard (Class D) set by Palestinian obligatory Technical Rule (TR 34-2012). For farmer's safety, soil and produce irrigated with reclaimed water, disinfection unit must be installed as an integral unit operation of any given wastewater reuse scheme.

Current liquid discharges form industrial enterprises within Nablus area shall be monitored by enforcing the municipal by-law governing limits discharge criteria and the polluter pays principle. This study underlines the importance of intra-collaborative efforts between the PWA and the WSRC to prepare relevant by-laws endorsed within the diverse water law articles. Of priority are by-laws pertaining to water service providers, monitoring of and sanitation facilities including effluent discharges. All this, shall promote sustainable water and sanitation facilities and enhance the economic development of Palestinian communities.

الخلاصة

لا تعاني فلسطين فقط من نقص المياه بل أيضا من تدهور نوعية المياه للموارد المتاحة. أكثر من 95% آبار المياه الجوفية في الحوض الساحلي مصدر الشرب الرئيسي في "قطاع غزة"، غير صالحة للاستهلاك البشري ولا للري الزراعي.

الافتقار إلى الموارد المالية والبيئة السياسية السائدة من بين الأسباب الرئيسية وراء تدهور نوعية المياه في فلسطين وضعف ادارتها. بناء المؤسسات والحكم الرشيد قضيتان حاسمتان للتنمية والإدارة المستدامة للمياه العادمة والبنى التحتية، يدعمها وركز عليها برنامج الإصلاح الحكومي لقطاعي المياه والصرف الصحي. كنتيجة لبرنامج الإصلاح تم المصادقة على قانون المياه الجديد في العام 2014، والذي هدف الى ضمان الحكم الرشيد في قطاع المياه والصرف الصحي

القانون الجديد قسم المهام التاريخية لسلطة المياه الفلسطينية الى مهام وزارية واخرى تنظيمية. اوكلت قضايا حماية ورقابة المصادر الطبيعية الى سلطة المياه واوكلت مراقبة ورصد خدمات المياه والصرف الصحي الى "المجلس التنظيمي لقطاع المياه"، كمؤسسة حكومية أنشئت حديثا حسب القانون الجديد.

الهدف من هذه الدراسة هو التركيز على التحديات ومنظور إدارة نوعية المياه مع التركيز بوجه خاص على قانون المياه والأنظمة ذات الصلة بمعالجة مياه الصرف الصحي واعادة استخدام المياه المستصلحة في الزراعة. الأهداف المحددة تنقسم الى شقين ؛ أولاً الاستعراض النقدي وتحليل التشريعات المائية الحالية والسارية ومعايير الجودة المطلوبة للاستخدامات المختلفة؛ وثانيا لدراسة الممارسات الحالية في رصد نوعية المياه المستصلحة لاعادة الاستخدام المياه المستصلحة في الأغراض الزراعية. ولهذا الغرض، اتخذت محطة معالجة مياه الصرف الصحي"غرب نابلس" كدراسة حالة، حيث جمعت تقارير شهرية عن الرصد الذاتي وتحليلها ومناقشتها.

إحدى النتائج الرئيسية لهذه الدراسة هو عدم وجود انظمة ولوائح بشأن آليات الرصد والمراقبة والإنفاذ لضمان المستدامة للمياه ومياه الصرف الصحي في مرافق المعالجة. هناك فقط نظام واحد تمت المصادقة عليه وهو المتعلق بربط المساكن والمنشاءات بشبكة الصرف الصحي العام وهو النظام الوحيد الساري حاليا.

مرافق معالجة المياه ومياه الصرف الصحي الحالية بالكاد يتم رصدها أوالمراقبةعليها، بحيث تنعدم إليه الرصد والمراقبة وغياب تطبيق مبدا الملوث يدفع.

القواعد المحلية واللوائح المحددة لرصد المياه العادمة وتصريفها في شبكات الصرف الصحي والمعايير المتعلقة بجودة المياه المعالجة لاستخدامات مفيدة ومتنوعة يكاد ينعدم تطبيقها او انفاذها. وتؤكد الدراسة على ضرورة اعتبار والنظر في مياه الصرف الصحي كجزء لا يتجزأ من إدارة موارد المياه، حيث يجب اعتبار بناء أو إعادة تأهيل شبكات الصرف الصحي ومحطات المعالجة ذات أولوية عالية. وخاصة الى بالنظر ان فلسطين سوف يتوفر لديها حوالي 180 مليون متر مكعب من المياه المعالجة بحلول عام 2025.

وتبين الدراسة أن الأنظمة الحالية والمعايير المطبقة في فلسطين تتماشى مع معايير منظمة الصحة العالمية والإقليمية والأنظمة. لرفع الضغط على المياه العذبة، وينبغي توجيه الأولوية لإعادة استخدام مياه الصرف المعالجة كمصدر للري. يجب أن تستهدف معالجة مياه الصرف الصحي الوصول الى مياه معالجة تمتثل لقواعد الصرف المحلية واللوائح. المياه المستصلحة للأغراض الزراعية يجب ان تاخذ بعين الاعتبار خصائص التربة، نوعية المحاصيل، طرق الري ونوعية المياه الأخرى إذا كانت مختلطة مع مياه الصرف الصحي المعالجة.

كشفت نتائج التحاليل لتقارير الرصد الذاتي الشهرية عن أداء ونوعية المياه المعالجة في محطة تنقية المياه العادمة لـ "غرب نابلس"ان نظام المعالجة يستجيب للمعايير المحلية المحددة للري الزراعي، باستثناء المعايير الميكروبيولوجية. الافتقار الى وحدة الكلورة والتعقيم في محطة تنقية غرب نابلس ادى الى عدم استجابة المياه المعالجة وتجاوزها بكثير لحدود الأدنى جودة قياسية (فئة د) المنصوص عليها في "المواصفات الفنية" إلزامياً الفلسطينية (م ف 34–2012). لسلامة للمزارعين والتربة والمحاصيل المروية بالمياه المستصلحة، يجب تثبيت وحدة التعقيم كوحدة لا تتجزأ في أي نظام إعادة استخدام المياه المستصلحة.

التصريف للمياه العادمة من المنشاءات الصناعية داخل منطقة نابلس يجب ان يتم مراقبته وتطبيق الانظمة واللوائح ومبدا الملوث يدفع. تؤكد هذه الدراسة على أهمية تضافر الجهود التعاونية بين سلطة المياه ومجلس تنظيم قطاع المياه من اجل اعداد الانظمة والوائح ذات الصلة المختلفة كما أقرت ضمن مواد قانون المياه الجديد. يجب ايلاء الاهمية الأولوية للانظمة المتعلقة بمقدمي خدمات المياه، ورصد ومرافق الصرف الصحي بما في ذلك تصريف المياه العادمة. كل هذا، يتعين بتعزيز مرافق المياه والصرف الصحي واستدامتها والذي سيسهم في تعزيز التنمية الاقتصادية للمجتمعات المحلية الفلسطينية.

Dedication

To
My awesome *husband and lovely family,*

Acknowledgments

My greatest thanks and appreciations go to all those who contributed to this work, whose active support, encouragement and guidance made this research possible.

My personal thanks go to my husband Dr. Shaddad Attili who helped me a lot on understanding better the water crisis in Palestine, the Water Sector Reform and the reality and challenges that faces the sector moreover taking care of my lovely kids Rashad and Natalie during the whole period of my MSc study and research.

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List of Abbreviations

Abbreviation	Description
BOD_5	Biochemical Oxygen Demand at 5 days
BOO	Build Operate Own
BOT	Build – Operate – Transfer
CPHL	Central Public Health Lab
COD	Chemical Oxigen Demands
DO	Dissolved Oxygen
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EQA	Environment quality Authority
JSC	Joint service Council
FAO	Food and Agricultural Organization of the United Nation
JWC	Joint Water Committee
K	Potassium
L	Liters
l/c/d	Liters per capita per day
LGM	Local Government Municipalities
IWRM	Integrated Water Resource Management
Mcm	Million cubic meters
MENA	Middle East North Africa
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoH	Ministry of Health
MoU	Memorandum of Understanding
MoLG	Ministry of Local Government
N	Nitrogen
NIS	New Israeli Shekel
NM	Nablus Municipality
NW	Nablus West
NWC	National Water Council
NW/WWTP	Nablus West Wastewater Treatment Plant
OM	Organic Matter
O&M	Operation and Maintenance
P	Phosphorus
PCBS	Palestinian Central Bureau of Statistics
PNA	Palestinian National Authority
ppm	Parts per million

PWA	Palestinian Water Authority
QMRA	Quantitative Microbial Risk Assessment
SS	Suspended Solids
TDS	Total Dissolved Solids
TOR	Term of Reference
TSS	Total Suspended Solids
USAID	The United States Agency for International Development
UV	Ultraviolet
WHO	World Health Organization
WSRC	Water Sector Regulatory Council
WUA	Water Users Association
WBWD	West Bank Water Department
WWTP	Wastewater Treatment Plant

CHAPTER ONE: INTRODUCTION

1.1 Overview

Water is essential for life. It's essential for people living, hygiene, health and deferent aspects of prosperity. Water is crucial element for all purposes including domestic, agricultural and industrials uses.

Globally, fresh water represents less than 3%, unequally distributed in the world. It faces huge threat and alteration in term of quality and quantities due to several factors, among them, pollutions and climate changes (USGS, 2005).

In arid and semi-arid countries, particularly in the Middle East- North Africa known as MENA region, countries suffer from Water Scarcity. Water shortages and crisis are even aggravated by consequences of climate changes, in many occasion political instability and conflict over shared river basins (World Bank, 2008).

Compared to the annual water threshold line known as 1000 cubic meter per person, Palestine is one among these countries lies under the threshold line. It even lies under the absolute threshold as water per capita is less than 500 cubic meters per person per year (World Bank, 2008).

Palestine like other water shortage' countries, does not suffer only from shortage of water quantity; the quality of water is another huge challenge that Palestine is facing. Gaza Strip Aquifer waters as well as many resources in the West Bank are suffering from pollution and increasing of water salinity and contamination. United Nation reports show that Gaza runs out of usable water by 2016 (PWA, 2014).

Clean, safe and adequate freshwater and non-conventional resources are essential. The issue of water quality has a great concern to address the shortage on fresh resources and its availability for different usage.

Quality of water is threatened by the uncontrolled industrial and agricultural practices. Pollution of sewage, solid waste and aquifers over abstraction are major reasons of pollution. Climate changes make the problem even worse and increase the tense over the available water resources (WHO, 2008).

Protections of resources from pollution, meeting standards and respond to regulations are essential for the functioning and viability of ecosystems and communities, and development of society.

Palestine, located in arid and semi-arid region known by its drought nature, water resources is scare and suffers not only from climate changes impacts but also the human practices and political conflict.

Problems on access and management due to prevailing political conflict between the Israelis and Palestinians have negative impacts on water quantity and quality. Water crisis and continued conflict on land and natural resources have resulted in mismanagement practices that affected the water quality and increased its deterioration. This has been worsening by lacking of a common plan for the management of the shared water resources, unfocused water and sanitation governance, poor investment in the water and wastewater sectors- usually huge investments required- lack of sewage treatment plants and sewer networks, lack of sanitary landfills, poor service provision with deteriorated water system (old water networks, old transmission lines, old reservoirs…etc.), absence of and/or

insufficient regulations and monitoring programs for protection of resources and for water supply and in many occasions; absence of law enforcement have led to water/wastewater mismanagement practices that directly impacted both water availability and water quality (PWA, 2014).

Such consequences on water quality have made the problem of water scarcity and water shortage in Palestine even worse.

1.2 Statement of the Problem

Water quality, which is as significant and important as quantity, has been overlooked for decades in terms of legislation, investment and public awareness.

Water and sanitation infrastructure, water and sanitation policies, good governance and practice, proper legislation, regulation and standards are key issues to safeguard humans and their surrounding environment.

Much legislations and regulations were designed worldwide to regulate the water resource protection, water supply and sanitation, protection of environment and prevention of pollution. Standards have been adopted for different purposes of water use and reuse. Monitoring systems have been put in place to ensure responding to these regulations and standards.

In Palestine, a recent water law (2014) was endorsed. The new law created the Water Sector Regulatory Council (WSRC). By law, the Palestinian Water Authority (PWA) has to prepare bylaws to be endorsed by the Cabinet of Ministers, the WSRC has to follow implementation.

Unfortunately, as of end 2015, there are only two bylaws related to water that approved by the government, one on tariff (yet needs to be modified according to

the new water law as tariff has to be endorsed by the WSRC and not PWA as it stated) and the second on the connection of households and facilities to public sewage networks.

Apart the effort that PWA is doing related to sampling and checking the water quality of natural resources, Ministry of Health (MoH) as well as water service providers are responsible for the monitoring ensuring water supply for domestic purposes.

Discharge of sewage and wastewater remain unregulated apart what has been articulated in by Law of household and facilities connection to public sewage network, not monitored and reuse of treated sewage is the challenge that Palestine is facing after engaging on building several small and large scale sewage treatment plants in both Gaza Strip and West Bank.

1.3 Research Objective and Questions

This research will discuss realities and challenges of the wastewater quality issues, regulation and monitoring in the Palestinian territories.. Furthermore, the research will address the issue of reuse as the status of water supply and sanitation required for maximizing the available resources, both conventional and non-conventional ones. Special focus will be given to the reuse of reclaimed wastewater and present the case in the neighboring countries and the region. Emphasis will be on wastewater discharge and reuse after treatment. The study will also shed the light on water quality as reflected in the Palestinian new Water law and as addressed by the Palestinian water reform program.

This research will try answering the following major questions:

- What are the current water resources, water supply regulations, legislations and monitoring programs?
- What are the measures, policies regulations and standards related to the protection of water resources and the safety of water use and reuse?
- What is the status of wastewater in Palestine and regional experience on reuse of treated wastewater?
- Nablus West Sewage Treatment Plant (NWWTP) will be the case study, monthly analysis of the treated water and possibility of reuse will be discussed.

1.4 Significance of the Study

The research study coincides well with the Palestinian government efforts pertaining to reform and institutional building (PWA, 2010a). It is important in light of the new water law (Water Law, 2014) and addressing the issue of reuse. The research is also important to identify and recommend set of guidelines for the management of wastewater and the reuse of reclaimed water as the treated wastewater. It should be noted that in light of constructed and planned wastewater projects, significant amount of reclaimed wastewater will be generated and should be reused. It's reported that around 180 MCM of treated wastewater will be available by the year 2025 (PWA, 2014). This amount represent an important amount of water that needs to be introduced in the water sector for aquifer recharge and reuse, which will ultimately play a major factor in lifting the pressure on fresh water as well as stress on aquifers. Such inclusion of reclaimed water indicates the country engagement in integrated water resource management (IWRM).

The research will serve both PWA and WSRC to better understand the reality and needed action to be taken and implemented. It will serve both institutions and other relevant institutions in time they are engaging in preparation of set of by laws for service provider's mainly on water use and reuse as well as on sewage discharge.

The study will shed some light on experience in the region (Jordan and Israel and Mediterranean countries) in term of wastewater reuse, regulation and standards.

1.5 Approach and Methodology

The research is both desk-based and field-based. Scientific articles, reports and books were reviewed on water quality, standards and regulations with particular focus on wastewater and reuse. Data on wastewater quality was collected. Nablus West Wastewater Treatment Plant (NWWTP) is taken as a pilot for the research, where review of the project documents, working reports of water quality outflow. Also interviews with the operators were carried out with actors in the wastewater dischargers, municipality, Palestinian Water Authority (PWA), Water Sector Regulatory Council.

- Insight research and literature review on current regulations, bylaws and reuse standards.
- In depth research on water wastewater status in Palestine
- Current monitoring programs and application of laws, by laws and standards
- Stakeholders interviews on existing monitoring programs and identification of problems faced

- Selection of a case study Nablus wastewater treatment plant (NWWTP) to study disinvestment related to industrial discharges and poor enforcement of municipal by-laws related to household connection to sewerage systems as well as treated wastewater reuse
- Recommended actions and measures to be taken case by case.

1.6 Assumptions and Limitations

The discrepancies of different operators, existing laws and multiples references of the resources whether conventional or non, lack of bylaws and absence of monitoring programs of wastewater discharge, no enforcement of law and Israel's control, have contributed on mismanagement of the wastewater sector in Palestine. Yet, a set of bylaws is still needed to be drafted by PWA and reviewed by relevant authorities before being endorsed by the cabinet of Minister. Such process will require time (years) before seeing by laws endorsed. Its questionable that the WSRC would be able to exercise it role before endorsement of bylaws and enforcement of law for implementation.

It's widely reported that occupation and Israel control to the territories, the Joint Water Committee JWC and huge investment required to build sewage treatment plants are the main reasons behind hindering the development of wastewater projects. Since the signature of Memo of Understanding at the JWC signed on 2003, on high standards treated water (BOD,TSS and TN being 10,10,10 ppm for each) criteria of Wastewater Treatment plant WWTP, huge investment required has prevented the donors community to build such facilities with huge capital investment and an expensive Operation and Maintenance (O&M) cost.

Such problem of delay of implementation of WWTP has a severe impact on the water sector as donors refrained on engagement on providing funds for sewer networks, and this is explain the low percentage of household connections to the sewer networks, absence of sewer networks led to discharge of sewage to the nature and the widespread usage of cesspits. Such practice was behind the major pollution of the environment added to that the uncontrolled discharge if settlements to raw sewage in wadis and environment.

It is expected that the data related to research is scattered, not available and /or not periodic. A small scale contribution mainly by NGO's at household level in rural areas (Arafah, 2012). Many researchers proved failure of most units built. The limitation of the study comes from absence of data on wastewater discharge quality or reuse. Access to information and data was problematic. Non-existence of monitoring programs, non-existence of bylaws on sewage discharge or reuse is also considered obstacles facing the study.

The pilot project for testing the regulation will be the Nablus West WWTP, it will serve as an example but not ideal in term of comparison with others WWTP as technology used differs on other similar large existing plant (Al-Bireh WWTP, Beitlahia WWTP, Jenin WWTP, Jericho WWTP or the other planned plants to be built in the coming 5 years (Hebron, Tubas, Ramallah, Khan Younis), but the case study will be informative on possible reuse of reclaimed water generated by other facility relaying on lesson learned from Nablus West WWTP.

1.7 Thesis Structure

This thesis is composed of seven chapters.

Chapter 1 is an introduction of the research, including the statement of the problem, research questions, objectives, research assumptions and limitations, significance of the study, approach and methodology.

Chapter 2 describes the literature review on status of water supply and sanitation, water quality and its status in the region

Chapter 3 is the approach and methodology carried out in the research

Chapter 4 addresses the legal and institutional framework of water quality, regulations and standards applicable in Palestine

Chapter 5 provides study on wastewater status and reuse in Palestine and experience in the region.

Chapter 6 provides the Case study on Nablus West Wastewater treatment Plant, analysis and discussion of reuse.

Chapter 7 presents the conclusions and recommendations as an outcome of the thesis.

CHAPTER TWO

LITERATURE REVIEW

Water Resources, Quality, Use and Reuse

2.1 The Overall Water Issue in Light of Israelis Palestinians Conflict

In 1948, Israel gained control of the upper Jordan River basin after occupying land outside both the green and truce lines. By 1950, the West Bank was put under the Jordanian control and the Gaza Strip was put under the Egyptian control, in consequence, water sector was regulated and managed by different administrative regimes.

Following Israel's control of the Arab territories (West Bank, Gaza Strip, Sinai and Golan Heights) after the 1967 war, they assumed control of all water resources: surface and groundwater. Israeli occupying power has issued military orders putting the water resources in these territories as property of the state of Israel of which any access or development of water resources including drilling of wells would require a special permit from the military governor (PWA, 2010).

Israeli control over water resources continued and did not end with the change in the political situation that accompanied the mutual recognition between the Palestinian Liberation Organization (PLO) and Israel in 1993. The signing of the Declaration of Principles (DoP) Agreement in Oslo, Norway (Oslo Accord – Gaza and Jericho first) in 1993 was considered as breakthrough in the Israeli-Palestinian conflict by which the Palestinian Autonomous government is created. The DOP was followed by the signature of the 1995 Oslo Agreement known as the Interim Agreement.

The interim agreement was set for four years then extended another year where both parties have to enter in permanent status negotiation. The interim agreement known as Oslo2 has tackled the water issues between the parties in Article 40 of the Annex III of the agreement; “The Economical Cooperation Protocol” of the transitional agreement entitled: “Water and Sewage”. On the basis of this agreement, Israel recognized Palestinian water rights in the West Bank and postponed agreement until which time final status negotiations took place.

It has been widely documented the issue of water conflict between Israel and Palestine. No one can neglect that the conflict on water rights, Israel control and Israel restriction on water sector development have led to the deteriorated water quality of the water resources in the Palestinian territories (World Bank, 2009).

Non resolution of water right and denial of access to resources like the Jordan River have led Palestinians in the Gaza Strip to overexploit the aquifer to meet there water demand. Such over abstraction has led to sea water intrusion and almost of Gaza Aquifer water become highly saline (UNRWA, 2012).

The over abstraction is not the only reason for water quality deterioration in Gaza, contamination and pollution of Gaza aquifer with raw sewage and heavy use of fertilizers have led the United Nation in its report 2011 entitled : Gaza 2020, a livable place? (UNRWA, 2012). In the West Bank, Israeli control of water resources and delay of water sector development has severe impact on water supply as well as on environment by hindering the development of the wastewater infrastructure and the discharge of sewage untreated, using cesspits have led in many occasion to domestic

water network contamination, contamination of ground water and pollution of wadis and resources.

Israel policy in the Joint Water Committee JWC and delay of approval of vital wastewater projects have played major role on water resources pollution and delay of the development of water sector including wastewater (PWA, 2010a, World Bank, 2009).

Lack of sewage infrastructure and wastewater treatment plants have led to widely usage of cesspits and discharge of raw sewage in Wadis. Such discharge into the environment has severely impacted on water quality of water resources; aquifers, Wadis, springs and wells.

2.2 The Status of Water Resources Available to Palestinians (West Bank and Gaza Strip)

In general terms, the Occupied Palestinian Territories known for the land occupied on 1967, namely West Bank includes East Jerusalem and the Gaza Strip.

The current population is 4.5 Million habitants (1.8 Million in Gaza Strip and 2.7 Million habitants in the West Bank) (PSCP, 2013). Only less than 15% of the total resources in historical Palestine are made available for the Palestinians. Part of that water is purchased from the Israeli company MEKEROT and other part is coming from over abstraction of the Gaza Aquifer (PWA, 2014).

The Palestinian water per capita is considered the lowest in the Middle East and MENA region (World Bank, 2009). The per capita varies from 70 up to 90 liter per capita per day, (PWA, 2014). Certain communities in the West Bank still have no water infrastructure and their per capita does not exceed 15 liter per day. In Gaza strip, the

water quality in the aquifer is deteriorating to unprecedented level, it's reported widely that less than 5% of Aquifer's water fit for human use (PWA, 2014).

2.2.1 The Shared Resources

Palestinians and Israelis are sharing both surface water namely the Jordan River Basin and Groundwater; *the Mountain Aquifer* in the West Bank and the Coastal Aquifer basin (PWA, 2014).

The Mountain Aquifer is divided into three Aquifer basins. These Basins are considered as shared aquifer basins; the Eastern Aquifer Basin, the North Eastern Aquifer Basin and the Western Aquifer Basin (PWA, 2014).

As related to surface water both Israelis and Palestinians are sharing The Jordan River Basin with other riparian countries (Jordan, Syria and Lebanon).

2.2.2. Article 40: Allocation of Resources: Status-Que Plus

As per the Interim Agreement, the water and sanitation arrangements between the parties are presented in Article 40 of Annex III of the Oslo Protocol. In Article 40, Israel recognizes the Palestinian water right yet postponed the definition of these rights to the permanent status negotiation.

Israel agreed to allocate a total of 118 million cubic meters of water from existing sources of the Mountain Aquifer Basins (springs and water wells in the West Bank) to the Palestinian Authority. Israel Occupying power keeps the control of all resources to Israel. Table 2.1 shows Article 40 allocation of resources between Israelis and Palestinians while Table 2.2 shows the quantity of water used from different resources.

Table 2.1 Allocation of shared water according to Oslo Agreements (PWA, 2014)

	Israeli		Palestinians		Total	Estimated potential	To be developed
	wells	springs	wells	springs			
Western	340		20	2	362	352	
North-	103		25	17	145	145	
Eastern	40		24	30	94	172	78

Article 40 of Oslo agreement kept the status quo (water allocation as of the day of signature of the agreement). Palestinians in the West Bank have been granted to use only 118 Million Cubic Meter out of 676 Million cubic meter of the sustainable yields of the Mountain Aquifer in the West Bank. It has been agreed that Israel will enable the Palestinians to develop an additional quantity of around 78 MCM during the interim period (end by 1999).

Only 23.5 MCM out of the 28.6 MCM of the urgent need has been allocated to Palestinian along the 20 years since signature of the interim agreement that supposed to last only 5 years (Shaddad Attili, personal interview 2014).

Table 2.2 Water use from different resources

	Oslo Agreement for West Bank MCM	Water use as of 2011 MCM	Purchased from Mekorot MCM (2011)	Unlicensed Wells /Over abstraction
Western Aquifer	22	25		
Northeastern Aquifer	42	20		4 MCM
Eastern Aquifer	54	42		7 MCM
Total West Bank	118 (Oslo Agreement)	87	51 MCM	
Gaza Strip	55-60	185.8 (including 2.8 MCM from small desalinated plants in Gaza)	4 MCM	120-128 MCM

Source (PWA,2014)

As of 2015, according to PWA, the total resources available to Palestinians in the West Bank has varied between 96-114 MCM and per capita has been decreased dramatically which in other words indicates the Israeli control of the resources (PWA water sector policy and strategy, 2014).

2.3 Status of Water Resources, Supply and Sanitation in the Palestinian Territories

2.3.1 Water Resources

The following table 2.3 shows the water usage in the Palestinian territories for both domestic and agricultural uses. According to table 2.3, in the West Bank, the resources are divided equally between domestic and agricultural uses. It should be also noted that Palestinian Government, since 2010, purchases around 50 Million Cubic meter on yearly basis to meet its people domestic demands mainly for domestic purposes. In the Gaza Strip, table 2.3 shows that the abstraction from the aquifer is three times its sustainable yield. Another note is that all water allocated to the agriculture sector is fresh water.

Table 2.3 Palestinian Abstractions from Wells (MCM) in 2012

Basin	Palestinian Abstractions from Wells (MCM) in 2012		
	Domestic	Agriculture	Total
Western Basin	12.3	18.1	30.4
Eastern Basin	11.0	9.9	20.9
North-eastern Basin	10.0	3.0	13.0
Total West Bank	33.3	31.0	64.3
Gaza Coastal Aquifer	102	83	185

Source (PWA, 2014).

It should be noted that springs discharge estimated as around 49 MCM has been used for both domestic and agricultural purposes (PWA, 2014).

2.3.2 Water Supply

The main water resources in the West Bank and Gaza are groundwater aquifers.

In the Gaza Strip the major source of supply is the ground water aquifer and it is hugely polluted. Around out of 185.5 MCM abstracted from the Aquifer (over abstraction above the sustainable use estimated at around 55-60 MCM), 102 MCM has been supplied for domestic purposes while 89 MCM for agricultural use. From that amount, 2.5 MCM is supplied from small desalination facilities and 5 MCM is purchased from MEKEROT; the Israeli Water Company, for domestic purposes.

Surface water and many wadis in the West Bank and Wadi Gaza are either dried or polluted with sewage.

2.3.3 Service Providers for Water and Sanitation

Water supply for domestic uses is the responsibility of many service providers based on different laws, mainly PWA laws and Local authority law; water is distributed for domestic uses through the following entities:

- West Bank Water Department the responsibility for distribution of bulk water to the Palestinian cities, villages who lack resources or have not sufficient resources (Bethlehem, Hebron, Ramallah, Tubas, Jenin). Other cities like Salfit, Jericho, Qalqilia, Tulkarem and Nablus they do manage and distribute their own resources, springs an wells.
- Jerusalem Water Under Taking serving (Ramallah, AL-Bireh and East Jerusalem), new mandate adding sanitation service to the JWU.
- Bethlehem Water and Sewage Authority (Bethlehem, Beit Sahor and Beit Jala)

- Gaza Municipal Coastal water Utility (Gaza strip apart Gaza City and small town separated from the Utility for water and sanitation.
- Major municipalities of cities and villages (Nablus, Jericho, Qaliqilia, Tulkarem, Salfit, Hebron).
- Joint service councils of villages for water and sanitation (Aqrab cluster, Tubas and Mythlon Joint service council for water and sanitation, North west Jerusalem, Dura joint service council, North west Jenin Joint service Council…etc.

2.3.4 Connection to Water and Sewage Networks

2.3.4.1 Connection to Water Networks

Around 200,000 Palestinians in the West Bank have no access to water network connections. As a result, they have to travel long distances to the nearest water source (e.g. filling point) and pay high amounts for tankered water of (which is sometimes un-safe water) quality.

A 2011 survey carried out by the Palestinian Central Bureau of Statistics (PCBS) found that the number of households in the Palestinian territories connected to the water network was 91.8% in 2011. In the West Bank, 89.4% of the households were connected while the connection share in the Gaza Strip was 96.3%. (PCBS, 2011)

There are 123 localities (22.9%) in the Palestinian Territory, with 177,275 residents, have no public water network, 251 localities in the Palestinian Territory have old networks, 247 localities suffer from the problem of interruption of water supply, and 192 localities suffer from the problem of non-served areas, all in the West Bank (Arafah, 2012).

2.3.4.2 Connection to Sewerage Networks

During the occupation period, the wastewater sector used to be highly neglected. Despite the establishment of PWA since 20 years, restriction imposed on PWA through the Joint Water Committee has played a major role on not to enhance the wastewater sector due to restriction imposed on approval of wastewater projects and the signature of the MOU 2003 that sets high standards criteria (BOD,TSS, TN as 10,10,10 for each) for the design and the disposal of wastewater. Such criteria has not been accepted by donors to engage on building high standards facilities.

The 2009 World Bank reports characterized the wastewater sector in the West Bank and Gaza by poor sanitation, insufficient treatment of wastewater, unsafe disposal of untreated or partially treated water and the use of untreated wastewater to irrigate edible crops (World Bank, 2009).

Today, only 44% of the population, 31% in the West Bank and 72% in Gaza Strip, is served with wastewater networks leaving more than 2 million people without proper sanitation facilities. Most communities that are not connected to sanitation network are typically serviced by either septic tanks or cesspits (PWA, 2014).

Many of these networks are old and poorly designed established before 1967 through Jordanian Administration and stayed without development. 42 MCM/Y of wastewater is generated in the West Bank and 41 MCM/y is generated in Gaza, around 15 MCM/Y is collected by network then discharged into open areas (wadis). Total effluent sewage discharged to the Wadis by Israeli Settlements is around 50 MCM (PWA, 2014).

Currently and since 2010, PWA has engaged on implementing major sewage treatment plants in West Bank as well as in Gaza after resisting the JWC-MOM 2003 and adopted

the concept of gradual improvement of treatment discharge; several wastewater treatment plants are now under operation (Nablus West WWTP, Jericho WWTP, Beitlahia WWTP known as NGEST, Central Gaza WWTP) while other major projects are either under tendering or under design (Tayaseer WWTP, Ramallah WWTP, Nablus East WWTP, Khan Younis WWTP) and other project piping the sewage to be treated inside the Green Line like Wadi Zeimar sewage transfer Pipe that collects the sewage from 9 communities in Nablus and Tulkarem ares.

It should be also noted that many small scale treatment plants has also constructed in many places with treatment capacity ranging from 100- 2000 cubic meter a day like Al-Tireh plant, Taybeh, Azon, Saeer, Anzeh …etc.

2.4 Water Quality of Resources

One of the sustainable development goals is to improve access to safe water that is an engine for socio-economic growth.

Water quality, monitoring and evaluation issue have been addressed by several health, environment, water and food international organizations, governmental and non-governmental institutions, scientific researchers and many others. (Australian guidelines for water quality monitoring and reporting, 2000) and (Robarts et,al, 2007).

One of the most important report on addressing the water quality issues is the Technical Report *Planning of Water Quality Monitoring Systems*, the report has been developed by WMO jointly with UNEP GEMS/Water providing basic know-how and materials needed to plan, establish and operate water quality monitoring systems on national levels.

The threat to water quality and water resources is not only coming from sewage, lack of proper management of solid waste and scatter dump sites, industrial uncontrolled discharge, heavy use of fertilizers and lack of regulation and monitoring system have also played a major role on water resources contamination and pollution. One can describe the different factors affecting the water resources quality as follow:

- Lack of rules and regulations for hygiene and ineffective monitoring programs.
- Lack of bylaws that regulate water quality for all purposes
- Discharge of wastewater into the nature
- Poor investment in water and wastewater infrastructure and storage of domestic sewage in cesspits, infiltration into groundwater,
- Over abstraction of resources and sea water intrusion
- Mixing between the Storm water runoff and seepage
- Leachate form wild dumpsite
- Uncontrolled industrial discharges, heavy use of fertilizers and agricultural drainage
- Population growth and urbanization

The following is a brief description of the quality of water resources; water supply and wastewater quality of water for reuse in the Palestinian Territories. It should be noted that due to severe water crisis in the Palestinian territories, water quality becomes a real concern in order to protect the available sources and maximize their use and make every possible to treat and reuse wastewater as a non-conventional resources.This will help identifying measures and actions to be taken in term of regulations and monitoring systems and programs.

2.4.1 Water Quality-West Bank

According to the World Bank report of 2009, water quality and environmental contamination are of increasing concern in the West Bank. There is a growing problem with biological contamination, particularly with springs and water tankers (World Bank, 2009).

According to PWA reports, most of the wells in the Jordan Valley show a high concentration of chloride exceeding 250 mg/L, while showing a relatively low nitrate concentration (PWA, 2014).

In Tulkarem and Qalqilia areas the nitrate concentration in some wells exceeds 50 mg/l due to usage of fertilizers and contamination of sewage discharge and usage of cesspits, while the chloride concentration in these wells stayed within the acceptable limit. The Wadis (Al-Nar, Zomar, Al-Farah, AlSaman, Qana) as for example suffer from raw sewage discharge by both Palestinian communities and settlements. Some of Wadis suffer from discharge of industrial waste like Qana wadi (discharge of industrial wastewater of settlements factories) and Al Saman Wadi in Hebron (discharge of stone crushing sludge).

In many places, springs suffer from contamination of sewage discharged into the environment or seepage from cesspits, example of Husan, Batir and Wadi Fukin springs.

2.4.2. Water Quality-Gaza Strip

As mentioned before, Groundwater from the coastal aquifer is the major source of water in the Gaza Strip. It provides about 98% of all water supplies, while the

remaining 2% is provided through purchasing from the Israeli water company (MEKOROT).

The water situation in Gaza is very bad in terms of quantity and quality, where the Coastal Aquifer in the Gaza Strip receives an annual average recharge of 55 -60 MCM/y mainly from rainfall, while the annual extraction rates from the aquifer is about 189 MCM (PWA, 2014).

This unsustainable high rates of extraction has led to lowering the groundwater level, the gradual intrusion of seawater and up conning of the underneath saline groundwater. Gaza Aquifer needs to be regenerated before it can be sustainably used again.

2.5 Guidelines of Water Quality

Many chemical substances emitted into the environment from anthropogenic sources pose a threat to the functioning of aquatic ecosystems and to the use of water for various purposes (*Ute* et al.,1997). The need for strict measures to prevent and to control the release of these substances into the aquatic environment has led many countries to develop and to implement water management policies and strategies based on, amongst others, water quality criteria and objectives (*Ute* et al.,1997).

The following recommendations have been put forward (UNECE, 1994) in order to provide further guidance for the elaboration of water quality criteria and water quality objectives for inland surface waters, and to strengthen international co-operation :

• The precautionary principle should be applied to protect and maintain individual uses of waters

- Particular attention should be given to safeguarding sources of drinking-water supply. In addition, the aim should be to protect the integrity of aquatic ecosystems and to incorporate specific requirements for sensitive and specially protected waters and their associated environment.
- Protection of water catchment areas, masseurs and actions should be agreed upon among the Water-management authorities in consultation with industries, municipalities, farmers' associations, the general public and others.
- Appropriate advice from health authorities in order to ensure that water quality objectives are appropriate for protecting human health have to be taken by the Water-management authorities.
- The water quality requirements for uses of the relevant water body, as well as downstream uses, should be taken into account. In transboundary waters, water quality objectives should take into account water quality requirements in the relevant catchment area. As far as possible, water quality requirements for water uses in the whole catchment area should be considered.
- The setting of water quality objectives (or modification thereof to account for site-specific factors) should not under any circumstances lead to the deterioration of existing water quality.
- Established water quality objectives should be considered as the ultimate goal or target value indicating a negligible risk of adverse effects on use of the water and on the ecological functions of waters.
- The setting of water quality objectives has to ensure the development of a time schedule for compliance with the objectives that takes into account action which is

technically and financially feasible and legally implementable. Where necessary, a step by- step approach should be taken to attain water quality objectives, making allowance for the available technical and financial means for pollution prevention, control and reduction, as well as the urgency of control measures.

- The setting of emission limits, the use of best environmental practices and the use of water quality objectives as integrated instruments of prevention, control and reduction of water pollution, should be applied. Action plans covering point and diffuse pollution sources should be designed allowing step-by-step approach to water pollution control which are technically and financially feasible.
- Both the water quality objectives and the timetable for compliance should be subject to revision at appropriate time intervals in order to adjust them to new scientific knowledge on water quality criteria, to changes in water use in the catchment area, and to achievements in pollution control from point and non-point sources.
- The public should be kept informed about water quality objectives that have been established and about measures taken to attain these objectives.

2.5.1 Major Chemical and Physical Parameters in Wastewater

Wastewater, is any water that has been adversely affected in quality by anthropogenic influence. Wastewater can originate from a combination of domestic, industrial, commercial or agricultural activities, surface runoff or stormwater, and from sewer inflow or infiltration.

Municipal wastewater (also called Sewage) is usually conveyed in a companied sewer or sanitary sewer, and treated at a Wastewater treatment Plant. Treated wastewater is discharged into receiving water via an effluent pipe. Wastewaters generated in areas

without access to centralized sewer systems rely on on-site wastewater system. These typically comprise a Septic tank, drain field, and optionally an on-site treatment unit. Sewage is a type of wastewater that comprises domestic wastewater and is therefore contaminated with feces or urine from people's toilets, but the term sewage is also used to mean any type of wastewater.

The wastewater from toilet is called black water. Amount of this water is very small but contain high in solid, COD and significant nutrients (as nitrogen and phosphorous). Other wastewater that generated and discharged from living activities of human such as cooking, bath, washing are called greywater. The greywater is high volume and contain high amount of organic matter but low in nutrients.

2.5.2 WHO Guidelines

In order to achieve safe and successful wastewater reuse schemes for irrigation purposes, WHO health guidelines should be integrated with Food Agricultural Organization (FAO) for water quality guidelines used for irrigation purposes. Accordingly there are common multi strategies ultimately combined the optimization of crop production and protecting the human health as summarized hereafter:

- Wastewater treatment level;
- Restriction of the crops grown;
- Irrigation methods; and
- Control human exposure to the waste, and hygiene.

Standards of effluent quality differ from one facility to another, depends on nature of effluents, treatment processes and technology used. The WHO in (1989) developed guidelines to assist policy makers to legislate permission for the safe use of wastewater

since the previous health standards were not high and did not reflect conditions in developing countries.

WHO has always revised their guidelines; the joint FAO, UNEP and WHO publication of Health Guidelines for the Safe Use of Wastewater, Excreta and Greywater has been updated in 2006, focusing on disease prevention and public health principles (WHO, 2006).

2.5.3. EPA Guidelines

The U.S. Environmental Protection Agency (USEPA) in 1992 developed guidelines for water reuse a comprehensive technical document, including a summary of state reuse requirements, guidelines for treating and reusing water, key issues in evaluating wastewater reuse opportunities, and case studies illustrating legal issues, such as water rights, that affect wastewater reuse. The 2006 guidelines updates the 1992 Guidelines document by incorporating information on water reuse that has been developed since the 1992 document was issued. It also expands coverage of water reuse issues and practices in other countries. It includes many new and updated case studies, expanded coverage of indirect potable reuse and industrial reuse issues, new information on treatment and disinfection technologies, emerging chemicals and pathogens of concern, economics, user rates and funding alternatives, public involvement and acceptance (both successes and failures), research activities and results (US EPA, 2006).

2.6 Relevant Laws, Standards and Specifications for Wastewater Reuse

An epidemiological study (Sinclair et al., 2010) was conducted to assess the public health impact of a dual reticulation system that supplied recycled water from sewage treatment plants for non-potable reuse. The outcome of this study suggested that the

residents in the dual reticulation system area were not experiencing significantly higher risk of adverse health effects due to their exposure to recycled water.

Potential growth of pathogenic microbes in reclaimed water distribution systems is a major concern. A study was conducted to investigate the impacts of biological wastewater treatment technologies, including membrane bioreactor (MBR) and conventional activated sludge, on various organic carbon parameters, including total organic carbon (TOC), biodegradable dissolved organic carbon (BDOC), and assimilable organic carbon (AOC). It was found that the concentrations of biodegradable organics are generally higher in the effluent from conventional plants than those from MBRs, which could impact the public health risk of reclaimed water. Adewumi et al. (2010) examined the need for wastewater reuse in the South African based on review of both water resources situation and wastewater generation. They concluded that the implementation of wastewater reuse would play an important role in non-drinking water supply, such as landscape irrigation and industrial processes.

Greywater Reuse. Godfrey et al. (2010) used QMRA; quantitative microbial risk assessment techniques to assess the health risk associated with greywater reuse for recycling shower water for toilet flushing in Madhya Pradesh, India. The study found that the systems had low risk and high quality. Maimon et al. (2010) presented a study regarding the potential benefits and drawbacks to greywater reuse. This study analyzed human health considerations through the potential uses within multi and single household systems. Pinto and Maheshwari (2010) examined the issue of the greywater reuse for irrigation around homes and emphasized the following critical issues for greywater reuse: the cost of plumbing and the health risks to human, plants and soil.

Irrigation and Agricultural reuse.

As part of the European Union (EU)-project "Safe and High Quality Food Production using Low Quality Waters and Improved Irrigation Systems and Management (SAFIR)", Styczen et al. (2010) presented an agricultural irrigation management model that can assist users in identifying safe mode of irrigation when applying low quality water, such as treated and untreated sewage.

The risk to consumers and farmers due to accumulated heavy metals and pathogens were evaluated in this model. Parsons et al. (2010) reviewed the safety and successful use of the reclaimed water in crop production in Florida and California and how it had played an important role in meeting the water shortage and urban demand of California. Qadir et al. (2010) discussed the challenges of wastewater irrigation in developing countries where comprehensive wastewater treatment is still largely unavailable. A number of opportunities for improving wastewater management were discussed, such as improved policies and institutional dialogues, and financial mechanisms, in order to protect public health and environmental quality from the wastewater irrigation practices. Forslund et al. (2010) studied the use of treated urban wastewater in agriculture. It was found that drip irrigation of treated urban wastewater can be practiced while ensuring food safety and protecting the health of consumers and farmers.

Due to a shortage of water resources in Algeria, reuse water has become a valuable source of water for agriculture. A sewage effluent and reuse irrigation investigation performed by Kesba et al. (2010) presented the influence of physicochemical characteristics of an irrigated soil on the behavior of cadmium and its impact on the

development and growth of tomato plants.

Based on a case study in Spain, Munoz et al. (2010) concluded that the potential health risks of reusing wastewater in agriculture would be lower with tertiary treatment than applying primary and secondary treatments. Nabulo et al. (2010) conducted a risk assessment of tropical leafy vegetables grown on agricultural lands irrigated with and/or contaminated by sewage and effluent from industry. The “hazard quotient“ rank, which measures the risk trace metal concentrations in soils have on human health, were as follows: cadmium > lead > zinc > nickel > copper.

In order to assess the health and environmental risks associated with wastewater reuse in agriculture, Smith and Badawy (2010) investigated the survival of *Escherichia coli* in laboratory-scale soil columns filled with three Egyptian agricultural soils. It was found that the growth rate of *E. coli* correlated with soil organic content. In the evaluation of using recycled water to grow vegetables, Nikaido et al. (2010) showed that there was no relation between the number of parasites or fecal coliforms and the different types of irrigation. Also, it was found that the risk of pathogens was higher for the vegetables without the use of bleach. Singh et al. (2010a, 2010b) assessed the human health risks associated with the consumption of milk, vegetables, and cereal crops from wastewater irrigated sites. While the contamination levels were within the permissible limits in milk samples, all the tested vegetables and cereals contained high concentrations of heavy metals, such as cadmium, lead and nickel, suggesting potential health risks to consumers.

A study performed by Lahav et al. (2010) examines the potential drawbacks associated with agricultural irrigation with treated wastewaters from desalinated water origins

within the coastal region of Israel, as well as the possible remedies to avoid potential health hazards. The study introduced the idea of lowering sodium adsorption ratio (SAR) values by adding magnesium, which could also be added at a low cost prior to reusing the desalinated water for irrigation purposes. Amponsah-Doku et al. (2010) conducted a study on wastewater-grown lettuce on farms, markets and at street food vendor sites for thermotolerant coliforms, enterococci and *Salmonella*. In farm lettuce, market lettuce and street lettuce food, as well as in irrigation water and refreshing water in the market, all bacterial counts exceeded the World Health Organization (WHO) and International Commission on Microbiological Specifications for food (ICMSF) standards. (Chen et. Al., 2010) found that the potential health risks caused by edible seeds of crops grown in areas irrigated with reclaimed water in Langfang of Hebei province, China was low. Germer and Sinar (2010) looked at the impact of pharmaceuticals in sanitary wastes in Greater Accra, Ghana as the water was applied to agricultural lands to recycle nutrients back to the land. The study found that the most problematic of pharmaceuticals were antibiotics, analgesics, drugs for diabetes, antimalrials, cardiovascular drugs, and anthelmintics.

The health implication of wastewater reuse in vegetable irrigation was studied by Gumbo et al. (2010). It was found that there are noticeable health risks to using wastewater for irrigation but can be managed using the incomes that are generated by the farmers. Al-Juaidi et al. (2010) presented a decision analysis of treated wastewater use for agriculture for area with limited water supply. They balanced benefits among economic efficiency of water use, public health risks, and environmental goals. The outcomes revealed that net benefit increased by 44%, groundwater demand decreased

by 29% and economic efficiency of water use increased by threefold.

The use of inadequately treated wastewater for agricultural irrigation and the health risks associated with such use was investigated by Jamil et al. (2010). It was found that continuous use can degrade soil and cause public health risks through transmission of enteric diseases and heavy metal ions causing toxic effects. Jan et al. (2010) tested food crop samples irrigated with wastewater and less polluted sources to determine the health risks of using wastewater for irrigation. Heavy metal concentrations were higher in wastewater irrigated crops, but were within WHO/ Food and Agriculture Organization (FAO, 1985) permissible limits except for zinc. In a study developed by Lydecker and Drechsel (2010), urban agriculture and sanitation in Accra, Ghana were examined. This study presented the fact that by mitigating the health risks for farmers and consumers associated with widespread wastewater irrigation, these urban farms could have the potential to significantly contribute to the city's sanitation needs. Oron et al. (2010) found that the health risks associated with wastewater irrigation may be minimized by using the subsurface drip irrigation technique.

Sewage sludge fertilizer containing endocrine disrupting compounds was applied to grazing pastures to determine the effects on the reproductive systems of fetal sheep (Bellingham et al., 2010). Results showed that the animals that grazed these pastures had many reproductive issues, such as lower gondotrophin-releasing hormone (GnRH) mRNA expression in the hypothalamus and lower GnRH receptor and galanin receptor mRNA expression in the hypothalamus and pituitary gland. Based on the examination of pregnant ewes exposed to multiple endocrine disrupting pollutants through sewage sludge-fertilized pasture, it was suggested that human exposure to low levels of

multiple endocrine disrupting compounds might have implications for bone structure and human health (Lind et al., 2010). Luvizutto et al. (2010) presented a study on the toxicity evaluation of treated urban sewage sludge in the State of Sao Paulo, Brazil. This study aimed at the establishment of protocols for potential usage in sewage sludge agricultural soil application.

Pritchard et al. (2010) discussed the main issues associated with land application of biosolids for crop production that has been practiced in Australia, including plant nutrient uptake, risk of heavy metal uptake, risk of pathogen contamination, effect on soil pH, and monitoring techniques for fecal contamination. Passuello et al. (2010) studied the accumulated concentration of persistent organic pollutants (POPs), such as 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, polychlorinated biphenyl-180, benzo(*a*) pyrene and dibenzo (*a*,*h*) anthracene, in sewage sludge applied soil, and their effects to human exposures. No significant human health risks, in terms of developing cancer, were found due to POPs exposure, even concentrations in food were linearly correlated to the concentrations in soil.

In Palestine, the key regulatory documents regarding wastewater treatment and reuse in the West Bank and Gaza are the new Water Law 2014 which supersedes all precedent laws and becomes the governing law for all aspect of water, wastewaters, resources and supply , the Agreements with Israel, particularly the Memorandum of Understanding (MOU) of December 2003, the Environmental Law No. (7) of 1999, the Local Authority Law No 1 FOR 1997 and instruction note signed by PWA, Palestinian Standards Institute and Ministry of Agriculture on criteria for reuse of reclaimed wastewater ,TS 34/2012,: The Palestinian Treated Wastewater Standards (Technical

Specification), Palestinian Standard Institute instruction PSI 742/2003 added to all the rules and guidelines pertinent to the safe use of treated wastewater, excreta and greywater for agricultural purposes (WHO, 2006).

The Technical Specification (TS 34/2012) divided the quality of treated wastewater into 4 categories, high quality (A), good quality (B), moderate quality (C), and poor quality (D). In addition, this specification regulates the approval of the effluent quality of the treated wastewater for irrigation by the Palestinian Water Authority (PWA) and the Ministry of Agriculture in order to use the treated wastewater for irrigation in accordance to their standards and specifications. Discussion of standards in comparison with other standards in the regions will be discussed later in this research.

2.7. Relevant Institutions That Deals With Water and Usage

2.7.1 The Palestinian Water Authority

In the new water law as well as in the previous water law no 3 for the year 2002 sets the Palestinian Water Authority (PWA) is the body responsible for monitoring and protecting the water resources in the West Bank and Gaza. Responsibilities of PWA include control of water pollution and water resources protection as well as ensuring the safety and health of Palestinian people.

The new Water law divided responsibility of water quality regulations and quality monitoring and inspection between PWA and Water Sector Regulatory Council WSRC where protection of resources and monitoring of quality is given to PWA as a responsibility while WSRC mandated to monitor service provision and applying the bylaws and enforcement.

2.7.2 The Palestinian Ministry of Health

The Palestinian Ministry of Health (MoH) sets the regulating health standards and guidelines in Palestine including standards and guidelines for drinking water and other uses of water. MoH is responsible for monitoring the quality of water reaching the users.

2.7.3 The Central Public Health Laboratory

The Central Public Health Laboratory (CPHL) is related to the Ministry of Health. The role the CPHL is to deal with agents that affecting human health.

2.7.4 Service Providers

In the West Bank and Gaza Strip, the service providers for water and sanitation are West Bank Water Department WBWD, Jerusalem Water Undertaking JWU, Beithlehem Water Supply and Sewage Authority (WSSA), Gaza Coastal Municipal Water Utility (CMWU), Municipalities and Joint service councils JSC.

The Service Water Providers are responsible for monitoring their water systems, which includes the sources, water tanks, and main distribution networks which fall under their jurisdiction (PWA, 2007). Regular monitoring includes physical and bacteriological testing, which have the most significance in regards to public health based on WHO guidelines (WHO, 2008).

2.7.5 UNRWA

The United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) provides assistance, protection and advocacy for Palestinian refugees.

2.7.6 The Environmental Quality Authority

EQA was established as the official Palestinian body with the mandate to monitor and implement all what is necessary for the protection of the Palestinian environment and the provision of clean and healthy environment to ensure the right of all Palestinians to the highest attainable level of health and welfare as guaranteed in the Palestinian basic law and environment law. Accordingly, EQA mission statement is articulated as follows: "Maintaining and protecting the environment, preserving human health, curbing and reducing the depletion of natural resources, combating desertification, preventing the aggravation of environment pollution, promoting environmental awareness and ensuring sustainable environmental development." The Environment Quality Authority (EQA) seeks to promote sustainable environmental development of the Palestinian society. Its core mission is to protect the environment with all its elements and prevent environmental hazards threatening all living organisms.

2.7.7 Ministry of Agriculture

The Ministry performs major duties in the regulation and management of the agricultural sector in addition to the oversight, supervision and delivery of certain basic services tasks. The agricultural legal framework is constituted from the Agricultural Law No. (2) of 2003, in addition to the (11) bylaws.

2.7.8 Palestinian Standards Institute

The PSI was established in 1996 with a view to being recognized by the business community and consumers, both locally and internationally, as the focal point for Palestinian participation in the global system of harmonized standards. The PSI's mission is to facilitate trade and investment in Palestine by meeting the metrology,

standards, testing and quality related needs of the business community while ensuring consumer and environmental safety.

2.8 Conclusion on Water Quality

Its obvious that water quality monitoring and water quality protection and water quality for different use (Domestic, Industrial and Agriculture) has to respond to legislation, regulations and standards either as set by WHO in general term and/or to respond to the country standards and regulation.

Its obvious that water quality is an issue related to drilling and abstraction (over abstraction led to sea water intrusion and made Gaza Aquifer saline), discharge of sewage to the wadi without treatment (impact on nature, surface and ground water), reuse of reclaimed water (impact on food and health), efficiency of water treatment process (need to meet guideline and standards for different purposes discharge and use).

The new water law 2014 (supersede all precedent laws) is the law that govern water and wastewater management and practices. The new Law has entitled PWA to prepare sets of regulations and by laws in coordination with different relevant institutions to respond to the new water law. The Water Sector Regulatory Council has to oversee and monitor the service providers to ensure compliance with law and regulations.

CHAPTER THREE: APPROACH AND METHODOLOGY

3.1 Approach

To achieve the objective of the study, the research will examine the overall water quality legislation and standards in Palestine with special emphasis on sewage water, issues of inflow and outflow as well as issues related to reuse. Special emphasis will be given to the regional experience on regulations and standards related to wastewater reuse.

3.2 Methodology

This research will review the Water sector reform aspects and documents related to Water Quality and legal and institutional legal framework, it will highlight the water quality aspects and required by laws to be issued to respond to the new water law.

It will highlight the legislations as per acting laws and the required regulations to be created for water quality, monitoring and inspection and usage of water and treated wastewater.

It will provide the present case of the Palestine and discusses the issue of quality of available resources and different usage. The research will focus on the wastewater treatment and reuse of treated wastewater. It takes Nablus West Wastewater treatment plants as a pilot for the study. It will present the challenges faces the facility, the influent and effluent and discharge of the facility and the reuse aspect.

The study will provide a comparison of water quality standards, regulation and reuse aspect with neighboring countries Israel and Jordan as well as the Food and Agricultural Organization of the United Nation (FAO).

It will highlight the research studies (water quality reports, Msc thesis's and technical reports of wastewater, reports and books were reviewed on water quality assessments and standards processes and systems with particular focus on wastewater and reuse.

In addition, data on wastewater quality was collected. Nablus West Wastewater Treatment Plant is taken as a pilot for the research, where review of the project documents, working reports of water quality outflow on monthly basis.

Also interviews with the operators and experts, were carried including Municipalities, Palestinian Water Authority and Water Sector Regulatory Council. Research data was sourced, collected and collated accordingly.

3.3 Data Collection

Data was obtained from electronic databases, Scientific articles, inception reports of major wastewater projects in Gaza and West bank (NGEST and Nablus West) and Msc thesis on water quality and wastewater treatments and reuse in rural areas of the West bank.

Officials from these institutions were interviewed to pursue in-depth information about the topics and to identify gaps and questions which can be tackled through this research.

Municipality of Nablus has provided the monthly working reports of Nablus West Wastewater treatment plant where different parameters has been analyzed and discussed. The field-study to the Nablus West WWTP facility and other facilities like Al-Bireh and Al-Tireh Wastewater treatment plant using different treatment process has been conducted for understanding different factor that effect treatment and reuse.

Table 3.1 present a summary of the research objective, approach and methodology and expected outcome.

3.4 Challenges of the Study

The absence of periodic analysis of many small wastewater treatment facilities and absence of monitoring programs is another challenge that the study faced and recommendations to address this issue is listed in the study. Absence of reuse (due to lack of infrastructure WWTP), mismanagement of the wastewater sector, Israel's control for approving projects of reuse (AL-Bireh for example) are considered the main factor behind the difficulties of gathering data for good assessment.

The Reform of the water sector and the new water law are considered a corner stone to readdress the wastewater sector and its management. Yet the new water law is still words on papers and need enforcement of law. The new law specifies that PWA has to prepare in consultation with relevant ministers and institutions sets of by laws including by- laws related to the water quality protection, safe discharge and treatment of wastewater and reuse of treated wastewater. Such preparation of bylaws will require consultation with different stakeholders, before submitting to the Cabinet for endorsement assuming the endorsement of draft bylaws will require time.

Table 3.1 The research objective, approach and methodology and expected out come

Research Objectives	Assessment of wastewater quality: polices and legislative frameworks, the guidelines and standard used for treatment and reuse.	
Research questions	**Methodology**	**Expected results**
Q1. What is the current Palestinian water policies and regulations and their legal frameworks in respective to water quality?	Literature review of available documents, reports, articles and laws.	Assessment of the present situation and defining gaps Present up to date status of the water sector in Palestine, present the actual situation in light of the reform process of the sector and implication of the new water law, discussing the legislation and required regulation and present the monitoring program of service provision for water supply and sanitation and reuse.
Q2.Are these frameworks responsive and provide an effective platform to protect these scare natural resources? Status of reuse of treated wastewater	Present the case of water quality for water resources and water supply and sanitation and reuse.	Discussing of current situation of pollution and challenges needed to be faced.
Q3. What policies are needed to promote and enhance the water quality monitoring programs to ensure protection of resources, safety of water supplied? Reuse of	Presentation of cases in Palestine represents the resources, the services and sources of pollution, action to be taken as requested by the new water law.	Recommendation to address the enforcement of polices and application of new water law
Q4. Nablus West Sewage Treatment Plant has been taken as a case study	discussing the challenges faced quantities and concentrations of major elements in wastewater influent and effluent.	The case study will serve as a pilot to assist the current situation of treatment and reuse; challenges and attempts for reuse.

CHAPTER FOUR

WATER QUALITY: LEGISLATION AND REGULATION

4.1 Introduction

This chapter discusses the relevant policies, legislation and regulation related to water quality in Palestine, the current status in light of the new water law and different laws, by laws and instructions related to water quality. This chapter addresses the new water law and the by-law recently endorsed by the Palestinian government identifying other by laws that need to be addressed as related to water quality protection and usage.

4.2 Water Sector Reform and the New Water Law 2014

Israeli control over water resources continued and did not end with the change in the political situation that accompanied the mutual recognition between the Palestinian Liberation Organization (PLO) and Israel. This was established by the signing of the Declaration of Principles Agreement in Oslo, Norway (Oslo Accord – Gaza and Jericho first) in 1993.

The Palestinian Water Authority was established under the Presidential Decree No. 90 of 1995. Water Law No. 2 of 1996. The water law founded a National Water Council (NWC) lead by the President of the PNA. This law remained in effect until it was replaced with Water Law No. 3 of 2002. Its purpose was to develop and manage water resources, increase output, improve quality, preserve the water resources, and protect the water resources from pollution and depletion. The law declared all water resources to be public property and entrusted the PWA with the management of both the water and wastewater sectors in addition to the projects associated with them. It also stated

that all water and wastewater projects (digging of wells, exploration, extraction, collection, desalination, water treatment, and the establishment and or operation of any water/wastewater facility) must initially obtain a permit from the PWA.

The water law entrusted the PWA with the role of regulator and supervisor, by means of establishing regional water utilities. This in turn left the establishment of these facilities in the hands of the PWA and a certain amount of responsibility to Local Authorities.

It should be duly noted; the Local Authorities Law No. 1 of 1997 dictates that local Authorities are responsible for managing services, including water (drinking water). This includes supplying residents with suitable water for drinking or any other purpose, determining service requirements: water meters, pipes, organization, distribution, determining subscription prices and preventing the pollution of canals, wells, spring and basins.

The NWC has not held a single meeting since its establishment, and this is why no regulations have been developed under the law no 3 for 2002 as the body (NWC) who is supposed to draw strategies, polices, regulations has never been met. The aforementioned situation restricts the PWA's efforts, specifically in regards to the issuance of laws and regulations in various aspects related to water. These laws and regulations were supposed to have been formulated by the NWC and submitted to the Prime Minister for approval.

The reform program was made to address the problems faced by the law itself as well as addressing the multiple references of the sector and to respond on good water governance.

Before the new water law is endorsed, PWA as leading body to manage resources has entered in conflict with the following institutions:

With the Ministry of Agriculture (MoA): The nature of the PWA's work, duties and jurisdictions intersect and intervene with those of other Ministries and public institutions. These entities are affiliated with the water and wastewater sector in accordance with the provisions of Paragraph (2) Article (7) of the Water Law. The MoA works with the PWA in devising plans and policies related to water, especially when they are in reference to the agricultural sector. The intersection of specialties between the PWA and MoA bears a contradiction in jurisdictions when it comes to: the issuance of permits to dig wells, using water allocated for agricultural purposes and treated water. This is due to the fact that the regulations of both institutions did not clearly specify this matter (i.e. the allocation of water).

With the Palestinian Environment Quality Authority (PEQA): Both the Water Law No. 3 of 2002 and the Environment Law No. 7 of 1999 regulate the relationship between the PWA and EQA in reference to the water environment, by virtue of the PWA's full responsibility of the management of water and wastewater resources. The PWA is also responsible for issuing permits for the reuse of treated water as part of its management of the wastewater sector. They require coordination with EQA who is responsible for the environmental aspects of managing wastewater, which includes its treatment and reuse. EQA also determines environmental standards and specifications in coordination with the PWA as they are one of the entities which hold some responsibility for the management of the water and wastewater sectors. The PWA participates in determining the approved specifications for water quality on the basis of

its usage, which includes drinking water. EQA determines the standards and specifications of water and treated water whereas the PWA can inspect any water source they believe to be contaminated; their inspectors have judicial authority. EQA will have the authority to perform routine inspections on facilities to make sure they conform to environmental standards and protect water sources from contamination.

With the Ministry of Local Government (MoLG): Water Law's No. 3 of 2002 and Local Authorities law No. 1 of 1997, organized the relationship between the PWA and MoLG in reference to the management of water resources as follows:

1. Some of the Local Government Municipalities 's jurisdictions include water and sanitation services within the boundaries of the LGM's structural plan. They are responsible for providing residents with water for various purposes, managing water distribution and determining pricing. On the other hand, the PWA is responsible for the management of water and wastewater resources. Meaning the PWA is generally responsible for securing water resources. The LGM's are responsible for managing, organizing and distributing water to residents within its boundaries.
2. LGM's jurisdiction also includes the management of sewage within their boundaries. Whereas the PWA is fully responsible for the management of wastewater, meaning that the LGU's must coordinate with the PWA to establish wastewater projects within the LGU's boundaries. The LGU's manage and supervise these projects.

The LGU's are responsible for determining the prices of water (used for various purposes) supplied to residents within their boundaries. On the other hand, the PWA is responsible for determining the tariff of water, within the framework of its duties in

implementing a tariff system. The LGU's must abide by the tariff system and refer to the PWA when determining the prices for water.

4.2.1 The Reform Plan:

The PWA submitted a request to the Cabinet of Ministers for approval of a comprehensive reform plan for the water sector. This plan coincided with the government's plan to reform all of their institutions in accordance with the 13th Governments strategic vision, whereby the PWA would play a crucial role. The government's water sector reform plan aims to develop the institutional situation of the water sector in a way that will ensure ending multiple references, food water governance and suitable water and wastewater services for Palestinians residing in the West Bank and Gaza Strip.

The PWA's reform plan was adopted by the Cabinet of Ministers by means of Legislation No. 13/13/04 in December 2009. The long term goals of the program are to establish strong/capable institutions within the framework of sustainable development and a legal framework that shall clearly define the roles, responsibilities and interrelationship between institutions in the water and wastewater sector, as well as those institutions that share responsibility on the periphery of the sector.

The new water law splits PWA functions as stated in law no 3 for 2002, into ministerial and regulatory functions. The new water law sat the basis to create the Water Sector Regulatory Council independent from PWA. The Water Sector Regulatory Council was established by the Cabinet in 2014 and has a Board of Directors derived from the public sector, private sector and civil society. Its mandate makes it responsible for water prices and monitoring the performance of Water and Wastewater Service Providers. It will

issue licenses for operators to establish the infrastructure needed to supply, desalinate and treat water and set the framework for quality assurance of services and manage consumer complaints. It will set the foundations to represent service providers in Regional Water Utilities and in addition, monitor the performance of Bulk Service Providers and ensure that their services are compliant with the accepted standards.

The Water Law includes directives to transform the West Bank Water Department into a governmental company which will be owned by the State of Palestine. The new law gives PWA the mandate, supported by a bylaw endorsed by the Cabinet, for establishment of Regional Water Utilities and Water User Associations.

The Law includes articles protecting water resources and defined protection zones. In addition, monitoring of water resources and provides the head of PWA the mandate to provide judicial policy. It also contains articles which allows for sanctions for the infringement of Water resources based on polluters pay principle. The following is a description of the new water law and legislations per the law

4.3 The New Water Law 2014

On June 2014, the President of the State of Palestine, has endorsed the new Palestinian water law superseding all other laws of relevance.

4.3.1. Aspects Related to Water Quality and Services:

The law aims to develop and manage the Water Resources in Palestine, to increase their capacity, to improve their quality, to preserve and protect them from pollution and depletion, and to improve the level of water services through the implementation of integrated and sustainable water resources management principles.

It states that all Water Resources in Palestine shall be considered public property, and the Authority has the power to manage these resources in a manner that ensures justice and efficiency in distribution. It is also states that the zone of Water Resource, water and waste water facilities shall be determined in accordance with specific criteria pursuant to a regulations issued by the Cabinet of Ministers.

It states that every person has the right to obtain his needs of suitable quality drinking water for utilization at specific prices set in accordance with the Tariff Regulation issued by the Cabinet of Ministers.

It calls upon Water Service Providers to take the necessary measures to ensure this right and prepare the plans required for the development of services in this regard, in accordance with the General Water Policy. The new law sets the uses of water and the required license shall be obtained prior to shifting the right of use from one purpose to another.

4.3.2 PWA Restricted to Ministerial Functions:

Contrary to the water law No 3 for 2002, the new water law restricts PWA to Ministerial functions, Strategies, Polices and Regulations, where monitoring of services has been given to the newly established body known as Water Sector Regulatory Body.

The new water law affiliates PWA to the cabinet of ministers and article 8 sets the following responsibilities in particular preparation of policies and regulations and reaching consensus with relevant authorities and ministries, it calls upon PWA to propose draft laws and draft regulations related to water, and submitting them to the competent authorities for their duly issuance, Article 8 reads as follow:

1. The full responsibility for managing Water Resources in Palestine, applying principles of integrated and sustainable management of water resources.
2. Preparing general water policies, strategies and plans, seeking their approval, and ensuring their implementation in coordination and cooperation with relevant parties, as well as submitting periodic status reports on water to the Cabinet of Ministers.
3. Surveying the available Water Resources, proposing water allocations for various sectors, and their utilization priorities on the basis of integrated and sustainable management principles, ensuring effective water demand management.
4. Protection of Water Resources and their surrounding environment through the establishment of protection zones to prevent pollution, in cooperation and coordination with relevant authorities.
5. Licensing and development of Water Resources utilization, in cooperation and coordination with the relevant authorities.
6. Setting a general policy for the planning and evaluation of water and wastewater projects in terms of their economic and social feasibility, setting design and quality control standards, technical specifications, and monitoring their implementation.
7. Taking measures and developing plans as may be required for the establishment and development of the National Water Company and the Regional Water Utilities, in coordination with the relevant authorities.
8. Supervising the organization of awareness raising campaigns in the sphere of water and wastewater and promoting the use of water saving fixtures, in coordination and cooperation with the relevant authorities.

9. The development of plans and programs for capacity building, training and qualification of technical staff working in the water sector and supervising their implementation with the aim of improving the management of water resources, in cooperation and coordination with the relevant authorities.
10. Endeavoring to achieve an equitable distribution and optimal use of water to ensure the sustainability of ground and surface Water Resources, in cooperation and coordination with the relevant parties. In addition to developing solutions and suitable alternatives in cases of emergency and contingency to ensure the continuity of water provision services, in coordination with Service Providers and relevant parties.
11. Coordinate and supervise scientific researches and studies related to water and wastewater and directing such research towards finding creative and innovative solutions to existing problems and following up on their recommendations with the specialized and relevant authorities.
12. Partake in the development of approved standards of water quality for various uses, in coordination and cooperation with the competent authorities, and ensure their implementation.
13. Development and coordination of effective participation in technical cooperation programs at the international, regional, bilateral and local levels, in the sphere of integrated and sustainable management of water resources, including through the organization of conferences, workshops, seminars and the representation of Palestine in international and regional fora and meetings in this sphere.

14. Proposing draft laws and draft regulations related to water, and submitting them to the competent authorities for their duly issuance.
15. Issuing and implementing directives and instructions related to Water Resources, and providing technical expert opinions in disputes related to Water Resources.
16. Cooperate with the relevant authorities in creating a climate that is stable and conducive to investments with the aim of encouraging private sector investment in the water sector, and implement required institutional, regulatory and economic reforms to encourage partnership with the private sector in accordance with a regulation issued for that purpose.
17. The establishment of advanced monitoring systems to monitor precipitation, surface flows, groundwater levels, utilization quantities, and water quality, as well as analysis of data to determine the safe and sustainable yield of Water Resources and improve water resources planning.
18. Develop principles and frameworks of water demand management with the aim of improving the efficiency of water supply, usage, conservation, recycling and reuse.
19. Build institutional capacities for the management of shared water resource and deepen regional and international cooperation.

4.3.3 The Water Sector Regulatory Council

The new water law created the base to establish the "The Water Sector Regulatory Council" by a decision of the Cabinet of Ministers and shall be regulated pursuant to this law. The Council enjoys a legal personality and is financially and administratively independent. The council has been established on June 2014 with objectives stated in the new water law in Article 18 that reads as follow: “The objective of the Council is to

monitor all matters related to the operation of water Service Providers including production, transportation, distribution, consumption and wastewater management, with the aim of ensuring water and waste water service quality and efficiency to consumers in Palestine at affordable prices.

Article 24 sets the responsibilities and powers of the Council as follows:

- Approval of water prices, costs of supply networks and other services required for the delivery of water and waste water services, as well as review and monitoring of these costs to ensure compliance with the policy adopted by the Authority.
- The issuance of licenses to Regional Water Utilities and any operator that establishes or manages the operation of a facility for the supply, desalination, or treatment of water or the collection and treatment of waste water, and the levying of license fees, in accordance with the provisions of this law and a regulation issued by the Cabinet of Ministers.
- The Monitoring and inspection of compliance with the terms, requirements and indicators stipulated in licenses and permits.
- The development of performance incentives programs for Service Providers, in accordance with a regulation issued by the Cabinet of Ministers for this purpose.
- The approval of internal bylaws, the financial and administrative regulations and organizational structure of the Council and their submission to the Cabinet of Ministers duly issuance.
- The approval of the annual budget for the Council and its submission to the Cabinet of Ministries.

- Monitoring operation processes related to the production, transport, and distribution of water and operational processes of wastewater management.
- Monitoring water supply agreements.
- Ensuring that production, transport, distribution and wastewater treatment costs take into consideration the interests of all concerned parties.
- Setting quality assurance standards for the provision of technical and administrative services by Service Providers to consumers, in line with relevant laws and regulations, and their dissemination to the public.
- Monitoring the compliance of the National Water Company and Service Providers with the adopted standards for the provision of water and Sanitation services.
- The establishment of a database for technical, financial and statistical information and the publication of this information periodically.
- Addressing complaints of consumers against Service Providers.
- Conducting a general review for the performance of the Council and its departments as well as a review of staff performance development plans, at least once per annum.
- Contracting experiences and competent experts, advisors, and technicians to implement tasks to be entrusted to them.
- Setting the basis for regulating the extent and percentage of local authorities' participation in the general assemblies of water utilities and ensuring implementation, in accordance with the provisions of the law and the applicable regulations.

4.3.4 The National Water Company: Bulk Water Provider

The new water law 2014 sets the basis to create the National Water Company with the following responsibilities:

- The supply and sale of bulk water to water undertakings, local authorities, joint water councils and associations.
- The extraction of water from Water Resources, desalination of water, and bulk water transmission in accordance with a license issued by the Authority for this purpose.
- The management, upgrade and development of any assets received from the Authority.
- Ensuring and guaranteeing smooth commercial relations with customers and suppliers.
- The provision of all the means necessary for the development of all activities and infrastructure works related to the supply of bulk water.
- The preparation of proposals for water supply tariff and related services and their submission to the Council for approval.
- Any other related tasks assigned by the Authority.

4.3.5 Regional Utilities: **The Service Providers**

In Article 45, The law calls upon PWA to establish, in coordination and cooperation with the relevant competent authorities, and in line with the public interest pursuant to the provisions of the law, Regional Water Utilities for the provision of water and wastewater services. The responsibilities, powers, and procedures pertaining to the licensing, structure, management, financial resources, dissolution, and all other matters related to the work of Regional Water Utilities shall be regulated pursuant to a regulation issued by the Cabinet of Ministers.

Article 47 sets the Regional Water Utilities responsible for the provision of water and wastewater services each within its specified administrative and geographical scope, in

accordance with a regulation issued by the Cabinet of Ministers in this regard. Accordingly, the objectives of Regional Water Utilities are:

1. The provision of water and wastewater services to consumers for various uses in line with sustainable economic, social and environment principles.
2. Meeting the needs for water of suitable quality and wastewater services through implementation of the required and appropriate measures and the development of the necessary plans and programs to develop these services.

4.3.6 Water Users Associations

The New Water Law sets the basis to create Water Users Associations with the aim of managing the service of supplying irrigation water at the local level in a sustainable manner, in accordance with a regulation issued by the Cabinet of Ministers upon a joint recommendation of the Minister of Agriculture and the Head of the Water Authority. The regulation shall stipulate the licensing procedures, responsibilities, powers, management, financial resources, dissolution and all other matters related to the work of Water Users Associations.

4.3.7 Protection of Resources and Sanctions and Polluter Pay Principle

Article 50 is an important Article related to protection of resources and ensuring a decent water service provision. It reads as follow:

With due regard to the provisions of the Environmental Law, and in coordination and cooperation with the authorities specialized in the protection of water resources and the prevention of their pollution, the Authority shall carry out the following:

1. Partake in regulating the use of industrial and agricultural materials that may cause the contamination of water resources or water supply systems.

2. Partake in the committees responsible for conducting environmental impact assessments with regards to any activity related to water resources or water supply systems.
3. Partake in the development of special mechanisms for crisis management in the event of drought, floods, epidemics that spread through water, or general pollution.
4. Partake in the preparation of a list of pollutants, which require licensing, and compensation for damages resulting from them.
5. Recommend a regulation to be issued by the Cabinet of Ministers for the protection of Water Resources and facilities.

Article 51 and 52 focuses on water pollution and the authority rights to suspends water extraction or supply. Article 52 declares Protected water zones

Article 53 gives the authority to take action against polluters and apply Polluter pay principle

In the new law, severe penalties are applied for the following according to Article 58:

1. Polluting any water resource or supply system, or causing such pollution through his actions without remedying it within the period set for him by the Authority.
2. Drilling groundwater wells or substitute wells, or extracting water without obtaining a license.
3. Infringement on any water resource or water and wastewater system, resulting in damage thereto or breakdown thereof.
4. The supply of water, or permitting the supply of water, to oneself or to others without a permit to do so.
5. Disposal of waste water without obtaining a license

An important article; Article 65 states that The Cabinet of Ministers, upon the recommendation of the Authority, may issue any regulations as it deems it appropriate for the implementation of this Law.

4.4. Environmental Law 7, 1999

The Environmental Law of Palestine (PEL, 1999) includes a framework for environmental protection including reused treated water and sets roles and responsibilities for the EQA as follows:

The PEL covers the following:

- Protection of the environment from all pollution sources and types;
- Reduction of public health hazards and securing human social welfare;
- Integration of environmental resources protection in all socioeconomic development plans and endorse the sustainability of development protects;
- Protection of all ecologically sensitive zones, biodiversity and bioremediation of environmentally degraded areas;
- ensuring inter-ministerial cooperation regulations and standards for various environmental protection areas and jurisdictions;
- Ensuring environmental information and data, knowledge sharing and raising public awareness, as well as enhancing environmental education and training.

Regarding hazardous substances and wastes, Article 12 of the PEL stipulates that: "No person shall be authorized to manufacture, store, distribute, use; treat, or dispose any hazardous substance or waste whether it is solid, liquid, or gas, unless such a process is in compliance with the regulations, instructions and norms specified by the Ministry, in coordination with the specialized agencies.

An Environmental Impact Assessment (EIA) shall be conducted for the following types of major development projects (examples are listed):

- Power plants (including gas turbines, substations and super tension lines)
- Wastewater treatment plants including main sewers
- Solid waste disposal sites and hazardous waste disposal sites
- Plants producing, storing or using hazardous substances including industrial estates
- Major dams and reservoirs as well as major roads

4.5 Discussion and Conclusion

The New water law becomes the law that governs all aspects of Water and sanitation. It is clear that by this law, the PWA has to prepare the needed policies, strategies and regulation in consultation with relevant ministries and institutions.

The water law set the role and responsibility of different actors, there should be no contradiction between different laws (Environmental Law and Local Authority Law), whenever there is a contradiction, the New Water Law supersedes.

Special attention should be given to preparation of by laws of service providers to eliminate the discrepancies in the sector as the local authority law remains the acting law for the service providers (joint service council, municipalities, village councils). The WSRC has to pressure PWA and the government to issue the needed regulations to be able to perform its mandate and licensing the service providers and monitoring them.

All by- laws has to indicate the standards for domestic, industrial and agricultural use for water and treated wastewater reuse. Discharge of wastewater and reclaimed wastewater reuse has also to be regulated.

CHAPTER FIVE WASTEWATER STATUS AND REUSE IN PALESTINE AND EXPERIENCE IN THE REGION

5.1 Introduction

This chapter will shed the light on wastewater reuse. It will serve for better understanding of the Case Study that has been chosen for this research (Nablus West Wastewater Treatment Plant and reuse).

Wastewater has an important role to play in water resources management. By releasing freshwater sources for potable water supply and other priority uses, wastewater reuse makes a contribution to water conservation and takes on an economic dimension and consider as an indicator for the country applying good governance for water and sanitation by applying the concept of integrated water resources management. Moreover, wastewater reuse, if properly planned and managed, can have positive environmental impact, besides providing increased agricultural yields.

In Palestine, due to conflict with Israel, the only substantial water resource available is groundwater. Presently the application of wastewater treatment was limited because of Israel imposed restrictions on projects implementation and imposing high standards for design and effluent of wastewater involving high cost and technological complexity of conventional systems.

Seepage of domestic wastewater from on-site cesspits, inadequately performing off-site sewage treatment plants (almost of rural NGO's built units) (Arafah, 2012), together with the excessive use of fertilizer in agriculture has resulted in a dramatic increase of

nitrate levels in aquifers and huge pollution of Wadis like Wadi AL Nar in Jerusalem and Beitlhem and Zimar wadi in Tulkarem, Qana Wadi in Salfit and AL Samen in Hebron.

The agriculture sector is the largest consumer of conventional resources including the groundwater aquifers in Palestine, meanwhile the water consumed for domestic purposes estimated to be 91 MCM/year (PWA, 2009). Currently, special attention has been paid to improve the water resource situation in the regional level, lifting the pressure on aquifers and encourage the reuse of treated wastewater. Reuse of wastewater could be one of the main options to develop the nonconventional water resources in the region, as it represents an additional renewable and reliable source. This marginal water resource could be used for agricultural purposes or groundwater recharge. This strategy will lead to reducing the gap of water deficit between supply and demand.

The Water sector reform of the Palestinian water authority and its strategy for 2032 has identified set of actions to increase reuse of non conventional resources and attempts to restrict fresh water for domestic purposes (PWA, 2013).

Reuse of reclaimed wastewater has two major objectives: it improves the environment quality by reducing the level of contaminants load into receiving water courses or to the Mediterranean Sea, and it conserves water resources by lowering the demand for freshwater abstraction. In the process, reuse has the potential to reduce the cost of both wastewater disposal and the provision of irrigation water.

The limited reliable data on existing situation and absence of clearly defined reuse policy for wastewater based on economic and health basis make the reuse of

wastewater issue top priority. So the main purpose of this chapter and the research overall is to provide adequate data and to facilitate transfer of knowledge and experiences and to assist in establishing regulatory and institutional framework for reuse of treated waste water. PWA and WSRC are engaging on preparation of regulations and by laws of wastewater discharge and reuse.

5.2 Status of Wastewater and Sanitation in Palestine

5.2.1 Connection to Sewer Networks

Hindering the development of wastewater sector in Palestine has led to inadequate infrastructure, both at sewer networks and wastewater treatment facilities, it also led to excessive usage of cesspits and bad practice in term of discharge of raw sewage to the environment and wadis. Lack of wastewater treatment plants has led to discouragement of donor to fund construction sewerage networks under the argument no need to transfer pollution from place to another without proper treatment.

The percentage of population connected to sewer networks in Palestine counts for approximately 52% distributed as 72% in Gaza Strip and 31% in West Bank while cesspits and septic tanks receive the rest as shown in Table 5.1.

In the West Bank, sewage collection has low coverage compared to the Gaza Strip. Only ten towns in the West Bank are served by sewerage systems. Many small and large scale treatment plants have been constructed and/or under tendering or construction.

Table 5.1: The coverage of wastewater network in 2009 (PWA, 2014)

Region	Population	Coverage %
North of West Bank	971,695	34.0
Middle of West Bank	711,979	43.6
South of West Bank	764,759	29.5
Total (West Bank)	2,448,433	35.5
North Gaza	286,246	80
Gaza City	519,027	90
Middle Area	215,808	65
Khan Younis	283,286	40
Rafah	182,449	65
Total (Gaza Strip)	1,486,816	84
Total (West Bank and Gaza Strip)	3,935,249	52

5.2.2 Wastewater Treatment Plants

5.2.2.1 Gaza Strip

There are four wastewater treatment plants in the Gaza Strip: Beit Lahia WWTP in the north, yet its not under full operation as lack of required energy, Sheik Ejlin WWTP in the Gaza City (under expansion), Khan Younis (new facility is under tendering) and Rafah WWTP in the south.

The existing WWTPs are heavily overloaded as the actual flow far exceeds the design flow. Blocked pipes and flooded manholes are daily events in Gaza Strip. The total effluent of the existing three WWTPs is approximately 41 MCM/year.

The Mediterranean Sea represents the final disposal of most treated, partially treated or untreated wastewater in Gaza strip. Table 5.2 shows Gaza Strip Wastewater treatment plants.

Table 5.2: Gaza Strip wastewater treatment plants

Municipalities WWTP	Type of Treatment	Construction date	Effluent Quantity m^3/d	Effluent Disposal Method
Beit Lahia	Stabilization ponds and aerated lagoons	1976	25,000	100% Infiltration basins East & North of Gaza Strip
Gaza	Anaerobic ponds followed with bio-towers	1977	60,000	100% to sea (50,000 partially 10,000 Raw)
Middle Area	without treatment	1998	More than 10,000	100% Wadi Gaza and to the Sea 10,000 Raw
Khan Younis	Anaerobic lagoon followed by aerobic lagoon	2007	8,000	100% to sea (partially treated)
Rafah	Anaerobic ponds followed with bio-towers	1983	More than 10,000	100% to sea 10.000 partially
Total effluent of Gaza (MCM/year)	41 MCM (38 MCM discharged to the Sea)			

Source: **(PWA, 2014 & BZU, 2004)**

5.2.2.2 West Bank

5.2.2.2.1 The Old Wastewater Treatment Plants

The existing treatment plants in the West Bank, namely in Tulkarm, Jenin and Ramallah was in the beginning of the 1970s, and consist of lagoon technology. All of these are not functioning well and consequently hardly achieve any treatment higher than primary. In addition to the aforementioned treatment plants, there are other three.

The first is a ponds system located in Hebron City, but since construction was never in use due to dispute between the Hebron municipality and the Israeli's authorities.

The second was constructed since 1980 at Birzeit University and consists of contact stabilization system serving 6000 students and employees. It has been functioning in an excellent condition however the operational cost is so high due to the cost of electricity for aeration. Treated effluent has been used for irrigation of the landscape within the University campus.

The third is built and put into operation (February 2000) extended aeration treatment plant serving Al-Bireh City with 50000 inhabitant for the first planning phase and 100,000 capita in final planning phase (BZU, 2004). About 25 MCM of raw sewage is being discharged each year in 350 locations. Israeli settlements are also discharging raw sewage to the environment (WORLD BANK, 2009). The type of treatment, quantity and final disposal of each wastewater treatment plant is summarized in Table 5.3.

Table 5.3: General Characteristics of Municipal Wastewater Treatment Plants in West Bank

Municipalities WWTP	Type of Treatment	Construction date	Effluent Quantity m^3/d	Effluent Disposal Method
Al-Bireh	Oxidation ditch	2000	3200	Valleys
Jenin	3 Aerated lagoons	1972	1500	Valleys
Ramallah	two aerated lagoons	1974	1370	Valleys
Tulkarem	Stabilization ponds	1970s	6742	Valleys
Total effluent in West Bank	4.7 MCM/year			

Source: **(PWA, 2014 & BZU, 2004)**

5.2.2.2.2 The New Wastewater Treatment Plants in the West Bank

Currently, as of 2015, and since 2010, major developments of wastewater treatment plants has been put in place, constructed or secured funds from donors and are either under construction or under tendering. Many small scale wastewater treatment units in rural area have been built. Other more adequate one (AL-Tireh and Rihan) has been built by the Municipality or the privet sector.

In the West Bank 10 sewage treatment plants are constructed or planned to serve about 550,000 inhabitants, while more than 60% of the population still lack central sewage treatment facilities. Very little progress in the construction of wastewater treatment plants has taken place on the ground. These plants will produce substantial quantities of treated effluent that are going to be used for agriculture and aquifer recharge. Table 5.4 summarizes the status of available information on the constructed and planned WWTPs

Table 5.4 the status of available information on the constructed and planned WWTPs

Name of T.P	Status of T.P	No. of population* 1000 served by T.P (year)	Capacity of T.P (MCM/yr)	Funding Agency	Estimated cost for construction (million US$)	Technology
Nablus East Nablus west	Detailed Design Operational	240 (2021) 225	9.2 9.0	KFW and EU Germany (KfW)	25 25	Activated Sludge Extended aeration
Salfeet	Stopped by Israel Detailed study	24 (2025)	2.3	Germany (KfW)	13	Extended aeration
Jenin	Rehabilitation is required	13.5 (1997)	0.5	Israel		Aerated Lagoons
Al-Bireh	Constructed	40 (2000)	1.8	Germany (KfW)	7	Extended Aeration Activated Sludge
Tulkarm	On hold Planning phase	223 (2030)	7.5	Germany (KfW)	50	Extended aeration
Abu Dees	Feasibility study	26 (2020)	1	Norway		Oxidation ditch
Tafuh	Feasibility study	16	0.5	UNDP		Anaerobic rock-filter
Halhul	Preliminary study	42 (2020)	1.0	Not funded	5.5	Aerated pond

Table 5.4 Continued…

Name of T.P	Name of T.P	Name of T.P		Name of T.P	Name of T.P	Name of T.P
Zeita Pilot WWTP		Overloaded, designed for 60 housed. Currently, 400 houses connected to the plant				Wetland
Beit Dajan WWTP			0.15			Conventional Activated Sludge
Birzeit area	Preliminary study	28 (1994)	1.2	Not funded	4.5	Imhoff tank and trickling filter
Hebron	tendering	695 (2020)	25.0	World Bank, AFD, USAID and EU	45	Activated sludge
Jericho	Constructed	26 (2000)	10	Jicka Japan		
Biddya	Preliminary study	24 (2000)	1.1	Not funded	10	
Ramallah	Tendering	40 (north) 40 (south)	? (Ask PWA)	KFW	7 7	Extended aeration
Al-Ram	Preliminary study	86.5 (2000)	3.3	Germany (KfW)	11	Aerobic sludge stabilization + Activated sludge
Al Tireh	Operational		1	Ramallah Municipality	4.5	Membrane Bioreactor
Diplomatic compound						Membrane Bioreactor
Al Rihan						Membrane Bioreactor
Azon				EU		Activated sludge
Sarrah			0.1	EU		Wetland
Ramoun - Taybeh			0.25	EU		RBC

Table 5.4 Continued…

Hajjah				EU		
Myselyah	Wet land	500		AFD		
Beitlhem Industerial Estate	Membrane	100		AFD		
Tayaseer Tubas	Tendering	2015		EU		
Northern Gaza	Under construction	(2015) (2025)	12.8 (Phase1) 22 (phase2)	World Bank, Sweden, France, EIB, Belgium	50 (Phase 1)	Plug flow/Complete mixing
Central Gaza	Detailed Design	(2025)	72.7	Germany (KfW)	70 (Phase 1)	Oxidation ditch
Southern Gaza	Detailed Design	(2025)	16.0 (phase1)	Japan	35 (Phase 1)	Oxidation ditch
Total (GS)		2900	111		155	

Sources: (interviews and internal reports of PWA)

The following Table 5.5 shows the status and capacity of different wastewater treatment projects in West bank and Gaza Strip

Table 5.5 Status and capacity of different WWTPs in West Bank and Gaza Strip (PWA, 2014)

Status of Wastewater projects in West Bank			
Project	Status	Capacity cubic meter/day	
		Short term	long term
Bethlehem Industrial sewage TP	Under construction	100	100
Western Bethlehem WWTP	Design	5000	
Hebron WWTP	Feasibility study	1005	15000
Myslyah	Design	240	400
Jenin WWTP	Upgrading and Rehabilitation	4500	9000
6 small WWTP	Constructed	10000	16000
Nablus West	Constructed	7000	12000
AlBireh WWTP	Rehabilitation	5770	
Ramallah	Design	1200	2000
Al Tireh WWTP	Constructed	1200	
Ramallah- Betonia WWTP	Design	6000	10000
Tayaseer	Design	1800	3000
Nablus east	Design	8400	14000
Gaza Strip			
North Gaza WWTP NGEST	Completed but not operational	35000	60000
Central Gaza Sheikh Ejlin	Upgrading	60000	200000
Khan Younes	Planning and secured fund	26000	44000

5.2.3 Reclaimed Wastewater

As shown in Table 5.4, the expected treated wastewater in the short term are expected to be around 50-70 MCM while more than 180 MCM is expected by the year 2025 (long term). Such figures show the importance of the reuse of reclaimed water in the agricultural sector. This section deals with aspect of reuse in agricultural sector.

Apart the Wastewater Treatment plants of Al- Bireh, Nablus West, Jericho, Beitlahia (NGEST), and other small plant using membrane processes for treatment, almost of old existing wastewater treatment plants in Palestine are overloaded and impose serious environmental problems. The quality of the effluents would nearly meet (class C) standards.

The public acceptance to use treated wastewater is a crucial aspect to ensure the success of any reuse project. Using treated wastewater in agriculture requires a comprehensive policy to avoid any environmental health, social and economic problems. In the light of deficiency of the water resources in and the strategic plan to utilize major parts of the non-conventional water sources for agricultural purposes, to this regard, the New Water law set the basis to establish Water Users Association and a successful example is achieved in Nablus where an association is established and will benefit from the Nablus West WWTP for reuse project associated to the facility it self as shown in the case study.

5.2.3.1 Wastewater Reuse in Palestine and in the Region:

Worldwide, wastewater has been used as a source of irrigation for centuries. In addition to providing a low cost water source, the use of treated wastewater for irrigation in agriculture combines three advantages. First, using the fertilizing properties of the

water eliminates part of the demand for synthetic fertilizers and contributes to decrease levels of nutrient in receiving waters (Wadies, Sea and lakes). Second, the practice increases the available agricultural water and third, it may eliminate the need for expensive tertiary treatment. However, wastewater is often associated with environmental and health risks. As a consequence, its acceptability to replace other water resources for irrigation is highly dependent on whether the health risks and environmental impacts entailed are acceptable and hence regulation of discharge and reuse of wastewater becomes a priority.

5.2.4 Wastewater Quality for Reuse

The existing wastewater treatment plants in Palestine are extremely different in both treatment system and cost. The existing ponds and trickling filter in Gaza and Rafah treatment plants seem to be a good combination if the treatment plant is not overloaded and the treatment cost becomes relatively acceptable. However, the system in both treatment plans is only designed for BOD removal and not capable for Nitrogen removal. The activated sludge system in Al-Biereh wastewater treatment plant proved to be a good system where the effluent quality can meet the required quality for reuse and recharge. Al Tireh plant (membrane) is considered the optimal working plant in term of quality of treated water (to add analysis as example) as well as on Nablus West and the planned ones.

5.3 Guidelines for Wastewater Reuse in Palestine

Around the world, the policy call on wastewater to be collected, treated and used according to guidelines to protect the environment and water resources, protecting

health and reduce the stress over fresh water resources by introducing the treated water for aquifer replenishment and irrigation purposes.

According to the new water law 2014, and the by law on household and facilities connection to the public sewage network its clearly stated that:

- The treated wastewater reuse should comply with the standards
- And has to be transported in accordance to the guidelines (closed pipes).
- Dilution of the wastewater to reach the compliance standard and direct injection to the aquifer without treatment is forbidden.
- In addition, wastewater treatment operator shall provide information and test results of quality of wastewater or any other information as requested.

At the end of this chapter, there is a section on the only by law that endorsed by the government and could be used as an indicative to the wastewater discharge and reuse.

5.3.1 Technical Principles for Irrigation and Recharge

5.3.1.1 General Instructions

The use of wastewater for irrigation and ground water enrichment is forbidden in drinking water protection zones. The ground water enrichment by wastewater is only allowed in facilities that are operated with a license from the competent authorities. The reuse of wastewater for irrigation is only allowed if it responds to the regulations and standards according to the relevant type of cultivation and irrigation technique. All kinds of vegetables are not allowed to be irrigated by treated wastewater.

5.3.1.2 Palestine Regulations:

According to the new water law, and regarding wastewater reuse, PWA is responsible for technical, financial and operational issues, including compliances (chemical,

microbial, samples, groundwater measures, and wells). EQA was responsible for environmental issues supervision. Its now an issue that the WSRC has to deal with in coordination with both PWA and EQA.

MoH is responsible for the public health supervision in regards to the consumption of food products that are irrigated (after licensing from MoA) by wastewater reuse and employees working on the reuse system.

Monitoring of groundwater, wastewater quality, soil quality of product and human health is required to ensure proper treatment, avoiding environmental degradation, minimizing adverse health impacts and increasing the agriculture production in a sustainable manner. The monitoring of facilities and operation includes self-monitoring, compliance with regulations of facilities and operations and required control facilities and documentations.

5.3.1.2.1 Technical Specification (TS) 34/2012

This Technical specification divide the quality of treated wastewater into 4 categories, high quality (A), Good quality (B), Moderate quality (C) and Poor quality (D). In addition, this specification regulate that the effluent quality of the treated wastewater for irrigation has to be approved by the Ministry of Agriculture to use of the treated wastewater for irrigation in accordance to their standards and specification.

5.3.1.2.2 Local Council Law, 1/1997

The local council law issued in 1997. According to the law, water collection and disposal are the responsibility of local councils, which was clearly stated as follows:

- Provision of potable water and other types of water. Addressing specification of water equipment i.e. pipes and water meter. Arrange for the distribution of water, the

tariff and prevention of pollution to the wells, basins and springs

- Protection measures for safe public health shall also be taken by the council; this includes the implementation of an efficient waste collection system.

It should be noted that as for water and sanitation services the new water law supersedes this law. According to the new water law, service providers including municipalities has to get license for services from the WSRC and has to follow by laws and instructions required by the competent authorities as discussed before.

5.3.1.2.3 Palestinian By-Law on Houses and Facilities Connection to Public Sewers Network:

The Palestinian Cabinet Resolution on the Connection of Houses and Facilities to the Public Sewers; No. 16 – 2013. The By-Law is shown in Annex 1 as unofficial translation. The following is a brief on instructions as per the by law:

- Discharge of any polluted wastewater to the public sewer is allowed after treatment of such wastewater, and require a license for connection to the public sewers from the service provider.
- Dilution of polluted water through mixing with fresh or potable water in order to reach the allowable limits listed in the resolution is prohibited.

The by law prohibits the following wastewaters from being discharge to public sewers:

- any wastewater with pH less than 5 or more than 9.5;
- any liquid or vapor with temperature exceeds 65 ^{O}C;
- any wastewater containing cyanide of more than 2 mg/L;
- any wastewater containing phenol in excess of 10 mg/L;

- any wastewater containing chlorinated organic solvents;
- any wastewater containing mass methylene-blue active substances;
- any wastewater containing mineral oils of more than 20 mg/L;
- any wastewater containing sulphates of more than 1000 mg/L;
- any wastewater containing sulphides of more than 2.0 mg/L;
- any wastewater containing chlorides of more than 500 mg/L;
- any wastewater containing fluorides of more than 60 mg/L;
- any wastewater containing sodium of more than 500 mg/L;
- any wastewater containing suspended solids of more than 600 mg/L;
- any wastewater containing chemical oxygen demand of more than 2000 mg/L;
- any wastewater containing toxic or heavy metals with concentration more than the listed values in the Table 5.6:

Table 5.6: Maximum concentrations of heavy metals for discharge to public sewer

Element	***Concentration (mg/L)***	***Element***	***Concentration (mg/L)***
Total chromium	5	Silver	1
Cupper	4.5	Boron	5
Tin	10	Mercury	0.5
Beryllium	5	Iron	50
Nickel	4	Zinc	15
Cadmium	1	Cobalt	0.05
Arsenic	5	Selenium	0.05
Barium	10	Lithium	5
Lead	0.6	Vanadium	0.1
Manganese	10	Aluminium	10

Source: Bylaw of house and facilities connection to public sewers.

The by law states also the following:

- For commercial, industrial and agricultural enterprises that have a valid license to apply for approval to link their sewage into the public sewage network after confirming their quality of sewage to the domestic sewage
- The service provider shall be bound to treatment matching the specifications standard the Palestinian water treatment No. (PS 742-2003) and any amendments as set by the Palestinian Standards Institute, as well as guidelines for the Food and Agriculture Organization and the World Health Organization, taking into account any new requirements.
- The sewage to be connected to the public sewage network must has the concentration of the chemical oxygen demand (COD) not to exceed (2000 mg / L), the service providers have the right to take fees to cover additional expenses of treatment
- The provider of water and sanitation services have the right to stop or suspend approval to connect the sewer network of any facility of public sewer network for the time period that it deems appropriate, while retaining the right to go to court to prosecute the perpetrator of these offenses criminally and civilians: 1. violation of the provisions of this Law or any conditions set by the water provider and sanitation when granting approval. 2. Do not enable the staff of water and sanitation services or bodies approved by the competent authorities to do their duty in the inspection and surveillance. 3. Non-compliance with any conditions or requirements of the service provider sees water and sanitation are essential to maintain the drainage system due appreciation to him.

- Its prohibited to discharge sewage to Wadis or to the environment unless after treatment and respond to the Palestinian Specifications No. (PS 2010-227 and its amendments) Palestinian specification number (PS 2003-742, as amended) and the technical instructions mandatory as set by Palestinian Standards Institution
- Its not allowed to discharge surface water and rainwater to the sewer system, unless after a written approval of the service provider.

5.4 Regional Experience on Wastewater Reuse

5.4.1 Wastewater Reuse Policy in Jordan and Israel in Comparison With the FAO Standards for Irrigation

Authority of Jordan has established the standard of wastewater reuse for irrigation purposes in 2006. These standards are currently applied to all municipal wastewater treatment systems. The standards establish a variable standard for wastewater quality for 7 categories of discharge or direct reuse. The direct use of treated wastewater for the irrigation of crops normally consumed raw was explicitly forbidden by the Standard.

The 1995 Standard # 893 includes the following categories of wastewater reuse standards depending on the fate of domestic wastewater after it is released from the wastewater treatment facility:

1. Recycling of water for irrigation of vegetables that are normally cooked,
2. Recycling of water used for tree crops, forestry and industrial processes,
3. Discharges to receiving water such as wadis and catchment areas,
4. Use in artificial recharge to aquifers,
5. Discharge to water bodies containing fish,

6. Discharge to public parks or recreational areas,

7. Use in irrigation of animal fodder.

The 1995 standard enabled design engineers and concerned health officials to adjust the level of treatment and, hence, the cost of treatment to the actual conditions of treated effluent reuse. Standards for BOD were limited to 150 mg/l for most forms of agricultural reuse and a more stringent standard was created for amenity irrigation in areas that can be accessed by the public.

Similarly, Israel has similar policy for reusing treated wastewater in irrigation with different quality standard.

Table 5.7 and 5.8 below present the comparisons of quality standards of Jordan, Israel, Palestine and the standard comparison with FAO.

Table 5.7 Comparisons of heavy metals quality standards of Jordan, Israel, Palestine and FAO

		Jordan JS 893/2006	Palestine TS 34-2012	Israel[1]	FAO[2]		
Parameter	**UM**	**A - D**	**A - D**		**Degree of restriction on use**		
					none	slight to moderate	severe
Heavy metals / trace elements							
Arsenic	mg/l	0.1		0.1	0.1		
Cadmium		0.01	0.01	0.01	0.01		
Chromium		0.1	0.1	0.1	0.1		
Copper		0.2	0.2	0.2	0.2		
Lead		0.2	0.2	0.1	5.0		
Mercury		0.002	0.001	0.002			
Nichel		0.2	0.2	0.2	0.2		
Zinc		5.0	2.0	2.0	2.0		
Aluminium		5.0	5.0	5.0	5.0		
Boron		1.0	0.7	0.4	< 0.7	0.7 - 3.0	> 3.0
Lithium		2.0 (0.075 for citrus)		2.5	2.5 (0.075 for citrus)		
Iron		5.0	5.0	2.0	5.0		

Table 5.8 Comparisons of physico- chemical characteristics standards of Jordan, Israel, Palestine and the standard of FAO

		Jordan JS 893/2006				Palestine TS 34-2012				Israel[1]	FAO[2]		
Parameter	UM	A	B	C	D	A	B	C	D		Degree of restriction on use		
		Cooked vegetables Parks Playgrounds Roadsides	Fruit tress Landscaped roadsides of highways	Industrial crops Forest trees	Collecting flowers	High quality	Good quality	Medium quality	Low quality	unrestricted irrigation	none	slight to moderate	severe
Physico-chemical characteristics													
BOD_5	mg/l	30	200	300	15	20	20	40	60	10			
TSS		50	200	300	15	30	30	50	90	10			
COD		100	500	500	50	50	50	100	150	100			
pH		6-9				6-9				6.5-8.5	6.5 - 8		
Turbidity	NTU	10			5								
EC	dS/m									1.4			
- salt sensitive		(EC: ~ 2.34)									< 0.7	0.7 - 3.0	> 3.0
- medium salt tolerant													
- salt tolerant													
- higly salt tolerant													
TDS	mg/l	1500				1200	1500	1500	1500		< 450	450 - 2000	> 2000
Ammonium as NH_4-N	mg/l					5	5	10	15	10			
Nitrate as NO_3 / NO_3-N		30 / 6.8	45 / 10.4	70 / 16.1	45 / 10.4	- / 20	- / 20	- / 30	- / 40		< 5	5 - 30 / 1.2 - 6.8	> 30 / > 6.8
Total Kjeldahl N		45	< 70	100	70	30	30	45	60	25			
PO_4-P		30				30							
Chloride		400				400				250	~ < 400	~ 400 - 1000	~ > 1000
residual Chlorine										1			
Bi-carbonate (HCO_3)		400			400						< 1.5 (me/l)	1.5 - 8.5 (me/l)	> 8.5 (me/l)
Microbiological characteristics													
Escherichia coli	MPN/100 ml	100	1000		< 1.1	100	1000	1000	1000	12			
Feacal coli						200	1000	1000	1000	10	1000 F. coli (irrigation of crops likely to be eaten uncooked; otherwise no standard recommended)		
Intestinal Nematodes	viable eggs/l					< 1	< 1	< 1	< 1				
Intestinal Helminthes		< 1	< 1	< 1	< 1						1 (irrigation of crops likely to be eaten uncooked)		

5.4.1.2 Reuse Policy in Jordan

The "Wastewater Management Policy" of Jordan was prepared in 1998 and consisted of 67 main points that were listed under 13 subtitles. The following key policy issues were included in the wastewater management policy:

- Wastewater shall not be treated as waste and therefore disposed. Wastewater shall be part of the national water budget.
- Adequate wastewater collection and treatment facilities should be available for all the major cities and towns in Jordan to protect the environment and public health.
- Priority of reuse of treated effluents should be directed as a source for irrigation.
- Treatment of wastewater shall be targeted towards producing an effluent fit for reuse

in irrigation that complies with the WHO and FAO guidelines.

- A high importance should be given for the establishment of a section in the Water Authority to be responsible for the development and management of wastewater systems, wastewater treatment and reuse.
- A basin management approach shall be adopted where possible. The use of treated wastewater in irrigation shall be given the highest priority and pursued with care.
- Effluent quality standards shall be set based on the best attainable treatment technologies, and calibrated to support or improve ambient receiving conditions, and to meet public health standards for end users.
- Wastewater intended for irrigated agriculture shall be regulated based on the soil characteristics of the irrigated land, the type of crops grown, the irrigation methods, and whether other waters are mixed with the treated wastewater.
- Industries shall be encouraged to recycle part of its wastewater and to treat the remainder to meet standards set for ultimate wastewater reuse or disposal.
- Wastewater from industries with significant pollution should be treated separately to standards allowing its reuse for purposes other than irrigation or to allow its safe disposal.
- Consideration shall be given to isolating treated wastewater from surface and ground waters used for drinking purposes, and to the blending of treated effluent with relatively fresher water for suitable reuse.
- Priority shall be given to protecting public health and water resources from chemical and microbiological pollutants.
- The transfer of advanced wastewater treatment technologies shall be endorsed and

encouraged. However, appropriate wastewater treatment technologies shall be selected with due consideration to operation and maintenance costs and energy savings, in addition to their efficiency in attaining and sustaining quality standards.

- Treated wastewater effluent is considered a water resource and is added to the water stock for reuse. Priority shall be given to agricultural reuse of treated effluent for unrestricted irrigation. Blending of treated wastewater with fresh water shall be made to improve quality where possible. Crops to be irrigated by the treated effluent or blend thereof with freshwater resources shall be selected to suit the irrigation water, soil type and chemistry, and the economics of the reuse operations.
- Farmers shall be encouraged to use modern and efficient irrigation technologies. Protection of on farm workers and of crops against pollution with wastewater shall be ensured.
- Treated effluent quality should be monitored and users are alerted to any emergency causing deterioration of the quality so that they will not use such water unless corrective measures are taken.
- Sludge produced from the treatment process would be processed so it may be used as fertilizer and soil conditioner. Care shall be taken to conform to the regulations of public health and environment protection norms.
- Wastewater charges, connection fees, sewerage taxes and treatment fees shall be set to cover at least the operation and maintenance costs. It is also highly desirable that part of the capital cost of the services shall be recovered. The ultimate aim is for a full cost recovery.
- Appropriate criteria in order to apply the "polluter pays" principle shall be

established.

- Treated effluent shall be priced and sold to end users at a price covering at least the operation and maintenance costs of delivery.
- All crops irrigated with treated or mixed waters shall be analyzed and monitored periodically.
- The role of the private sector will expand with management contracts, concessions and other forms of private sector participation in wastewater management such as BOO / BOT.
- The role of private sector in reuse of treated wastewater shall be expanded.

5.4.2 Regional Experience

The benefits of promoting wastewater reuse as a means of supplementing water resources have been recognized by many countries. In some of them such as Egypt, Tunisia, Jordan, Malta, Cyprus, Israel and Spain, several projects are already in operation or under planning, while in Israel, shear necessity has dictated the construction and operation of wastewater reuse for agriculture irrigation. Other countries, such as Greece, France and Italy are seriously considering wastewater reuse and reclamation.

The status of treated wastewater reuse practice is evolving continuously, although quantitative information on wastewater treatment and reuse is difficult to obtain. In arid regions, like Greece, Spain, Italy, Israel, Jordan and Tunis are among the leading countries in wastewater reuse (MED WWR WG, 2007).

The treated wastewater reuse rate is high in Cyprus (100%) and Malta (just under 60%), whereas in Greece, Italy and Spain treated wastewater reuse is only between 5 % and 12 % of the effluents. The amount of treated wastewater reused is mostly very small (less than 1%) when compared with a country's total water abstraction. Only Malta and Israel augment their water supply by 10 % and 18 % respectively, using treated wastewater as an alternative source (Bixio et. Al, 2006).

Throughout the Mediterranean, about 75% of the treated wastewater is applied in agriculture for irrigation. The remaining 25% is almost equally shared between industrial applications, urban uses, groundwater recharge and ecological enhancement. It becomes evident that compared to the use of freshwater resources reclaimed irrigation applications are "over-represented" whereas the industrial and cooling water sector is hardly making use of wastewater recycling. In Europe most reuse schemes are located along the coastlines and islands of the semi-arid Southern regions, and in the highly urbanized areas of Northern and Central Europe (Hidalgo et. Al., 2005).

In Mediterranean countries there are many coastal and southern regions where there is a severe pressure on freshwater resources, due to low and seasonally uneven precipitation and high run-off. In some cases this is exacerbated by especially high demand from tourism and agriculture during the summer months. The main reasons are very high population density and low to medium precipitation. A summary of the regional experience of reclaimed wastewater is presented below.

5.4.2.1 Jordan

Jordan has worked to manage irrigation with wastewater for several decades. Since the early 1980s the general approach has been to treat the wastewater and either discharge

it to the environment where it mixes with freshwater flows and is indirectly reused downstream, or to use the resulting effluent to irrigate restricted, relatively low-value crops. Given the diminishing per capita freshwater supply, the increasing dominance of effluent in the water balance, the overloading of wastewater treatment plants, local riparian water rights, and the need to protect domestic and export produce markets, effectively managing water reuse, including enforcement of existing regulations, has become increasingly challenging.

In Jordan, the total amount of wastewater produced is estimated at 232 MCM/yr. Approximately 70 MCM/yr are treated at fourteen treatments all over the country. Almost 85% of the treated wastewater is utilized in irrigation either directly at the outlet of the treatment plants or after being discharged into watercourses, particularly into the reservoir of the King Talal Dam. The reuse of treated wastewater in Jordan is among the highest in the world and provides a major resource potential for the Jordan valley farmers to meet the future needs of irrigated agriculture (MED WWR WG, 2007).

5.4.2.2 Israel

Israel is a large user of treated wastewater in the region. In 1987, it has about 230 projects, which produced 3,000 l/sec reclaimed water from a population of over 4 million people. About 92% of the wastewater is collected by municipal sewers. Subsequently, 72% is used for irrigation (42%) or groundwater recharge (30%). The total quantity of wastewater that is currently generated in is 385 MCM/yr, of which 250 MCM are treated to varying degrees. The balance is discharged to watercourses and the sea for lack of treatment and reuse facilities (MED WWR WG, 2007)..

The use of recycled wastewater must be approved by local, regional and national authorities. Effluent used for irrigation must meet water quality criteria set by the Ministry of Health. The trend is towards bringing all effluents to a quality suitable for unrestricted irrigation with wider crop rotation, which will require more storage and higher levels of treatment in the future. Cost-benefit analysis indicates that recycled wastewater is a very low cost source of water in Israel. As a result, treated wastewater within the overall water supply, particularly for irrigation, has risen to 24.4% of the allocations. The water crisis in Israel and the relatively low cost of treated wastewater, rather than pure environmental considerations, are the main driving forces behind the high percentage of reuse (MED WWR WG, 2007).

5.4.2.3 Egypt

The Egyptian water strategy comprises the treatment and reuse of treated wastewater. Treatment of domestic wastewater is either primary or secondary. At present, wastewater is estimated at 4,930 MCM/yr, with 22 operational wastewater treatment plants, and about 150 plants under construction. The total capacity of the installed treatment plants amounts to about 1,752 X 10^3 MCM/yr (MED WWR WG, 2007)..

Treated wastewater reuse in Egypt is an old practice. Sewage farming is deliberated as one of the most environmentally sound practices for disposing of sewage effluent. The major problem related to the current use of treated sewage water in Egypt is not enough infrastructures (treatment plant) to treat the amounts of wastewater produced and negative impacts of the above problems on both health and environment (MED WWR WG, 2007).

CHAPTER SIX

CASE STUDY: Nablus West WWTP

6.1 Concept

Nablus city is located in the northern West Bank, with population of 126,132 inhabitants (PCBS,2013). Located in a strategic position between Mount Ebal and Mount Gerizim, it is the capital of the Nablus Governorate and a Palestinian commercial and cultural center. (93%) of households are connected to a public sewage system while 7% are connected through cesspits. The Nablus West WWTP will treat sewage arriving from Nablus West Area and to be discharged into Wadi Zomar (Alshaeer) and then Alexander Stream in the coastal plane.

6.2 The Design of Nablus West WWTP

The Nablus WWTP will treat 5.4 million cubic meters of raw sewage serving a Population of 150,000 and the discharged effluent will be compliant with EU effluent standards design.

The Nablus West WWTP is based on activated Sludge treatment. The process of the wastewater treatment at Nablus is divided into the mechanical treatment stage, the biological treatment stage and the sludge treatment stage. Annex 3 provides the Plant as designed.

6.3 Location

The Nablus West Wastewater Treatment Plant (NW/WWTP) is located in the Upper Wadi Zeimar Basin (see Figure 6.1) is serving the Nablus West and Deir Sharaf. In the near future its rural environs between Nablus and Deir Sharaf village will be also

included. The NW/WWTP was put into operation in July 2013.

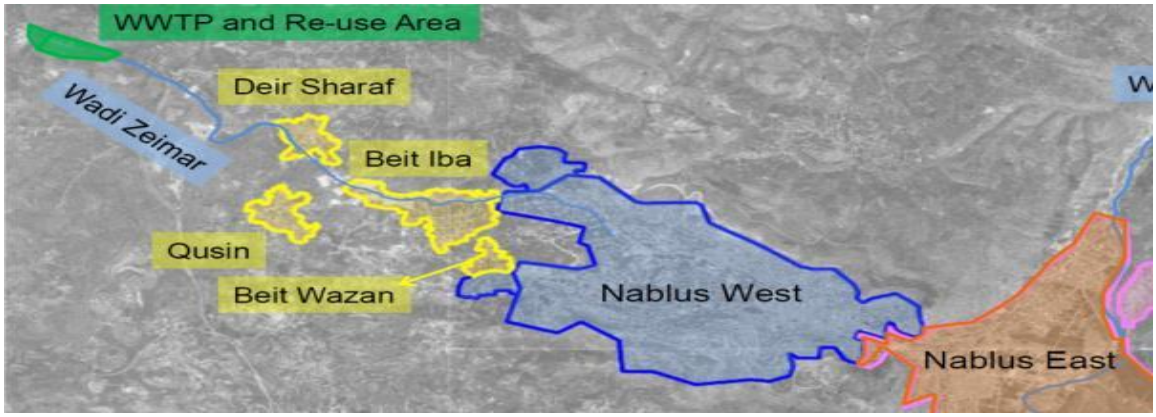

Figure 6.1: Project Location of WWTP and Reuse Area in Nablus West (Reference Nablus Municipality Internal Report)

6.3.1 Project Area

As part of the "Sewerage Nablus WEST" project two pilot reuse schemes (Figure 6.2), inside (labeled: Reuse Inside Scheme) and outside (labeled: Reuse Outside Scheme) the NW/WWTP are designed, planned, implemented and evaluated in the course of the Project. The Outside Reuse Scheme is located outside the fenced area of the treatment plant. The reuse area is divided into two plots, one west of the entrance to the treatment plant and one east of the entrance.

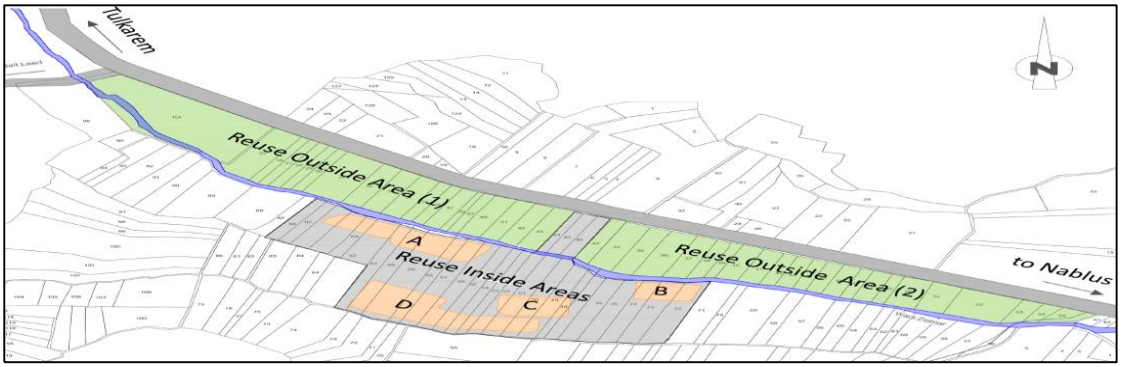

Figure 6.2: Reuse Outside and Reuse Inside Scheme Areas (Reference Nablus Municipality Internal Report)

The Project is working closely with Deir Sharaf farmers to make use of the treated effluent directly within their farms adjacent to NW/WWTP. Currently, all areas are rain fed and no irrigation infrastructure exists. The project will cover an area of about 12 ha. See Figure 6.3

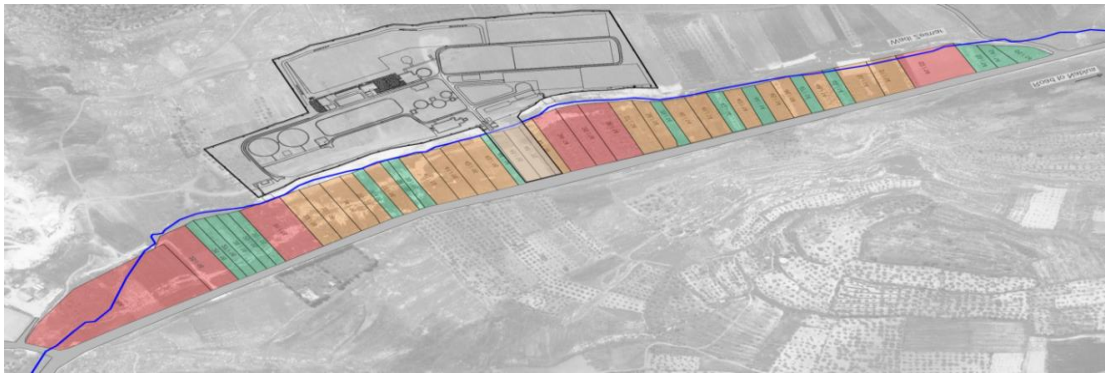

Figure 6.3: Overview of WWTP Nablus West and Land available for Outside Reuse Scheme (Reference Nablus Municipality Internal Report)

Rainfall: Monthly rainfall data were collected from two weather stations, Anabta and Nablus weather stations for the last four years. The average rainfall ranges from 0 mm in summer months to its maximum (150-160 mm/month) in December and January, with an annual average of about 529 mm and 631 mm for Anabta and Nablus, respectively, for the last 4 years (2010/11 – 2013/2014). Over 50 percent of the precipitation occurs in December and January.

Temperature: The Tulkarm area is considered to have been a temperate region over the last 15 years (1997-2011). The average minimum temperature ranges from around 9.4^{o}C in January to a maximum temperature of about 32.6^{o}C in July and August.

Relative Humidity: The relative humidity in Tulkarm is moderate and consistent

throughout the year, ranging from 56.9% in November to around 68.3% in February, for the last 15 years (1997-2011).

Wind: The wind speed in Tulkarm is generally consistent throughout the year, ranging from 13.68 km/hr in October to 17.64 km/hr in February, with an average 15.48 km/hr.

in January 2015. However, according to the latest information the implementation is currently on hold.

system design was based on a design flow of 60 m^3/hr and the selected irrigation method is drip irrigation. The irrigation efficiency was assumed with 90% and the peak irrigation duty was estimated at 5.1 mm/day at Deir Sharaf. An Environmental Assessment for the USAID/Compete was conducted by USAID project the year 2014. The assessment concluded that "the selected locations, selected irrigation techniques and the criteria proposed for crops selection is appropriate and can lead to a fruitful experimental and educational project in wastewater reuse in irrigation and can set forward the conditions and methodologies for farther expansion in wastewater reuse in irrigation in the West Bank."

6.4 Effluent Quantity

Unlike the influent to the Nablus West WWTP, effluent quantity has only been reported since December 2014to date. The average daily volume of wastewater influent was approximately 9,700 m^3/d. The flow rate is relatively consistent and is only interrupted by temporary periods of maintenance when treatment capacity is less and individual surge events to the sewage collection system resulting from storm (high precipitation) events. During rainy days and periods of snowmelt,

considerable runoff from streets and roofs of buildings collects in the Nablus wastewater collection system is directed to the Nablus West WWTP.

The available measured effluent quantities from the WWTP are greater than the measured influent volumes. The increase occurs because liquids from the sludge treatment process are added to the flow stream as part of the designed treatment process.

The difference between influent and effluent quantities is, thus, a function of the liquid content of the sludge which varies in time. The average effluent quantity was approximately 1,600 m^3/d higher than the influent flow.

The wastewater collection system within the city of Nablus has been designed as a pure sewerage system, but operates as a combined system that collects the storm water as well as the wastewater. Thus, during rainy days considerable amount of rain water runoff from streets and building' roofs is diverted to the wastewater collection system.

6.5 Effluent Quality

The Stage 1 design standards for secondary treated effluent at the Nablus West WWTP (design horizon 2020) are 20 mg BOD_5/l and 30 mg/L SS. Nitrogen removal was originally not included in Stage 1 but is done since early 2015. Influent and effluent wastewater samples are routinely collected and analyzed in the new laboratory of the Nablus West WWTP. Data received from the WWTP laboratory are presented in the following tables provides the design value 2020 and analysis of the effluent for the period December 2014 till September 2015. Table 6.1 shows the design value for 2020 of the WWTP

Table 6.1 Design Values of Nablus West WWTP 2020

Parameters	Design value 2020
Average incoming waste water m^3/d	14000
Inlet chemical oxygen demand COD_{in} mg/L	1100
Outlet chemical oxygen demand COD_{out} mg/L	100
Outlet biochemical oxygen demand BOD_5 mg/L	20
Inlet Biochemical oxygen demand BOD_5 mg/L	550
Sludge age (day)	13.7
MLSS g/L	3
TSS_{inlet} mg/L	500
TSS_{outlet} mg/L	30
Electrical consumption $/m^3$ kW/m^3	0.85
Electrical consumption/kg$COD_{removed}$ kW/kg	0.8

Source: (Municipality of Nablus Internal Technical Report)

Table 6.2 is a summary for the monthly analysis as done by the Nablus Municipality facility team. Taking from the working monthly reports:

Table 6.2: Summary Analysis of Effluents for the period December 2014-september 2015

Parameters	**Design value 2020**	Month 12/2014	Month 2/2015	Month 3/2015	Month 4/2015	Month 5/2015	Month 6/2015	Month 7/2015	Month 9/2015
Average incoming waste water m^3/d	14000	10420	13913	12685	12161	10636	10651	11285	9740
COD_{in} mg/L	1100	859	685	775	776	921	915	971	941
Outlet COD_{out} mg/L	100	63	111	63	50	81	47	53	72
Outlet BOD_5 mg/L	20	12.6	22	13	10	16	9.5	11	14
Inlet BOD_5 mg/L	550	430	343	387	388	461	458	485	471
Sludge age (day)	13.7	15	13	17.8	11	12	13	12	10
MLSS g/L	3	3.8	3.9	4	3.44	3.6	3.8	4.5	3.3
TSS_{inlet} mg/L	500	412	436	319	359	340	358	374	351
TSS_{outlet} mg/L	30	18	47	36	19	28	17	29	33
Power consumption kWh/m^3	0.85	0.61	0.36	0.566	0.57	0.69	0.85	0.74	0.80
Electrical consumption/kg$COD_{removed}$ kWh/kg	0.8	0.76	0.62	0.795	0.79	0.82	0.98	0.8	0.98
Avg. out NH_4-N mg/l		NM	67	5.7	1.58	39	4.5	8.08	3
Avg. inlet NH_4-N mg/l		NM	105	74.1	78.3	78	76	76	78.4
Avg. out PO_4-P mg/l		NM	-NM	6.37	2.95	NM-	2.8	4.4	4.4
Avg. in PO_4-P mg/l		NM	-NM	25.9	15.1	NM	37	NM	39
Avg. out NO_3-N mg/l		NM	-NM	NM	NM	1	2.3	NM	1.8
Avg. in NO_3-N mg/l		NM	-NM	3.2	3.55	2	0.8	3	NM
Avg. out TN mg/l		NM	-NM	11.2	8.2	40	9	13.16	7

NM: Not measured (Municipality of Nablus Internal Technical Reports)

6.6 Data Analysis and Discussion

6.6.1 Operation of Nablus West WWTP

The NW/WWTP began operation in July 2013. During the first seventeenth months (September 2013 – January 2015) of operation, effluent flow ranged from 8,285 to 13,658 m^3/day, with an average of 9,710 m^3/day. Inflow and effluent quantities are affected by episodic storm surges during rainfall events in the winter months, as rainwater and snow melt are entering the sewage collection system. The treatment plant is designed for secondary treatment (Stage 1; design horizon 2020) and effluent design parameters are 20 mg BOD_5/l and 30 mg/L SS. Nitrogen removal and disinfection is not included in Stage 1. However, Nablus Municipality has been operating the treatment plant with nitrogen removal since early 2015.

Nitrogen removal of the effluent is a precondition to satisfy the requirements of the Palestinian standards (PSI 742/2003 and/or TS 34/2012) for effluent reuse in agricultural irrigation. Effluent salinity measured as electrical conductivity averaged at 1,646 μS/cm. Such salinity might result in a significant yield reduction for sensitive crops, but the impact to yield would be slight if used for only moderately sensitive crops.

Inlet and outlet effluent total dissolved solids (TDS) were measured using the evaporation approach on 22 June, 6 July, 4 November and 23 November 2014. The TDS values at the outlet ranged from 690 to 838 mg/L, with an average of 789 mg/L, which is within the acceptable range for the Palestinian TS 34/2012 for treated wastewater reuse (1,500 mg/L).

The total suspended solid (TSS) for the NW/WWTP design specification is

30mg/L. The effluent quality from the treatment plant is mostly compliant with this design standard of 30 mg/L. The geometric mean of the influent and effluent is approximately 400 mg/L and 24 mg/L, respectively. Attesting the efficiency overall of SS removal in the treatment process.

Chloride concentration in the effluent sample collected on 5 November 2014, was 312 mg/L, which is within the normal range for chloride concentration in irrigation water (0 to 350 ppm) and Palestinian technical specifications (TS 34/2012) for treated wastewater reuse (400 ppm). Boron concentration in the effluent samples collected on 12 November 2014, ranged from 0.15 to 0.20 mg/L, which is in the normal range for boron concentration in irrigation water and within the Palestinian technical specifications (TS 34/2012) for treated wastewater reuse (0.7 mg/L). Currently, no disinfection of the treated wastewater takes place at NW/WWTP. Therefore the microbiological quality of the treated wastewater will fail to meet the limits of even the lowest quality standard, class D, according to Palestinian Standard (TS 34-2012). Thus, the installation of a sand filtration and Ultraviolet (UV) disinfection unit with a capacity of 110 m^3/hr is recommended for the reuse in the inside and outside schemes. The implementation of the disinfection unit will consider possible future extensions. For the irrigation system, overhead sprinklers for alfalfa and drip irrigation for the olive and almond fruit trees is recommended.

6.6.2 Influent

The following figure 6.4 shows the influent for the period December 2014 till September 2015. An average of around 11436 M3/d of wastewater enters the WWTP.

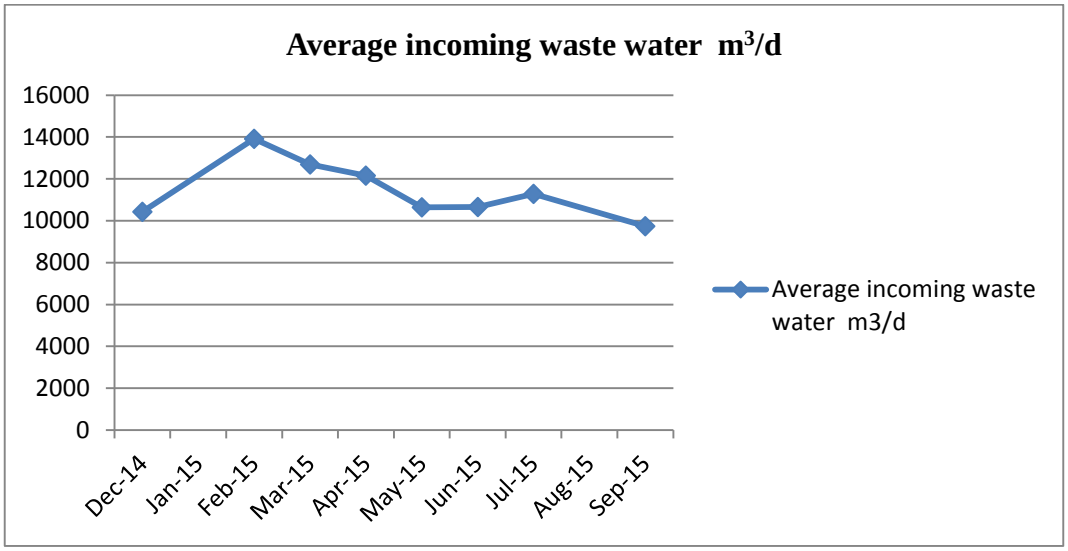

Fig 6.4 Inffleunt flow m^3/day (Municability of Nablus Internal Technical Report)

6.6.3 pH and Effluent and Electrical Conductivity (EC)

pH is measured in the effluent. pH is relatively stable with an average of 8.3. EC has been measured in the influent. EC is not significantly affected by the treatment process, thus, the data shown in Figure 6.5 is considered to also reflect the effluent. the EC ranged between 116 and 2,170 µS/cm, with an average and geometric mean of approximately 1,600 µS/cm. The lower values are associated with dilution during high rainfall events.

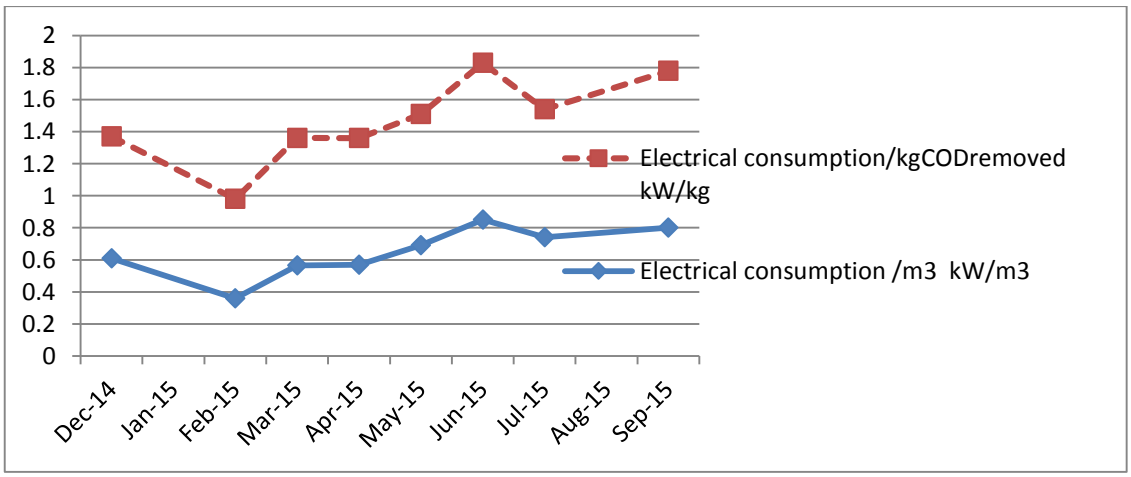

Fig 6.5 Electrical consumption (Municability of Nablus Internal Technical Report)

EC is a particularly important parameter as an indicator of salinity. Salinity is a

determining factor in the suitability of the effluent for irrigation purposes, along with suspended solids in the effluent and the mineral content of the soil. In arid and semi-arid climates, irrigating with water rich in mineral salts may, over time; result in the accumulation of these salts in the surface layer of the soil. The salts rise by capillary action and evaporation. A film of varying thickness may consequently develop on the soil surface, which may become incompatible with plant growth. Such salinity might result in significant yield reduction for sensitive and slightly for moderately sensitive crops, but it would be low to negligible for moderately tolerant and tolerant crops.

The effluent is determined to a great extent by the levels of electrical conductivity, sodium, chloride, boron, and bicarbonate in irrigation water. Toxicity normally results within the plant itself when certain ions are taken up with the soil-water and accumulate in the leaves during water transpiration to an extent that result in damage to the plant.

The usual toxic ions in irrigation water are Cl^-, Na^+ and B. Regardless of the treatment process utilized; Na, Ca and Mg content will basically remain unchanged in relation to their concentrations in the raw wastewater. The most common plant toxicity is from chloride in the irrigation water. The normal range for chloride concentration in irrigation water is 0 to 355 ppm.

Conductivity and salinity are strongly correlated. As conductivity is easier to measure, it is used in algorithms estimating salinity and TDS, both of which affect water quality. When calculating TDS from a conductivity measurement, a TDS factor is used. This TDS constant is dependent on the type of solids dissolved in water, and

can be changed depending on the water source.

6.6.4 Boron and Chloride

Plant toxicity is influenced by chloride and boron concentrations of the irrigation water. Sample analysis conducted for this study indicate a measured chloride concentration in the effluent of 312 ppm on 5 November 2014, which is within the "normal" range for chloride concentration in irrigation water (0 to 350 ppm) and Palestinian TS 34/2012 for treated wastewater reuse (400 ppm).

Boron (B) is an essential element for plant growth but only in small concentrations. For some crops, 0.2 mg/L of boron in water is essential. At high concentration, usually >1-2 mg/L, it can become toxic. Boron concentration in the effluent samples collected on 12 November 2014, ranged from 0.15 to 0.20 mg/L, which is in the normal range for boron concentration in irrigation water and in the Palestinian technical specifications (TS 34/2012) for treated wastewater reuse (0.7 mg/L). Such B concentration will not pose any restriction for all crops.

6.6.5 Total Dissolved Solids (TDS)

Influent and effluent TDS was were measured, using the evaporation approach, on 22nd of June, 6th of July, 4th of November, and 23rd of November 2014 (Figure 6.6). The TDS values at the outlet ranged from 625 to 980 mg/L, with an average of 789 mg/L, which is within the acceptable limit for the Palestinian standard TS 34/2012 for treated wastewater reuse (1,500 mg/L).

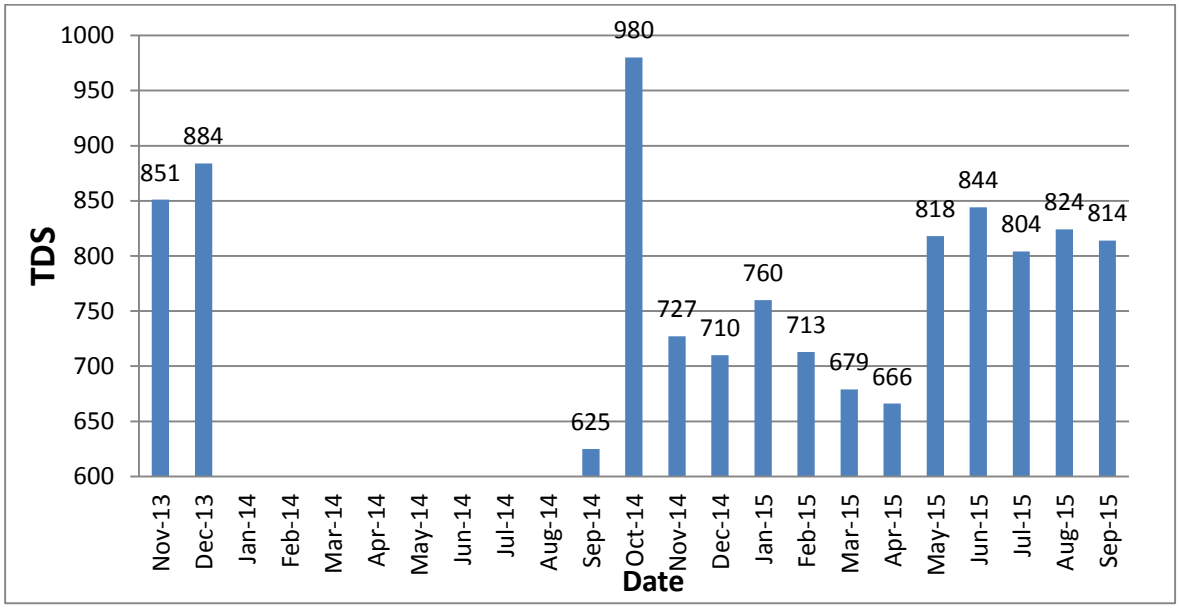

Figure 6.6 :Inlet and Outlet effluent total dissolved solids (Municability of Nablus Internal Technical Report)

6.6.7 Suspended Solids (SS)

Suspended solids data are presented in Figure 6.7 the effluent quality is mostly compliant with the effluent design standard of 30 mg/L. The geometric mean of the influent and effluent is approximately 400 mg/L and 24 mg/L, respectively.

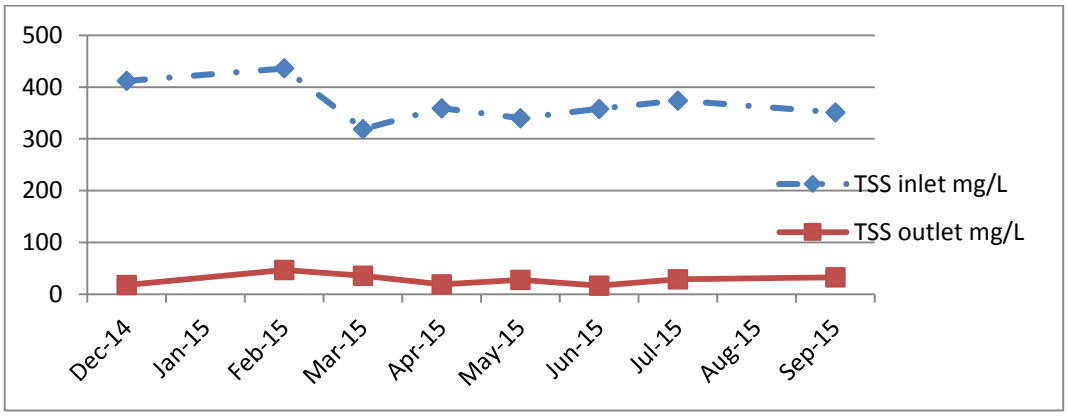

Figure 6.7 Influent and Effluent Suspended Solids (SS) Concentrations (Municability of Nablus Internal Technical Report)

SS is an important parameter for irrigation purposes. The SS added to the soil by highly turbid effluent may be held on the surface by the soil particles, and may eventually cause clogging, reducing infiltration of the water. The risk is tied to the quantity of suspended solids contained in the water and the diameter of the solid particles, but it is only a concern for perennial crops for which the soil is not labored every year. Also, the amount of total suspended solids in the effluent relates to the clogging problem in drip irrigation systems and the efficacy of effluent disinfection using ultraviolet radiation if no proper functioning filtration system is in place.

6.6.8 Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD_5)

The Stage 1 effluent design standard (design horizon 2020) for BOD_5 is 20 mg/L. The available BOD data are presented in Figure 6.8 as follows:

- BOD_5 in the influent and effluent, both directly measured by the WWTP laboratory;
- BOD_5 of the effluent, as derived/estimated from effluent COD analyses (based on the measured relationship, as an average ratio BOD/COD of the effluent samples).

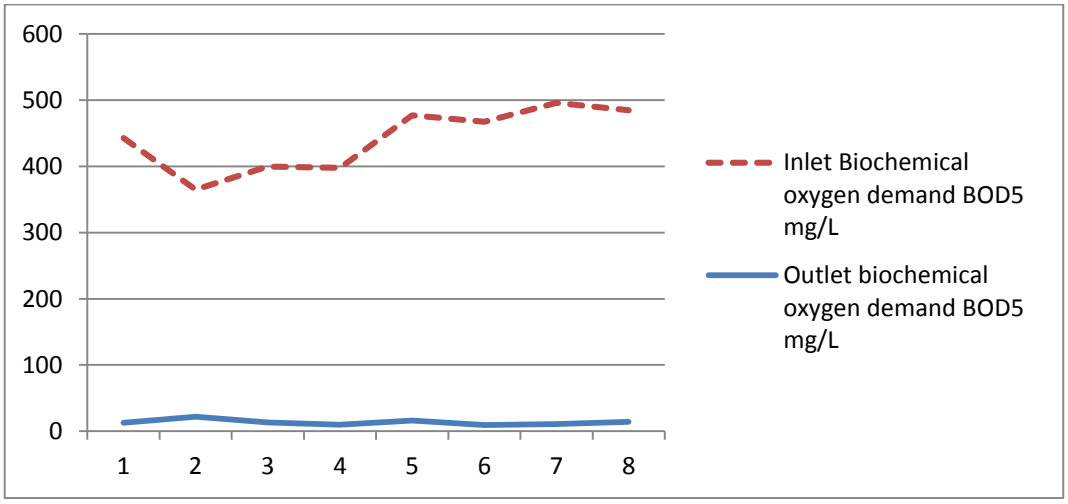

Figure 6.8: Nablus West WWTP influent and effluent BOD Content

Results suggest that the treatment process is effectively reducing BOD concentrations prior to discharge. Although the dataset of directly measured BOD concentrations is limited, the influent concentrations range from 383 to 471 mg/L whilst the effluent concentrations range from 10 to 22 mg/L.

As for the COD Results suggest that the treatment process is effectively reducing COD concentrations prior to discharge. The influent concentrations average of around 900 mg/L and has been reduced to concentration of around 68 mg/l. to be discussed as allowable concentration for reuse should not exceed 30. Figure 6.9 shows the Influent and Effluent COD.

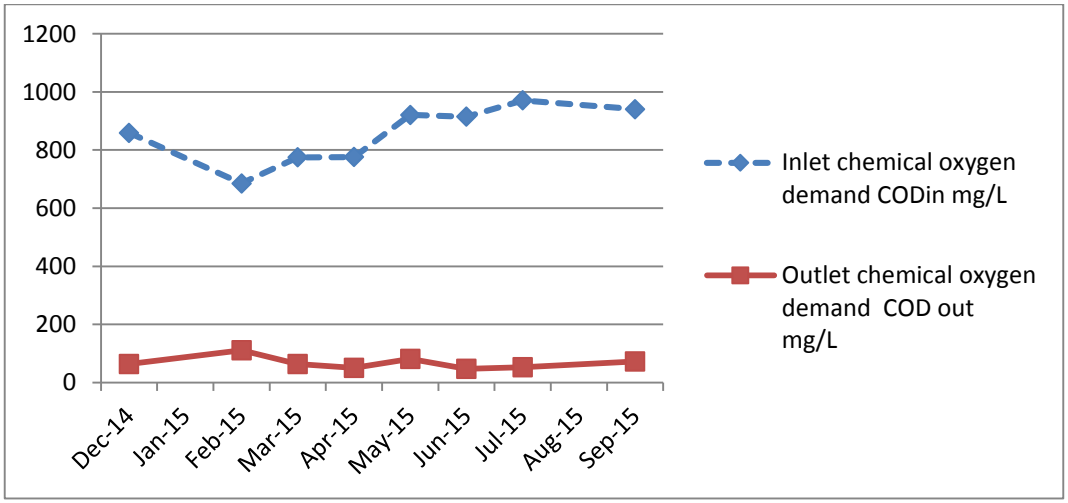

Figure 6.9: Nablus West WWTP Influent and Effluent COD Content

6.6.9 Effluent Nitrogen Content

Stage 1 of the WWTP (design horizon 2020) does not include active nitrogen removal capability, but it is considered for longer-term stage 2 and 3 design horizons. The Total N standard to be achieved in Stages 2 and 3 is ≤ 25 mg/L. According to the process design description, the biological treatment tanks are designed to consider extended effluent requirements for nitrogen removal (< 25 mg TN/l) in the future

design and construction stages, (Figure 6.10).

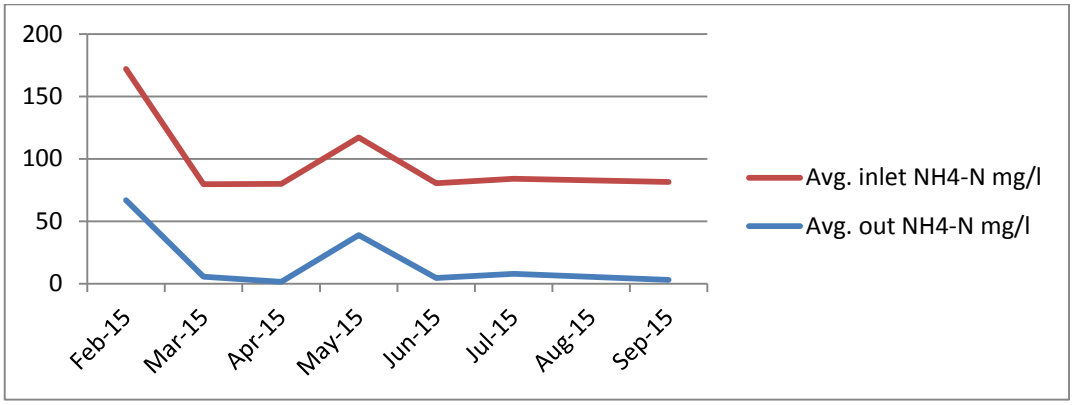

Figure 6.10 Average inlet and outlet NH_4-N mg/l

However, since beginning of this year the process of the treatment plant has been modified and now the treatment plant is operated with N removal with very good results complying to the Palestinian technical specifications (TS 34/2012), which requires that treated wastewater NO_3-N, NH_4-N, and total-N content should not exceeds 40, 15, and 60 mg/L, respectively, for the lowest category D. Also, according to the Palestinian standards (PSI 742/2003), for treated wastewater to be used in agricultural irrigation its content of NO_3-N and/or Nitrogen-N should not exceed 50 mg/L, Figure 6.11.

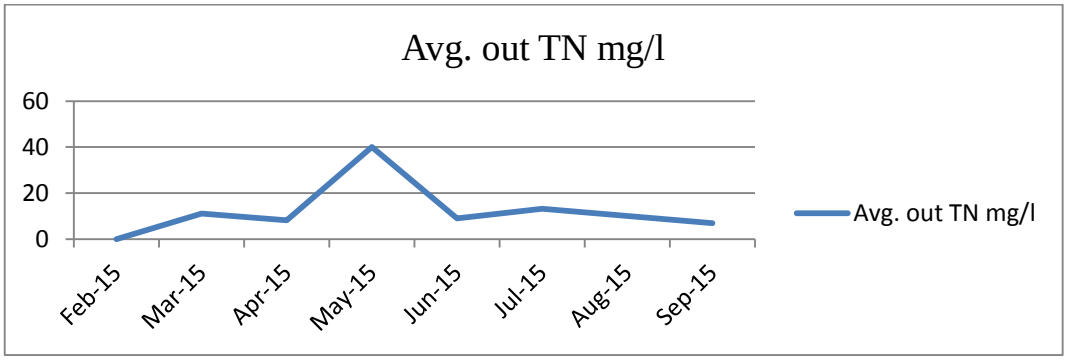

Figure 6.11 Total nitrogen at outlet flow (Municipality of Nablus Internal Technical Report)

6.6.10 Effluent Microbial Content

Effluent disinfection has not been included in the Nablus West wastewater plant

design, in stage1. It can be generally assumed that the given characteristics of secondary treated effluent without disinfection include high levels of microorganism, limiting its use for agricultural irrigation.

To date, no measurement was made for NW/WWTP effluent microorganism. Published data by IWA (2009) for "Influent Constituent Characteristics of the Modern Waste Stream from Single Source" reveal that because microorganism counts typically range over several orders of magnitude the data is best represented by the range and geometric mean. In raw wastewater, Faecal coliform bacteria ranged from 1.0×104 to 1.73×108 MPN/100 mL and E. coli ranged from 1.0×104 to 8.16×107 MPN/100 mL. The geometric mean was 1.58×106 for Faecal coliform and 3.04×105 for E. coli. Some measurements for raw wastewater were made in Palestine (in Attil, Zeita, Bidya, and Seir) indicate that Faecal coliform ranges from 20 x 106 to 150 x 106 cfu/100mL (Arafeh, 2012).

According to the Palestinian standards and specifications effluent E. Coli content should not exceeds 1000 colony/100ml to satisfy the lowest allowed effluent category "D" for reuse. Therefore prior to taking in operation a disinfection unit will be installed at the treatment plant to ensure that the effluent is disinfected to Palestinian Standards for irrigation use.

Effluent quality with regard to micro-organisms will be monitored in the long-term. Influent will also be monitored periodically to demonstrate and document efficiency of treatment. The details of monitoring will be recommended when details of the effluent treatment and disinfection systems are designed and specified. Parameters to be included for monitoring are faecal coliforms, pathogens, intestinal nematodes, and

amoeba and Gardia (all named in the Palestinian Standards.

6.6.11 Effluent Heavy Metals

There are no available data or measurements made for NW/WWTP effluent chemical composition and its heavy metals content. Recommendations have been provided under separate cover for more detailed effluent quality characterization based on external laboratory analyses, including heavy metals and will be conducted in the course of the Reuse Inside Scheme. However, it has to be mentioned that Nablus Municipality conducted tests regarding the chemical composition of the sludge from the WWTP Nablus West and no traces of heavy were found in the tested samples. Figure 6.13 shows a general view of Nablus West Wastewater Treatment plant

Figure 6.12 General overview of Nablus West WWTP (Municipality of Nablus Internal Technical Report)

6.7 Conclusions

The ultimate goal of wastewater treatment and disinfection is to produce an effluent of such quality that minimal additional controls are needed to manage any human

health, agricultural or environmental risks. For wastewater reuse on land, the need for disinfection will depend on its intended uses. The selection of suggested best practice measures for the disinfection of wastewater is different to those where effluent is discharged to surface waters. When reuse involves high level risks of exposure for humans or livestock, effluent may require going under a specific disinfection process. However, uses that involve a low risk of direct exposure will generally not require effluent going under a specific disinfection process.

Currently no disinfection of the treated wastewater takes place at the NW/WWTP. Therefore the microbiological quality of the treated wastewater will fail to meet even the limits of the lowest quality standard, class D, subject to Palestinian TS 34-2012. Therefore a disinfection unit will be installed at the treatment plant. The details of disinfection methodologies largely reflect site-specific issues, such as effluent quality, volumes and the management approach. The required level of pathogen reduction in treated wastewater use is determined by the nature of the reuse application and potential for human or stock exposure to this water.

CHAPTER SEVEN CONCLUSIONS AND RECOMMENDATIONS

Palestine suffers not only from shortage of water but also from the quality of available resources, like Gaza's water. Threat on water quality from pollution and sewage contamination is reported in both Gaza and West Bank. Impact was on Ground Water (Gaza Aquifer, seepage of sewage from scattered cesspits in the West bank, discharge of raw sewage from Palestinian Communities and Settlements in the nature (Wadi Gaza, Al Nar, Al Saman, Zomar and Qana).

The wastewater sector has suffered from neglect of development since occupation of 1967, restriction on development of the sector since Oslo agreement was reported due to restriction of the Joint Water Committee and Israel control to area C that bot hindered the development of wastewater project specially after the signature of MOU 2003 that imposed high quality treatment of sewage before discharge. Such criteria have a severe impact on donor engagement for the high capital cost involved and operation and maintenance required. Lack of building wastewater treatment plants has also resulted on lack of donor investment to build sewer networks. Only 52% of population has connection to sewer network.

Such complicity of the sector has call NGO's to build small scale treatment units in rural areas. Not until 2010, PWA has resisted the Joint Water Committee 2003 MOU and reached to understanding with the Israelis for gradual upgrade of facilities as a second stage.

The country has witnessed improvement of development of wastewater facilities. Large scale Wastewater treatment plants has been built (NGEST project, Expansion of Central Gaza WWTP, Securing Fund of Khan Younes).

In the West Bank, many small and large scales have been added to the only functioning facility established on 2000; Al- Bireh WWTP. Currently, Large Scale WWTP are on operation (Nablus West WWTP, Jericho WWTP or under tendering (Tubas EU funded project, Nablus East, Hebron WWTP, Ramallah WWTP). Many small high technology plants has been also installed (Al-Tireh WWTP), others using different treatment technologies (RBC, Wet Land, extended aeration, activated sludge) are now built in the industrial zone of Bethlehem, Beit Dajan, Ramon and Taybeh, Anzah and many others.

Implementation of large and small scale WWTP will generate up to 180 MCM of treated wastewater by 2025. All effort should be given toward maximizing the use of reclaimed water.

The wastewater infrastructure improvement has conjoint in parallel to the country's reform program of the water and wastewater sector. The reform has resulted on a New Water Law 2014.

The new law divided the historical functions of PWA to Ministerial and regulatory functions. The law kept the regulatory aspect of resources' protection and monitoring of both conventional and non conventional ones to PWA while water and sanitation services monitoring aspects has been given to the newly established body named as Water Sector Regulatory Council.

The new water law is a turning point in the water sector. It supersedes all other laws and becomes the governing law for all issues related to water. All service providers for water and sanitation has to be licensed by the Regulatory Council and has to perform its services according to the law and by laws. Many conclusion and recommendations have been obtained by the study:

The New Water Law is sitting new era in water and wastewater management. Its expected to be highly resisted specially by Service Providers (JSC, Municipalities, Villages Councils…etc) who used to manage their resources based on different laws and never been subjected to monitoring for their services.

PWA (in consultation with relevant authorities) and Water Sector Regulatory Council (WSRG) have to prepare set of by laws that reflect the new water law articles. Priority should be given to service provider's bylaw, wastewater discharge and reuse. Its for the country wealth and people health; enforcement of law is required and has to be respected.

The current regulations and standards applied in Palestine are in line with regional and WHO standards and regulations.

To elevate the pressure on fresh water, priority of reuse of treated effluents should be directed as a source for irrigation. Wastewater should be considered as part of the national water budget.

The Nablus West WWTP project includes a reuse scheme . The reclaimed water for reuse should be followed and monitored to serve as pilot project for reuse. Regional experience should be studied and considered.

Adequate wastewater collection and treatment facilities (as to respond to water law and by law) should be available for all the major cities and rural areas to protect the environment and public health.

Treatment of wastewater should be targeted towards producing an effluent fit for reuse in irrigation that complies with the WHO and FAO guidelines until regulation is issued.

Effluent quality standards should be set based on the best attainable treatment technologies, and calibrated to support or improve ambient receiving conditions, and to meet public health standards for end users.

Wastewater intended for irrigated agriculture should be regulated based on the soil characteristics of the irrigated land, the type of crops grown, the irrigation methods, and whether other waters are mixed with the treated wastewater.

Industries should be encouraged to recycle part of their wastewater and to treat the remainder to meet standards set for ultimate wastewater reuse or disposal. It's a must by the by new water law, by- law.

To respond to the "Polluter pay principle"; Wastewater from industries with significant pollution should be treated separately to standards allowing its reuse for purposes other than irrigation or to allow its safe disposal.

Treated effluent quality should be monitored and users are alerted to any emergency causing deterioration of the quality so that they will not use such water unless corrective measures are taken. All crops irrigated with treated or mixed waters should be analyzed and monitored periodically.

As for the case study, currently no disinfection of the treated wastewater takes place at the NW/WWTP. Therefore the microbiological quality of the treated wastewater will fail to meet even the limits of the lowest quality standard, class D, subject to Palestinian TS 34-2012.

Annex1: Houses and Facilities' Connection System to the Public Sewage Network

Cabinet resolution number (16) for the year 2013

On the House and Facilities' Connection System to the Public Sewage Network

The Cabinet:

Based on the regulations of the amended Basic Law for the year 2003 and its modifications, particularly, article (70) and based on the Water Law number (3) for the year 2002, particularly article (42) and on the law of local councils number (1) of the year 1997 and the law number (7) of the year 1999 on Environment and after reviewing the Law of Standards and Specifications number (6) of the year 2000, and based on the appointment of the Minister of Local Government and the Head of the Water Authority, and based on the necessities of public interest and on the powers delegated to us by law, and based on what the Cabinet decided in its meeting held in the City of Ramallah on 02.12.2013

We produced the following by-laws:

Article (1)

The following expressions and phrases mentioned in these by-laws will have the below-listed specific meanings should the context not indicate otherwise:

The Law: Law of Local Government number (1) of the year 1997 or Water Law number (3) of the year 2002 or Law number (7) of the year 1999 on the Environment.

Authority: Palestinian Water Authority.

Service Providers: water and waste water service providers whether in local councils or joint service councils or regional water and waste water facilities or water associations or any other operator of a licensed water and waste water facility.

Local Council: local government unit in a specific geographic and administrative scope which provides water and waste water services.

Board: board of directors of water and waste water facility or the board of the local council.

Head of the Board: head of the local council board or head of the board of directors of water and waste water facilities.

Franchise Area of the Service Provider: is the area lying within the scope of work of the

service provider and includes for the purpose of these by-laws any area connected to the service providers' sewage network.

Water Tariff System: the system issued based on the provisions of article (20) of the Water Law number (3) of the year 2002.

The Competent Official Authorities: includes all relevant sides such as: Ministry of Local Government, Ministry of Health, Ministry of National Economy, Ministry of Agriculture, Environment Quality Authority, Water Authority or any other side each according to its specialization.

The Employee: a person representing the service provider and specialized in applying these by-laws.

The Way: each paved or non-paved road, yard, square or path, of a dead-end nature or not, designated for the access of the general public and includes all canals, sewage, drainage and channels lying on the side of the road or above or below it.

Land Area: any land measured by square meter ready for residential, commercial, industrial, agricultural or any other use and which is connected to the Public Sewage Network.

Construction Area: construction area by square meter belonging to the proprietor and producing waste water.

Residence (residential unit): is a building or part of a building set as a residence for one family with a separate door or entrance or more than one separate door or entrance leading up to the public road or path without passing any other residential unit.

Facility: is a project or part of a project implementing one or more types of economic, commercial or service activities under one administration. The project could be owned by a natural or nominal personality or governmental body.

Industrial Facility: is any project having as its main aim transforming raw material into full or semi finished products or transforming semi –finished products into fully finished including mixing, separating, forming, aggregating, filling and packaging work on condition that part or all of these activities are mechanized. This applies also to knowledge and environment industries.

Proprietor: the person in whose name the property is registered. In case of joint ownership of the property, the person considered as proprietor is the owner of the unit or floor or any other part of the property. The owner can have a representative representing them.

User of the Property: is the person who operates the property whether they are the owner or beneficiary (tenant) or the person in whose name the water meter of any water authority or local council is registered.

Person: natural or nominal person.

The Stream: a pipe used for drainage in different diameters made out of metal, concrete or plastic or any other water-proof material that doesn't affect the process of waste water treatment and is not damaging to the environment.

Private Stream: is the stream lying inside the property's boundaries which belongs to the property owner or user and includes inspection holes and connections and all devices related to them.

Residential Sewage Connection: the stream which connects residential sewage to the public sewage network.

Private Sewage Connection: is the stream connecting private sewage (commercial or industrial) with the public sewage network.

Public Stream: is the stream owned and supervised by service providers and includes inspection holes, connections and all devices related to them.

Public Sewage Network: is a cluster of collection devices, pipelines, links and pumps specifically used for waste water drainage which is transported from its production location to the service providers waste water treatment station.

Sewage System: is a holistic sewage system including public sewage networks, links, inspection holes, pumps, treatment plants and their auxiliaries owned and maintained by service providers inside and outside their boarders and residential areas and is used in the sewage and waste water treatment.

Septic tanks: are a solid waterproof reservoir made up of more than one part, produced from concrete, solid cement or any other material that is not leachable and is leakage proof designed and implemented according to technical standards and specifications that allow for the partial anaerobic decomposition of organic material found in liquid remnants being drained into it.

Absorption Hole: is a well or hole in which waste or waste water and other garbage are being stored and which does not leach or leak.

Waste Water: is polluted water due to solid, liquid, gaseous material or energy or other microorganisms emanating from residences, buildings or different facilities.

Industrial Waste Water: is the water emanating from using water in some or all phases of industry, cleaning or cooling whether treated or not.

Commercial and Agricultural Waste Water: is the water emanating from using water in non-industrial fields and contains additional pollutants such as: water emanating from restaurants, gas stations, carwash facilities, mechanic workshops, slaughterhouses, poultry and livestock farms, vocational workshops, shops selling live poultry as well as waste water emanating from

medical facilities which do not contain dangerous material.

Quarry Deposits: deposits emanating from stone cutting.

Treatment Station: cluster of facilities and devices used for purifying and treating waste water. **Treatment:** is the process of removing deposits from waste water by using natural and technical methods so that the water is treated according to specific specifications and for use in a specific manner. This treatment could be primary, secondary or tertiary.

Biological Treatment of Waste Water: is the treatment of waste water by using live aerobic or anaerobic microorganisms resulting in refined liquids and in separate sludge that contain a microbic mass mixed with pollutants. This treatment is used separately or in conjunction with other mechanical treatment processes or in advanced processes.

Chemical Treatment of Waste Water: treatment methods used to incur complete dissolution of dangerous material and mostly transforming them into non-lethal gases; or to modify the chemical characteristics of waste water, for example, by decreasing its dissolution capacity, its acidity or alkalinity.

Mechanic Treatment of Waste Water: is the treatment of waste water which leads to separating refined liquid waste from the sludge. Mechanic treatment is used side by side with biological treatment and advanced treatment. Mechanic treatment includes sedimentation and floatation.

Treated Waste Water: is the waste water that has some or no portable mass or sediments or any other material that has been dissolved in it chemically, physically or biologically.

Fat Trap: is a unit with a special engineering design linked to internal private stream installations in commercial kitchens, restaurants, food factories, hotels and other. The fat traps separate food oils and fats from the liquid remnants before draining them into the public stream or to the septic tanks**.**

Oil Trap: is a unit specifically designed to separate mineral oils and fats from sewage water emanating from carwash and auto- mechanic workshops.

Perfusion Tank: is a vehicle with an insulated metal tank designated and used by service providers and competent official authorities to extract and transport liquid remnants. **Discharge Points:** are locations designated for discharging liquid remnants in treatment stations or any other place designated and defined by the service provider in cooperation with competent official authorities which transport the remnants by means of the perfusion tanks from the septic tanks.

Capital Costs: are the construction costs of the sewage system.

Running Costs: are all the operating and maintenance costs necessary to operate the sewage

system.

Environmental Approval: is the conditional or unconditional approval emanating from the Ministry of Environment after completing all environmental requirements or completing the appropriate assessment measures for the development venture for purposes of issuing the permit (license) from the competent authority and which does not contradict with other laws and regulations.

Environmental Impact: is the process by which the potential negative environmental impact of the development venture is studied and reviewed prior to granting environmental approval.

Assessment of Environmental Impact: is an elaborate study to assess the negative impact based on the approved reference frameworks and the environmental assessment methodology.

BOD5: is the chemical oxygen requirement and it is the amount of oxygen necessary for the oxidation of organic material found in waste water through microorganisms within five days at 20 degrees centigrade and is measure by milligram/liter.

COD: is the chemical oxygen requirement and is the amount of oxygen required for the chemical oxidation found in waste water and is measured by milligram/liter.

MBAS: is a measurement indicating the concentration of chemical purifiers and which is considered a pollutant and is poisonous for water and soil.

Article (2)

The regulations of these by-laws are applied on any person benefiting from water and waste water services; produces, transports or divests from waste water inside or outside the boundaries of the service providers.

Article (3)

Setting up the Sewage System

1. The service provider takes the responsibility of setting up, administering, operating and maintaining the sewage system as well as implementing any task related to its operation including regular maintenance according to local plans and as part of previously agreed upon national plans and in line with current and future needs.
2. The service providers commit to setting up the sewage system and pipelines for the drainage of rainfall in streets and public spaces. Should this not be possible for technical reasons, the service provider has the right to set up the system partially or wholly on their private property and within the rebound area. If this is the case, the service provider has to fix any damage that may occur to the private properties as a result of this or pay fair compensation equal to the cost of the damage and in line with the valid law.
3. The service provider has to receive the necessary approval and permits for implementing works related to the sewage system outside the boundaries of local councils from the Ministry of Local Government and Water Authority.
4. In order to receive environmental approval, the service providers commit to conduct an assessment report on the negative environmental impact according to the requirements of the Palestinian environmental assessment policies for sewage systems.

Article (4)

Setting up of Treatment Stations

1. The service provider takes over the responsibility to set up waste water treatment stations in locations that are remotely situated from potential future urban development

areas. The locations are chosen in coordination with competent official authorities and their approval. Due relevance is granted to interact with the land owners and with the nearby population communities.

2. The service provider has to obtain the necessary approval and permits to set up the treatment stations from the Ministry of Local Government, Water Authority and the Environment Quality Authority.
3. The service provider commits to endorsing and encouraging the transfer of advanced techniques of waste water treatment taking into consideration the selection of appropriate techniques based on the cost of the operation, maintenance and energy saving; additionally efficiency should be taken into consideration which fulfills and maintains quality criteria in order to safeguard the environment and public health.

Article (5)

Obligatory Connection to the Public Sewage Network

1. The service provider has the authority to impose obligatory connection of all existing buildings within the scope of their franchise area.
2. In the case that the proprietor fails to abide by the obligatory connection, the service provider has the right to connect the private stream with the public stream and collect the due fees and wages in addition to 20% for administrative and supervisory expenses. These estimated amounts are considered final by the service providers. The proprietor has the right to object with any legal or official authority.

Article (6)

Measures for Connection to Public Sewage Network

1. The service provider makes the public stream available until the boundary of the proprietor's property. Hence, the beneficiary has to connect the private stream with the public sewage network on his own expense and under the supervision of the service provider after paying the fees which include covering the expense according to these by-laws and on condition that the property's private stream intended for connection with the public sewage network has fulfilled all licensing requirements.
2. The properties' proprietors and in the case that it is not possible to connect directly with the public sewage network, have to permit the passage of sewage connections in nearby lands which lay at a higher altitude than theirs and based on the approved master plan by the local council. It is necessary that this stream is within rebound. The

owners of these connections have to provide a written assurance to maintain these connections on their own expense and change their routes in case they are impeding the freedom of the land owner to use their land and remove them when there is the possibility to directly connect with the public sewage network.

3. The proprietor, whose private stream has been connected to the public sewage network, has to empty the suction holes and the septic tanks that lay within the boundaries of his properties and to fill it with suitable material on their own expense within at most two months from the connection date and without harming public health.
4. Should it not be possible to discharge the property's or any other part of its waste water by connecting it to the public sewage network from the property (or through a nearby property) by natural flow, the proprietor will have to install a suitable pump in a manner that is approved by the service provider in order to raise the level of the waste water to the public stream's level or apply the regulations of article (7) of these by-laws.
5. The service provider has the right to conduct laboratory tests to all waste and running liquids in any private or public stream on the expense of the property user or facility owner and according to approved specifications and as needed.
6. The service provider has the right to request from the property user to provide necessary information to ensure abidance to the regulations of these by-laws.

Article (7)

Setting up Septic tanks

1. The proprietor, and in the case that there is no public sewage network near their land, or in the case that for technical reasons it is not possible to connect the private stream with the public sewage network within the boundaries of the service provider, has to:
   (a) Set up on their own account a septic tank in their private land, after submitting a request to receive the necessary approval for this from the service provider and the competent official authorities.
   (b) Attach plans and specifications to the request to ensure compatibility to the service providers' requirements. These have to be in line with the volume of the septic tank and with the requirements of the service provider and the competent official authorities according to criteria and engineering principals.
   (c) Put up warning signs in the appropriate place indicating the presence of a septic tank on the property and alert from the dangerous and polluted material it may

contain in addition to the collection date of these materials inside the hole. The base and walls of the pool have to be leak-proof.

2. The user of the property has to perfuse the septic tank on their own account, regularly or as soon as it is full through perfusion tanks, and to empty it in the specified location within the boundaries of the waste water treatment station of the service provider or in the locations specified by the competent authorities based on a suggestion provided by the service provider.
3. The proprietor has to fill in the suction holes existing on their property and replace them by septic tanks according to the technical specifications approved by the service providers within their boundary and approved by the Ministry of Health outside the boundaries of the service provider within two years from the publishing date of these by-laws in official newspapers.
4. The proprietor or property user has to apply the above mentioned conditions in addition to any other conditions imposed by valid regulations and laws.

Article (8)

Procedures for Emptying Septic tanks

1. The companies, contractors and vehicles used in the field of waste water perfusion and licensed by the Ministry of Transport have to obtain the necessary permits to operate inside the boundaries of local councils from the service providers. In order to operate outside the boundaries of local councils, they have to obtain the necessary operation permits from the competent official authorities.
2. The companies, contractors and the perfusion vehicles used to empty septic tanks have to empty their load only in the designated location inside the waste water treatment station or in any other location designated by the service provider inside the local councils' boundaries or by the competent official authorities outside the boundaries of local councils.
3. If any company, contractor or perfusion vehicle does not honor their commitments in emptying the contents of septic tanks in the waste water treatment station or the designated location, they lose their permit for a period of at least one year and in case of repeating the violation once again they will be completely denied permits to empty septic tanks. They have to pay the expenses of removing the damage that they have caused.

4. The service provider can operate their own perfusion vehicles without paying the fees of emptying septic tanks.
5. The specifications of the waste water in septic tanks have to comply with the specifications of the waste water in the public sewage network. The proprietor or user has to commit to conduct the primary treatment if necessary.

Article (9)

Discharge of Commercial, Industrial and Agricultural Waste Water

1. It is prohibited to discharge commercial, industrial and agricultural waste water into the public sewage network until it is treated and a written approval is provided by the service provider in line with the instructions presented in the annex.
2. It is prohibited for any person to discharge, cause or allow the discharge any radioactive material or radioactive industrial isotopes into the public sewage network.
3. It is prohibited for any person to discharge or allow the discharge of waste water and waste emanating from medicine factories and polluted hospital remnants and the remains of disposables into the public sewage network unless after subjecting it to treatment and obtaining a special permit from the competent official authorities.
4. It is prohibited for any person to discharge, cause or allow the discharge of waste water and waste emanating from olive presses into the public stream. The owners of the presses have to modify the manufacturing process so as to abide by the instructions presented in the annex.
5. It is prohibited for any person to discharge, cause or allow the discharge of waste water from commercial kitchens, restaurants, food factories and hotels into the public stream unless after setting up a fat trap unit and after obtaining written approval from the service provider while committing to upholding maintenance of the fat trap.
6. It is prohibited for any person to discharge, cause or allow the discharge of waste water emanating from carwashes and auto-mechanic workshops to the public stream unless after setting up the oil trap unit and obtaining the written approval of the service provider, while upholding the maintenance of the oil trap.
7. It is prohibited for any person to discharge, cause or allow the discharge of waste water and sediments emanating from stone saws and construction material factories into the public sewage network or any other natural stream, valley or open space. The service provider has to provide for specified locations to dry and get rid of stone saw sediments.

8. It is prohibited to decrease the concentrations of pollutants in industrial waste water by mixing it with fresh water or potable water in order to obtain the required concentrations as mentioned in the instructions attached to these by-laws.

Article (10)

Permits for Connecting Commercial, Industrial and Agricultural Facilities' Sewage

1. The commercial, industrial and agricultural facilities with a valid license have to submit an application to obtain written approval to connect their sewage to the public sewage network and according to the approved forms of the service providers and after subjecting it to treatment so that it becomes compatible with household waste water according to the regulations of these by-laws. Final approval to connect the sewage is decided upon by the head of the local council. The applications should include the following details:
   (a) The commercial or industrial operations conducted and from which emanate waste water.
   (b) The chemical material used during these operations and what emanates from them.
   (c) The amount of water used; its source and the amount of discharged water after the manufacturing process.
   (d) The physical, chemical and biological characteristics of the waste water which is intended for connection to the public sewage network.
   (e) The technical details of mechanical, chemical and biological operations of the primary treatment unit (if existing) and which is designed from an accredited authority.
   (f) The locations and volume of waste water collection tanks that must be used in emergencies such as: halt of the treatment station, the occurrence of a defect in the drainage of this water.
   (g) Any information deemed necessary by the service provider in order to consider the application for connection to the public sewage network.

Article (11)

Conditions for Connecting the Private Stream with the Public Sewage Network

1. The following conditions have to be considered when connecting the private stream of commercial, industrial and agricultural facilities to the public sewage network:
   (a) In its request to obtain a written approval to connect to the public sewage network, the commercial, industrial and agricultural facilities have to attach a plan indicating the method and specifications of setting up the private stream and inspection points taking into consideration their presence inside the boundaries of the factory or facility or any other appropriate location close to the public stream.
   (b) The applicant has to abide by these plans once the service provider approves them. The applicant has to implement them on their own account and under the supervision of the service provider. The service provider keeps those plans for a period no less than 15 years at the least.
   (c) The approval to allow commercial and industrial facilities to connect waste water to the public sewage system is issued based on the recommendation of the service provider's competent authority if this authority within the service providers sees no damage emanating from this connection to the sewage system and the quality of the treated water.
   (d) The service provider can – on the applicant's account - request the assistance of any authority that they deem appropriate to participate and submit technical recommendations on any issue related to connecting the commercial and industrial facilities to the public sewage network such as the amount and quality of the flow of waste water and its impact on the public sewage network. The applicant bears the cost of rehabilitating the public stream to become appropriate to connect the commercial and industrial facilities to it.
2. The service provider or any other relevant supervisory body has to be informed of any changes in the production lines or the addition of a new production line or the activation of one of the idle production lines at the facility or change in the characteristics of the waste water emanating from the facility.
3. The preliminary approval to connect new or existing industrial, commercial and agricultural facilities is based on submitted information and information stated in the application to connect to the public sewage network which was submitted to the service provider. The application is reviewed in light of the actual results of tests on industrial waste water emanating from the facility within a period of 6 months from the start of the

manufacturing process. In case of the results exceeding the specified concentrations according to the instructions of commercial and industrial waste water discharge, the owner of the facility has to modify the situation by removing the violating reasons during a time frame defined by the service provider and which should not exceed two months. The approval is deem invalid if this duration has elapsed without modifying the situation while informing the competent official authorities about this so as appropriate legal proceedings are taken.

4. Renew the commercial, industrial and agricultural waste water connection permit annually. The permit is issued in writing by the head of the board.
5. It is prohibited for any person who has acquired a final approval to discharge waste water into the public sewage network to discharge any waste water that is different in its quality or that exceeds in its amount what was approved by the service provider. Otherwise, it is obligatory to duly obtain a new approval.
6. The service provider can request treatment of waste water prior to and after the approval to discharge it into the public sewage network if it is verified to harm the sewage system.
7. The service provider or the competent official authority can – for licensing purposes to connect to the public sewage network - collect or request to examine samples according to the schedule they see fit for each factory or facility and on the account of the beneficiaries.
8. The service provider has to be informed about transferring or changing the ownership, administration or operation of any existing facility using the public stream whether it was producing waste water or conveying it.

Article (12)

Treated Waste Water

The service provider ensures that the treated water is compatible with the Palestinian standard specifications concerning treated water number (2003-742 mf), its amendments and the related binding regulations issued by the Institute of Specifications and Standards as well as the instruction manuals of the World Food and Agricultural Organization (FAO) and the World Health Organization (WHO) taking into considerations any arising requirements.

Article (13)

Public Sewage Network Connection Fees (investment costs)

The service provider collects fees for the public sewage network connection in order to retrieve the investment costs of setting up the public sewage network according to the following regulations:

1. Connection fees are levied on all lands and buildings that can be used for residential, commercial, industrial or institutional purposes and for which an approval for connection to public sewage network has been granted according to the water tariff system.
2. As far as existing residences and facilities are concerned, public sewage network connection fees are paid to the serviced provider when the connection request has been approved by the service provider.
3. Connection fees for residences and facilities that have been planned are due prior to issuing the final construction permit. They are paid by the proprietor when the plan to obtain a construction permit is submitted or when applying for a connection after the construction has been completed.
4. If the properties belong to more than one person, each person is responsible to pay the connection fees according to their share in the property.
5. For the purpose of defining fees, each piece of land has to be connected with one stream connection in the public sewage network. Nevertheless, it is possible to connect a number of buildings with one residential stream connection if the proprietors agree to pay the connection fees for all buildings so that the fees for each separate building are calculated.
6. The service provider has the right to approve the payment of fees in installments after providing the required guarantees to this end.
7. The water and sewage service provider commits to connect existing residences and facilities in a period of sixty days from the date of payment of connection fees and approval to grant a construction license.
8. A tariff for the connection and membership fees are put in place by the board according to the water tariff system.

Article (14)

Fees for Clearing Septic tanks

1. The water and sewage service provider collects fees for emptying septic tanks in order to recover part of the capital and running costs for its treatment at the waste water treatment stations. This also includes inspecting the quality of the contents of these holes and

ensuring they are void of any material that can be damaging at the treatment station.

2. The owner of the perfusion vehicle or any other devices used in the transfer of the septic tank contents commits to paying clearing fees according to the rate defined by the water and sewage service provider.
3. Fees for clearing septic tanks are paid to the water and sewage service provider immediately when the perfusion vehicle arrives at the waste water treatment station upon which a payment receipt is handed out.
4. Clearing fees are levied on the bases of cubic meter of the septic tank.
5. The board establishes the clearing fees according to the water tariff system.

Article (15)

Sewage System Maintenance and Operation Fees

1. The water and sewage service provider collects fees for maintenance and operating work on the sewage system to cover costs according to the water tariff system.
2. Maintenance and operation fees of the sewage system are levied on all forms of water usage.
3. Water quantities that are used and are subjected to utility fees are established as follows:
   (a) Registered water quantities according to a meter for residences and facilities being provided by water from water systems belonging to the water and sewage service provider.
   (b) Registered water quantities according to a meter for residence and facilities that are provided with water from their private wells.
   (c) Water quantities for residences and facilities being provided by water through private water tanks are established through a decision from the head of the board and based on a joint recommendation from the water and sewage service provider and the institution designated by the head of the water and sewage service provider.
   (d) The total water quantities designated for residences and facilities being provided by water from more than one source.
4. Exemption from paying maintenance and operation fees for the sewage system is granted when there is no public sewage system and for waste water collected privately in septic tanks or tanks while perfusion fees are paid for the holes and tanks according to the water tariff system.
5. Water quantities used for commercial and industrial purposes and are part of the manufacturing process but are not discharged into the public stream are exempt from the

sewage system fees. A request is submitted to the head of the board to this end and the water quantity is established by the head of the board based on the recommendation of a committee assigned by the head of the board.

6. The water and sewage service provider is committed to separate the water and sewage accounts from the other accounts and to open a unified bank account for all incoming revenues from the sewage service.

Article (16)

Additional Fees for Maintenance and Operation

1. The water and sewage service provider collects additional fees to those mentioned in article (15) of these by-laws from commercial and industrial facilities after issuing approval to connect them to the public sewage system. This ensues in case the required chemical oxygen concentration (COD) exceeds the maximum allowed concentration in waste water discharged into the public sewage system and which stands at (2000 milligram/liter) and in order to cover the additional expenses incurred on the water and sewage service provider during the treatment process.
2. The additional fees designated to cover treatment costs according to a formula decided by the water and sewage service provider and according to specifications in line with the principal of "the polluter pays".
3. The water and sewage service provider is responsible for issuing special claims for additional fees for facilities and factories that have been connected to the public sewage system.
4. The calculated average of the required chemical oxygen concentration is used to determine additional fees to cover the quarterly (every three months) treatment expenses on condition that the number of samples taken from the factory is not below one sample monthly if possible.

Article (17)

The Duty to Pay Utility Fees

1. The duty to pay maintenance and operation fees for the sewage system to water and sewage service providers lies with the proprietor or the user of the property whether the water meter was registered in their name or not.
2. The proprietor or user of the property is responsible for paying the sewage system's maintenance and operation fees according to their share in the joint ownership of the

building which they own or operate. This occurs in case the property utilizes water services. In case the building or apartments are connected to one water meter, the person in whose name the meter is registered or the user of the property is considered collectively or individually responsible to pay sewage fees.

3. The user of the property is in charge of paying fees in the case of not being able to establish who the proprietor is.
4. Sewage system maintenance and operation fees have to be paid every month or every two months after completing reading the water meters or estimating the amount of used water by an employee designated by the water and sewage service provider.
5. Sewage system maintenance and operation fees are registered or integrated into the water fees in one bill issued by the water and sewage service provider.
6. The duty to pay sewage system maintenance and operation fees starts once the property is connected to the public sewage system.

Article (18)

Inspection and Administrative Oversight for Connecting Installations to the Public Sewage System

1. The water and sewage service provider is responsible for inspection and administrative oversight to ensure abidance to the regulations of these by-laws inside the boundaries of the local council. Outside the boundaries of the local council, the responsibility lies with the water and sewage service provider and the Ministry of Local Government and the competent official authorities.
2. Each of the water and sewage service provider and the competent official authority work towards exchanging information in written form related to damage emanating from waste water management processes when they occur.
3. Inspectors from the competent official authorities, who have legal capacity according to their specific laws, have the power to monitor residences, monitor and inspect facilities as well as the sewage system. They have the authority to detect violations which occur in contravention to the laws and the regulations of these by-laws. They have the right to request any information or clarification from the proprietor of the residence or facility or the service provider for the sake of monitoring the waste water quantity which is discharged from the facilities and the industrial activities on a regular bases for the sake of checking their abidance to the approved specifications and instructions for discharged waste water. The purpose is to protect the environment and the vital sources according to the regulations of these by-laws and the attached instructions.

4. The water and sewage service provider and for the purpose of inspection and monitoring and in coordination with competent authorities, has to inspect the waste water quality through obtaining samples from the facility's discharge point.
5. The service providers have to conduct regular tests, measurements and analysis relevant for regulating waste water quality, waste water treatment and sludge according to the most modern standardized means issued by the Palestinian Institute for Specifications and Standards. The scientific analysis methodology contained in the following reference is to be used for this purpose: (Standard Methods for the Examination of Water and Waste Water).
6. The service providers have to conduct regular microbic, physical, chemical and biological analysis as mentioned in the previous paragraph and maintain documentation pertaining to it.
7. The Ministry of Health or the Environment Authority has the right to request from the water and sewage service provider additional samples for waste water discharged from industrial facilities or treated waste water.
8. The service providers abide by providing a regular report to the competent authorities on the activities of the service provider in the management of the treatment stations.

Article (19)

Stopping or Suspending Approval to Connect Facilities with the Public Sewage Network

The water and sewage service provider has the right to stop or suspend approval to connect any facility's private stream with the public sewage network for any period of time they see fit, while reserving the right to revert to the law to pursue the perpetrators of the following violations in criminal or civil courts:

1. Violating the regulations of these by-laws or any condition placed by the water and sewage service provider when granting approval.
2. Not allowing employees of the water and sewage service provider, any other approved authority or any other competent official authority to undertake their duty in inspection and monitoring.
3. Not abiding by the conditions or requirements deemed necessary and established by the water and sewage service provider to maintain the sewage system.
4. Not paying fees levied on relevant institution or facility.

Article (20)

1. It is prohibited for any person to discharge any waste water into water sources or into a natural stream or valley or any other exposed space unless after treating it and obtaining written approval from the service provider to discharge it. The Palestinian specifications number (2010-227 mf and its amendments) is used in addition to the Palestinian specification number (2003-742 mf and its amendments). Additionally, the obligatory technical instructions of relevance issued by the Palestinian Institute of Specifications and Standards should be used as reference.
2. It is prohibited for any person to discharge surface water and rainfall into the sewage system unless by written approval from the service provider.

The service providers commit to coordinate with the competent official authorities to apply the necessary standards and criteria on methods to collect, transfer, store and treat waste water in a sound manner to protect the environment and public health.

Article (21)

Annulment

All what is in contravention of these by-laws is null and void.

Article (22)

Enforcement

All competent authorities, each according to their competence, have to implement the regulations of these by-laws and abide by them starting from the date of their publication in the official newspaper.

Issued at the City of Ramallah, on 03.12.2013 A.D. 30 Muharram 1435 Hijri

ANNEX

Instructions for Discharging Commercial, Industrial and Agricultural Waste Water into the Public Sewage Network

Article (1)

It is prohibited to discharge polluted and non-polluted commercial and industrial waste water into the public sewage network unless after treating it and obtaining written approval from the service provider in line with these instructions.

Article (2)

It is prohibited for any person to discharge, cause or allow the discharge of the following water and waste into the public sewage network:

1. Any solid or liquid material in quantities, volumes or biological, chemical or physical characteristics that may lead to obstructing flow in the public sewage network pipes or cause damage to public health, cause the emission of odors, cause damage to the public sewage network and its employees, is in contravention with maintenance and operation works of treatment stations or the treatment process in these stations that may produce treated water that threatens public health and safety. For example amongst others ash, remains of burnt coal, sand, mud, hay, sawdust, metals, glass, clay, feathers, tar, plastic, wood, rubbish, blood, animal intestines, animal manure, hair, paper plates, bottles of all sizes, fats and greases and oils, acids, carbon, mineral salts, steam, hot gases, dyes, insecticides, liquid remains from olive presses, dairy products, animal blood emanating from slaughterhouses.
2. Any solid, liquid or gaseous material containing poisonous or mineral elements or heavy metals that may according to the opinion of the service provider cause damage or contradict with the treatment process or may individually or in interaction with other waste cause danger to human beings, animals or plants.
3. Any material that may lead to:

(a) Not being able to complete treatment during the treatment process.

(b) Form material that may precipitate, freeze or become sticky under temperatures between (0-40) degrees centigrade.

(c) Obstruct the final use of treated water such as cause a high concentration of dissolved salts such as the liquid remains emanating from Sesame Oil (Tahini) presses and jeans wash workshops.

4. Any waste water discharged from a facility with a PH less than (0.5) and more than (9.5).
5. Liquid remains emanating from stone saws, tile, marble and brick factories, cement mixer as well as any liquid remains in which the concentration of solid material clinging to it exceeds (50 milligram/liter) and with a weight exceeding (1.5 gram/cubic centimeter).
6. Any liquid or steam the temperature of which exceeds (65) degrees centigrade. If the service provider establishes that these liquids and steams can be damaging to the sewage system or can cause any other damage at lower temperatures, then the service provider has the right to prohibit their discharge.
7. Waste water that contains emulsified vegetable and animal oils, greases and fats or wax and with a concentration exceeding (100 milligram/liter).
8. Any waste water or material containing cyanide or its ingredients with a concentration that may produce (2 milligram/liter) of a form of cyanide.
9. Any waste water or material containing phenol components with a concentration exceeding (100 milligram/liter) in the form of phenol void of halogens.
10. Any waste water or material containing sulphide with a concentration exceeding (2.0 milligram/liter) forming hydrogen sulphide.
11. Any waste water or material containing chlorinated organic solvents.
12. Any waste water or material containing chemical cleaners such as MBAS with a concentration exceeding (40 milligram/liter).
13. Waste water containing mineral oils from cutting machines and distillators with a concentration exceeding (20 milligrams/liter).

14. Any waste water or material containing Sulfate compounds (SO4) with a concentration exceeding (1000 milligram/liter).
15. Any waste water or material containing chloride compounds (Cl) with a concentration exceeding (500 milligram/liter).
16. Any waste water or material containing Fluoride compounds with a concentration exceeding (60 milligram/liter).
18. Any waste water containing solid material (TSS) with a concentration exceeding (600 milligram/liter).
19. Any waste water in which the chemically absorbed oxygen (COD) exceeds (2000 milligram/liter).
20. Any waste water or material containing sodium compounds with a concentration exceeding (500 milligram/liter).

Article (3)

Heavy Elements

It is prohibited to discharge any liquids or materials containing heavy or poisonous elements with concentration at discharge points exceeding those indicated below:

Element	**Concentration (milligram/liter)**
Chrome*	5
Cupper*	4.5
Tin	10
Beryllium	5
Nickel*	4
Cadmium*	1
Arsenic	5
Baritone	10
Lead*	0.6
Magnesium	10
Silver*	1
Boron	5

Mercury*	0.5
Iron	50
Zinc	15
Cobalt*	0.05
Selenium*	0.05
Lithium	5
Vandiom*	0.1
Aluminum	10

*On condition that the total of these elements collectively do not exceed (10 milligram/liter). The service provider has the right to modify the above table should a Palestinian specification be issued to this end.

Article (4)

It is prohibited to dilute the concentration of pollutants in industrial waste water by mixing it with fresh water or potable water in order to achieve the above mentioned concentrations.

Annex 2: Quality of treated water results summary

based on Municipality of Nablus Monthly technical reports

For period of 01/9/2015 to 30/9/2015, the results summary were as following

Parameters	Design value 2020	Present value	Treatment %efficiency
Average incoming waste water m^3/d	14000	11285 ≈	------
Inlet chemical oxygen demand COD_{in} mg/L	1100	971	-----
Outlet chemical oxygen demand COD_{out} mg/L	100	53	95%
Outlet biochemical oxygen demand BOD_5 mg/L	20	11	98%
Inlet Biochemical oxygen demand BOD_5 mg/L	550	485	------
Sludge age (day)	13.7	12	-----
MLSS g/L	3	4.5	-----
TSS_{inlet} mg/L	500	374	
TSS_{outlet} mg/L	30	29	92%
Electrical consumption $/m^3$ kW/m^3	0.85	0.74	------
Electrical consumption/kgCOD_{rd} kW/kg	0.8	0.8	------
Avg. out NH_4-N mg/l	------	8.08	------
Avg. inlet NH_4-N mg/l	------	------	------
Avg. out PO_4-P mg/l	------	4.4	------
Avg. in PO_4-P mg/l	------	------	------
Avg. in NO_3-N mg/l	------	------	------
Avg. out NO_3-N mg/l	------	3	------
Avg. out TN mg/l	------	13.16	------

For period of 01/6/2015 to 30/6/2015, the results summary were as following:

Parameters	**Design value 2020**	**Present value**	**Treatment %efficiency**
Average incoming waste water m^3/d	14000	10651 ≈	------
Inlet chemical oxygen demand COD_{in} mg/L	1100	915	-----
Outlet chemical oxygen demand COD_{out} mg/L	100	47	95%
Outlet biochemical oxygen demand BOD_5 mg/L	20	9.5	98%
Inlet Biochemical oxygen demand BOD_5 mg/L	550	458	------
Sludge age (day)	13.7	13	-----
MLSS g/L	3	3.8	-----
TSS_{inlet} mg/L	500	358	
TSS_{outlet} mg/L	30	17	95%
Electrical consumption $/m^3$ kW/m^3	0.85	0.85	------
Electrical consumption/kg$COD_{removed}$ kW/kg	0.8	0.98	------
Avg. out NH_4-N mg/l	------	4.5	------
Avg. inlet NH_4-N mg/l	------	76	------
Avg. out PO_4-P mg/l	------	2.8	------
Avg. in PO_4-P mg/l	------	37	------
Avg. in NO_3-N mg/l	------	2.3	------
Avg. out NO_3-N mg/l	------	0.8	------
Avg. out TN mg/l	------	9	------

For period of 01/5/2015 to 31/5/2015, the results summary were as following:

Parameters	**Design value 2020**	**Present value**	**Treatment %efficiency**
Average incoming waste water m^3/d	14000	10636 ≈	------
Inlet chemical oxygen demand COD_{in} mg/L	1100	921	-----
Outlet chemical oxygen demand COD_{out} mg/L	100	81	91%
Outlet biochemical oxygen demand BOD_5 mg/L	20	16	97%
Inlet Biochemical oxygen demand BOD_5 mg/L	550	461	------
Sludge age (day)	13.7	12	-----
MLSS g/L	3	3.6	-----
TSS_{inlet} mg/L	500	340	
TSS_{outlet} mg/L	30	28	92%
Electrical consumption $/m^3$ kW/m^3	0.85	0.69	------
Electrical consumption/kg$COD_{removed}$ kW/kg	0.8	0.82	------
Avg. out NH_4-N mg/l	------	39	------
Avg. inlet NH_4-N mg/l	------	78	------
Avg. out PO_4-P mg/l	------	------	------
Avg. in PO_4-P mg/l	------	------	------
Avg. in NO_3-N mg/l	------	1	------
Avg. out NO_3-N mg/l	------	2	------
Avg. out TN mg/l	------	40	------

For period of 01/4/2015 to 30/4/2015, the results summary were as following:

Parameters	**Design value 2020**	**Present value**	**Treatment %efficiency**
Average incoming waste water m^3/d	14000	12161 ≈	------
Inlet chemical oxygen demand COD_{in} mg/L	1100	776	-----
Outlet chemical oxygen demand COD_{out} mg/L	100	50	92%
Outlet biochemical oxygen demand BOD_5 mg/L	20	10	97%
Inlet Biochemical oxygen demand BOD_5 mg/L	550	388	------
Sludge age (day)	13.7	11	-----
MLSS g/L	3	3.44	-----
TSS_{inlet} mg/L	500	359	
TSS_{outlet} mg/L	30	19	89%
Electrical consumption $/m^3$ kW/m^3	0.85	0.57	------
Electrical consumption/kg$COD_{removed}$ kW/kg	0.8	0.79	------
Avg. out NH_4-N mg/l	------	1.58	------
Avg. inlet NH_4-N mg/l	------	78.3	------
Avg. out PO_4-P mg/l	------	2.95	------
Avg. in PO_4-P mg/l	------	15.1	------
Avg. in NO_3-N mg/l	------	------	------
Avg. out NO_3-N mg/l	------	3.55	------
Avg. out TN mg/l	------	8.2	------

For period of 01/3/2015 to 31/3/2015, the results summary were as following:

Parameters	**Design value 2020**	**Present value**	**Treatment %efficiency**
Average incoming waste water m^3/d	14000	12685 ≈	------
Inlet chemical oxygen demand COD_{in} mg/L	1100	775	-----
Outlet chemical oxygen demand COD_{out} mg/L	100	63	92%
Outlet biochemical oxygen demand BOD_5 mg/L	20	13	97%
Inlet Biochemical oxygen demand BOD_5 mg/L	550	387	------
Sludge age (day)	13.7	17.8	-----
MLSS g/L	3	4	-----
TSS_{inlet} mg/L	500	319	
TSS_{outlet} mg/L	30	36	89%
Electrical consumption $/m^3$ kW/m^3	0.85	0.566	------
Electrical consumption/kg$COD_{removed}$ kW/kg	0.8	0.795	------
Avg. out NH_4-N mg/l	------	5.7	------
Avg. inlet NH_4-N mg/l	------	74.1	------
Avg. out PO_4-P mg/l	------	6.37	------
Avg. in PO_4-P mg/l	------	25.9	------
Avg. in NO_3-N mg/l	------	------	------
Avg. out NO_3-N mg/l	------	3.2	------
Avg. out TN mg/l	------	11.2	------

For period from 01/2/2015 to 28/2/2015 the results summary as follow:

Parameters	Design 2020value	Present value	Treatment % efficiency
m^3/d Average incoming waste water	14000	≈ 13913	-----
Inlet chemical oxygen demand COD_{in} mg/L	1100	685	-----
Outlet chemical oxygen demand COD_{out} mg/L	100	111	84%
Outlet biochemical oxygen demand BOD_5 mg/L	20	22	94%
Inlet Biochemical oxygen demand BOD_5 mg/L	550	343	
Sludge age (day)	13.7	13	-----
MLSS g/L	3	3.9	-----
TSS $_{inlet}$ mg/L	500	436	
TSS $_{outlet}$ mg/L	30	47	89%
Electrical consumption /m^3 kW/m^3	0.85	0.36	
Electrical consumption/kgCOD_{red} kW/kg	0.80	0.62	-----
Avg. out NH4-N mg/l		67	
Avg. inlet NH4-N mg/l		105	

For period from 01/12/2014 to 31/12/2014 the results summary as follow:

Parameters	Design value 2020	Present value	Treatment efficiency %
m^3/d Average incoming waste water	14000	≈ 10420	
Inlet chemical oxygen demand COD_{in} mg/L	1100	859	-----
Outlet chemical oxygen demand COD_{out} mg/L	100	63	93%
Outlet biochemical oxygen demand BOD_5 mg/L	20	12.6	97%
Inlet Biochemical oxygen demand BOD_5 mg/L	550	430	
Sludge age (day)	13.7	15	-----
MLSS g/L	3	3.8	-----
TSS $_{inlet}$ mg/L	500	412	
TSS $_{outlet}$ mg/L	30	18	96%
Electrical consumption /m^3 kW/m^3	0.85	0.61	
Electrical consumption/kg$COD_{removed}$ kW/kg	0.80	0.76	-----
OPM cost NIS/m^3 (including direct and indirect costs)	----------		

Parameters	Month 12/14	Month 2/15	Month 3/15	Month 4/15	Month 5/15	Month 6/15	Month 7/15	Month 9/15
Average incoming waste water m^3/d	10420 ≈	13913 ≈	12685 ≈	12161 ≈	10636 ≈	10651 ≈	11285 ≈	9740 ≈
Inlet COD_{in} mg/L	859	685	775	776	921	915	971	941
Outlet COD_{out} mg/L	63	111	63	50	81	47	53	72
Outlet BOD_5 mg/L	12.6	22	13	10	16	9.5	11	14
Inlet BOD_5 mg/L	430	343	387	388	461	458	485	471
Sludge age (day)	15	13	17.8	11	12	13	12	10
MLSS g/L	3.8	3.9	4	3.44	3.6	3.8	4.5	3.3
TSS_{inlet} mg/L	412	436	319	359	340	358	374	351
TSS_{outlet} mg/L	18	47	36	19	28	17	29	33
Electrical consumption /m^3 kW/m^3	0.61	0.36	0.566	0.57	0.69	0.85	0.74	0.80
Electrical consumption/kg$COD_{removed}$ kW/kg	0.76	0.62	0.795	0.79	0.82	0.98	0.8	0.98
Avg. out NH_4-N mg/l		67	5.7	1.58	39	4.5	8.08	3
Avg. inlet NH_4-N mg/l		105	74.1	78.3	78	76	------	78.4
Avg. out PO_4-P mg/l		-	6.37	2.95	------	2.8	4.4	4.4
Avg. in PO_4-P mg/l		-	25.9	15.1	------	37	------	39
Avg. out NO_3-N mg/l		-	------	------	1	2.3	------	1.8
Avg. in NO_3-N mg/l		-	3.2	3.55	2	0.8	3	------
Avg. out TN mg/l		-	11.2	8.2	40	9	13.16	7

Annex 3: Nablus West WWTP Design

The Nablus West WWTP design include:

- **Reception Station –** To receive the partially treated septic wastes (40m3 septage per day).
- **Inlet Structure** - Wastewater from the catchment areas flows by gravity through an interceptor to the wastewater treatment plant.
- **Screening and Septage Station –** it consists of coarse screens, conveyor for coarse screening, fine screens spiral conveyor for fine screenings, and a screening press. The pre-treated water will flow to the Grit and Grease Removal Chamber. The screened septage will flow by gravity to an underground storage tank which has storage capacity of one day. The septage will be pumped upstream of the WWTP coarse screens during the low-load period.
- **Grit and Grease Removal Chamber -** Wastewater flows into the grit chambers at the head of the tanks and is discharged at the opposite end via an overflow. A spiral flow of the sewage is created by the force of the aeration and allow the settling down of sand and collecting of light fats and grease at the surface of the separate grease traps.
- **Primary Sedimentation Tank -** aimed to reduce the suspended solids content of the wastewater before biological treatment and the BOD.
- **Biological Treatment -** it is based on the activated sludge process with surface aerations by using the Mammoth Rotor.
- **Distribution Chamber -** Effluent from the primary sedimentation tanks is flown to the distribution chamber of the activated sludge tanks, the wastewater is mixed with the return activated sludge (RAS) from final sedimentation tanks to form mixed liquor which is then equally distributed to two activated sludge tanks via overflow weirs.
- **Aeration Tanks –** two independent lines of activated sludge tanks are installed, equipped with surface aerators to provide the oxygen demand for the process, and four agitators were built into each tank ensuring solids suspension and mixing of the tanks. The activated sludge tanks have been designed based on a minimum wastewater temperature of 12°C.
- **Final Sedimentation Distribution Chamber -** The mixed liquor of water and biomass is transported from the activated sludge tanks via motorized overflow weirs and pipe lines into the distribution chamber of the final sedimentation tanks.

- **Final Sedimentation Tanks -** In the final sedimentation tanks, a mechanisms to separate the activated Sludge is installed from the treated wastewater by gravity.
- **Sludge Pumping Station -** it consists of return activated sludge and excess pumping stations.
- **Service Water Supply It is** installed before the effluent metering for the WWTP Nablus. The service water supply is provided by a booster station at the outlet flow measurement. The booster station serves a net of underground pipes and hydrants, which is also used for fire fighting purposes.
- **Primary Sludge Thickening -** Primary sludge is pumped into a gravity thickener to reduce the volume of primary sludge. The thickener has volume of about 550 m^3 with residence time of the sludge to be about 2 days.
- **Mechanical Sludge Thickening –** is installed in order to reduce the volume of the excess sludge (ES) as well as the downstream sludge treatment processes
- **Mesophile Anaerobic Sludge Digestion –** it consisted of one mesophile anaerobic digester with associated mixing, heating, biogas storage and utilization equipments, and a secondary thickener.
- **Digester Mixing** –to ensure full overall mixing in the digester by injecting digester gas through gas booster and gas lances.
- **Digester Gas Production and Gas System -** During the degradation of the organic dry solids by the anaerobic digestion, biogas is produced as one of the natural by- products of this biochemical process. This biogas is a mixture of about 2/3 methane and 1/3 carbon dioxide. In order to protect the digester against accumulation of pressure, a special combined protection device for gas over-pressure and sub-pressure, in the gas hood is installed.
- G**as Utilisation Plant (Biogas Pre-Treatment) -** The generated biogas was with drawn via the gas withdrawal dome out of the head of the digester with a pipeline. The gas was then flown into the gravel filter which allowed the pre-dewatering and pre-filtering (coarse filtering) of the biogas. The condense water was then separated at the surface of the filling material (gravel) and collected at the bottom of the filter.
- **Combined Heat and Power Unit –** designed to recover energy from the waste and return it to the energy grid. The Combined Heat and Power Unit (CHP) installed served this purpose. The heated water flowed through the lines from the boilers to the distributor battery.

- **Boiler Plant -** The biogas used in the boiler plant with dual fuel burner, was first driven to the gas filtering devices, to ensure optimum operational efficiency. During this process fine polluted matter and the remaining moisture were filtered out of the gas and dumped into a collection chamber, while the purified gas was flown on to the boiler station.
- **Lime Stabilisation -** To stabilize the sludge, quicklime (CaO) powder was often added to the sludge. Furthermore the lime also helped by serving as a sterilizing agent on the sludge.
- **Sludge Liquor Storage Tank –** a sludge liquor storage tank is installed for the short term storage of sludge liquors during high load periods to ensure optimum biological treatment performance.
- **Sludge Drying Beds –** a sludge drying beds is built that were used during the hot summers. This also helped the WWTP to reduce operation costs of the sludge dewatering plant.
- **Secondary Thickener** – To store and further thicken the digested sludge, a gravity secondary thickener is installed. The secondary thickener was also equipped with an agitator to ensure homogenisation of the digested sludge before pumping to the dewatering plant.
- **Sludge Dewatering** –Sludge dewatering was carried out by two belt filter presses. The building was equipped with ventilation devices, drainage systems and an overhead crane, and also included a control room for the low voltage distribution switchgear.

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