Guidelines

Reuse of treated waste water from Nablus Waste Water Treatment Plant (NWWTP) in Production of Ready Mix Concrete

SGF Project No. 3

By

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1. Background

Recently many wastewater treatment plants has been established or planned to be established in the Palestinian territories. In 1998, Nablus Municipality and the German government signed an agreement through the Kreditanstalt Fur Wiederaufbau (KfW) in Germany to establish a waste water treatment plant (NWWTP). The plant was designed to treat 14,000 m3 / day and 8.0 tons of BOD5 per day. The plant is located approx. at 12 km West of Nablus City, near Beit Leed village junction.

The wastewater is collected from different villages and towns west to Nablus city. The water is collected by gravity after the implementation of relevant sewerage networks. Currently the capacity of NWWTP is about 10,000 m^3/day. Part of the treated waste water is used in agriculture for irrigation. With reference to the Ministry of agriculture by-law 34-2012 the treated wastewater quality of NWWTP is classified as Grade (A) as shown in Table (2).

In the year 2017 about three millions nine hundred and sixty three thousands (3,963,000 m^3) cubic meters of wastewater were treated. In the year 2017-2018 only 233 m3/year have been reused in 4 projects in agriculture. In the year 2019-2020, the total amount of treated wastewater used in agriculture is 260,000 m^3/year.

One potential reuse of treated wastewater is by partially replacing fresh water in the production of ready mix concrete. The ready mix concrete industry is considered one of the largest consumers of fresh water, beside the stone cutting industry. Currently there are more than 60 ready mix concrete plants distributed in the west bank.

In Palestine, there are not enough policies or legislations related to the use of treated wastewater, so far. It is essential that there must be regulations and bylaws that regulate the reuse of the out coming treated wastewater in agriculture and concrete production.

Specifications for concrete mix and cast stone adopted by Palestinian Standards Institution (PSI) must be modified to allow for the use of treated wastewater from the wastewater treatment plants in partial replacement of fresh water in producing concrete mixes.

Nablus Wastewater Treatment Plant (NWWTP) year [Abu Ghosh, et.al 2019].

2. Treated Wastewater Management Policy and Legislation

In Palestine, several governmental bodies are expected to be responsible for the licensing and approval of wastewater treatment plants, and consequently the management and reuse of the treated wastewater. The main relevant Palestinian authorities are:

- Ministry of Local Government (MoLG)
- Environmental Quality Authority (EQA)
- Ministry of National Economy (MoNE)
- Palestinian Standards Institution (PSI)
- Palestinian Water Authority (PWA)
- Ministry of Agriculture (MoA)

The following table shows the acceptance criteria of concrete mixing water laid by ASTM C94. These criteria must be met and considered in any Palestinian legislation related to the reuse of any type of non-traditional fresh water as mixing water in concrete production.

Table (1) : The acceptable criteria of concrete mixing water (ASTM-C94)

Concrete Properties	Limits	Test Method
Compressive Strength, minimum percentage of control at 7 days	90	ASTM C 109 or T 106A
Time of set, deviation from control, hr: min	From 1:00 earlier to 1:30 Later	ASTM C 191 or T 131

Comparisons shall be based on fixed proportions and the same volume of test water Compared to control mix using city water or distilled water.

Table (2) : Properties of of Quality Treated Wastewater from Nablus WW TP

Maximum limits for chemical and biological properties	Quality of Tech. Spec 34-2014			
	High Quality Grade (A)	Good Quality Grade (B)	Medium Quality Grade (C)	Low Quality Grade (D)
(BOD_5) mg/l	20	20	20	60
suspended solids mg/l	30	30	30	90
FC (Colony/100ml)	200	1000	1000	1000
(COD) mg/l	50	50	100	150
Dissolved Solids mg/l (TDS)	1200	1500	1500	1500
pH	6--9	6--9	6--9	6--9
NO3-N ppm	20	20	30	40
CL ppm	400	400	400	400
SO_4 ppm	300	300	300	300
Na ppm	200	200	200	200
Mg ppm	60	60	60	60
Ca ppm	300	300	300	300
SAR	5.85	5.85	5.85	5.85
P ppm				
Al ppm	5	5	5	5
Cu ppm	0.2	0.2	0.2	0.2
Fe ppm	5	5	5	5
Mn ppm	0.2	0.2	0.2	0.2
Ni ppm	0.2	0.2	0.2	0.2
Pb ppm	0.2	0.2	0.2	0.2
Se ppm	0.02	0.02	0.02	0.02
Cd ppm	0.01	0.01	0.01	0.01
Zn ppm	2	2	2	2
Cn ppm	0.05	0.05	0.05	0.05
Cr ppm	0.1	0.1	0.1	0.1
Hg ppm	0.001	0.001	0.001	0.001
Co ppm	0.05	0.05	0.05	0.05
B ppm	0.7	0.7	0.7	0.7
Ag ppm				
E. coli (Colony/100ml)	100	1000	1000	1000
Nematodes (eggs/L)	1>=	1>=	1>=	1>=

Grade A : Tertiary treated wastewater used in concrete production in the <u>SGF03 Project</u>

3. Purpose of Guidelines & who will benefit from them

The guidelines are intended to:

1) Promote integrated approach for reuse and management of the domestic treated wastewater.
2) Outline the manner in which , the tertiary treated wastewater may be utilized in production of ready-mix concrete, to minimize the environmental impact and benefit from it in saving fresh water;
3) Provide concrete production plants with instruction to use tertiary treated WW in concrete production
4) Provide civil and construction engineers with guidelines that allow them to use tertiary treated wastewater in concrete for structural and non-structural concrete members.
5) Provide the administrations of WW treatment plants with guidelines about the required amounts of tertiary treated WW to be used in concrete production and to promote cooperation with concrete industry sector.
6) Provide the ministers public works, environmental affairs, local governments , the Palestinian Water Authority (PWA), the Palestinian Standard Institute (PSI) with guidelines to utilize (Partially) the tertiary treated wastewater in concrete production.

4. Problems in efficient reuse of tertiary treated wastewater in concrete

1- Concrete industry is reluctant to use treated wastewater from treatment plants, because it might have harmful effect on concrete compressive strength as they belief.
2- No legislative laws exist, because the wastewater treatment plants are new in Palestine. Therefore, most of the treated wastewater is currently used for agricultural irrigation.

5. Guidelines for Concrete Production by Using Tertiary Treated Wastewater

The first step to promote utilization of tertiary treated wastewater in concrete production is to the design the concrete mixtures which will give the required compressive strength of concrete. As part of the SGF03 project and the SRP08 project we recommended the percentages of concrete ingredients shown in step No. 1 in the following table. It was found from laboratory testing that using concrete mixture with 30% tertiary treated WW in partial replacement of tap water in concrete production (at water/cement ratio, w/c = 0.5), will give compressive strength not less than 90% compared with traditional concrete made with tap water only, after 28 days curing.

Stages of the Guidelines

Stage	Description

1- Mix design

The concrete mix for a required nominal compressive strength is designed considering the use of a mixture of fresh water with different percentages of tertiary treated wastewater from (NWWTP) at different w/c ratio. The table shows the amounts of different ingredients to produce 1 m^3 of concrete with nominal compressive strength of 30 MPa after 28 days. Concrete with mixtures with w/c of 0.5 and 0.6 at 30% replacement gives the best compressive strength after 28 days curing.

Water Type , Replacement %, (w/c Ratio)	Portland cement type 1 (kg/m^3)	Tab Water (kg/m^3)	Tertiary treated WW ($kg/m^{3)}$	Fine Aggregate (Sand) ($kg/m^{3)}$	Coarse Aggregate (Crushed limestone) (kg/m^3)
Tap W (0.5)	347	174	0	896	956
Tap W (0.6)	309	185	0	896	956
Tap W (0.7)	279	195	0	896	956
WW30 (0.5)	347	121	53	896	956
WW30 (0.6)	309	130	55	896	956
WW30 (0.7)	279	137	58	896	956
WW60(0.5)	347	69	104	896	956
WW60(0.6)	309	74	111	896	956
WW60(0.7)	279	78	117	896	956
WW100 (0.5)	347	0	174	896	956
WW100 (0.6)	309	0	185	896	956
WW100 (0.7)	279	0	195	896	956

2- Preparing the ingredients of ready mix concrete

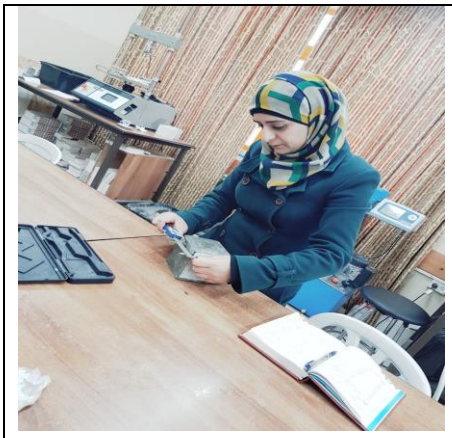
- **Coarse Aggregates**
- **Fine Aggregates**
- **Sand**
- **Cement**
- **Mixing fresh water (W)**
- **Mixing Treated Water (WW)**

The dry materials are usually stockpiled and water is saved in tanks.

3- Loading ready mix trucks with dry materials (Cement, coarse aggregates and fine aggregates)	
4- Adding mixing water (Tap water and tertiary treated w water) to the dry mix and mixing it with the dry loaded materials in the truck while the truck is moving to the construction site. **It should be noted that storage tanks for mixed water of both tertiary treated and tap water must always be available at the concrete ready mix plants in order to provide to concrete trucks.** **Properties of Grade A of Tertiary Treated WW is shown in the Table (2)**	

5- Fresh concrete sampling for testing after curing for 28 days	
6- Testing Workability of fresh concrete : Slump is measured onsite according to ASTM C 143	
7- Casting fresh concrete in moulds to prepare specimens for compressive strength test: After measuring workability, concrete is cast in cubes, 10 samples should be casted for testing 2 samples after each curing time.	

8- Casting concrete in its place on site	
9- Vibrating of concrete using mechanical vibrators	
10- Surface finish and smoothing	

11-Testing hardened concrete specimens: Concrete cubes to be tested at room temperature according to ASTM C39. Cubes are taken from the curing tank after the respective days, wiped off and kept in room temperature for 2 hours. The cube samples are to be tested by applying load at constant rate up to ultimate strength.	 
12- Comparing test results with international and local standards and specifications for fresh and hardened concrete. **The Engineer should check that, the maximum compressive strength after 28 days curing is not less than 90% of the maximum compressive strength of concrete made with tap water. This is the criteria for adopting nontraditional mixing water in concrete production.**	 

6. Abbreviations

NWWTP: Nablus Wastewater Treatment Plant (In The West Bank)

KFW: Kreditanstalt Fur Wiederaufbau (in germany)

BOD5: Biological Oxygen Demand, Consumable by Bacteria in 5 days at 20 C^0

ASTM C94: American Standards Specifications for Concrete Mixing water

ASTM C143: American Specifications for Workability (Slump Test) of Fresh Concrete

ASTM C39: American Specifications for Compressive Strength of Hardened Concrete

PSI: Palestinian Standard Institute

WW: Tertiary treated Wastewater

Tap W: Drinking Water