



Faculty of Graduate Studies

**REUSING OF TREATED WASTE WATER
IN CONCRETE PRODUCTION**

إعادة استخدام المياه المعالجة في صناعة الخرسانة

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A thesis submitted in fulfillment for the Master Degree in Water and Environmental Engineering to the Faculty of Graduate Studies at Birzeit University – Palestine

March, 2015

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Date of Defense: 10 March, 2015

The finding, interpretation and conclusions expressed in this study do not necessary express the views of Birzeit University, the views of the individual members of the MSc-committee of the views of their respective employers.



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آذار, 2015



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Abstract

The present consumption of potable water for concrete production creates indirectly a great burden of cost, especially these days in light of the global water crisis which is summarized in a great demand on water against the limited resources. This Project was conducted to study the feasibility of usage of treated waste water in concrete production, in an attempt to provide tap water for other purposes and so to reduce the total cost of concrete production.

In this research, water samples were taken from the effluent of Al-Tireh (MBR) Treatment Plant, Al-Bireh (EA) Treatment Plant, Al-Quds University (RO) Treatment Plant, in addition to the wastewater samples at Biologically treated wastewater, MBR treated wastewater, and effluent of Al-Tireh Treatment Plant as a second phase in the research, all specimens were tested and then used as mixing water in concrete production. The resulted concrete tests were in comparison with the potable water-mixed concrete. Compressive strength, slump, setting time, air content, permeability, and specific gravity were tested to all concrete mixtures. All tests in this research made taking into consideration the criteria and requirements of the standard specifications of the ASTM.

The compressive strength was 281, 299, 286, 288 at 7 days, 394, 394, 392, 380 kg/cm² at 28 days, and 417, 413, 416, 402 kg/cm² at 56 days for potable water, Al-Bireh treated wastewater, Al-Tireh treated wastewater, Al-Quds University treated wastewater respectively. With a values of 258, 311, 288, 282 kg/cm² at 7 days, 358, 410, 391, 390 kg/cm² at 28 days, 377, 425, 408, 403 kg/cm² at 56 days for potable water, Biologically treated wastewater, MBR treated wastewater, and the effluent respectively. The slump values were 123, 119, 127, and 125 mm for potable water, Al-Bireh treated wastewater, Al-Tireh treated wastewater, and Al-Quds University treated wastewater respectively. With values of 123, 137, 132, 132 mm for potable water, biologically treated wastewater, MBR treated wastewater, and the effluent respectively. The initial setting time was 4:50, 4:50, 5:00, 5:50 hours for potable water, Al-Bireh treated wastewater, Al-Tireh treated wastewater, and Al-Quds University treated wastewater respectively. And 4.5, 6.0, 5.0, 4.5 hours for potable water, biologically treated wastewater MBR treated wastewater, and the effluent respectively.

On the other hand the final setting time was 8:50, 8:30, 8:40, and 8:35 hours for potable water, biologically treated wastewater, MBR treated wastewater, and the effluent respectively, and 8:50, 8:30, 8:40, and 8:35 hours for potable water, Al-Bireh treated wastewater, Al-Tireh treated wastewater, and Al-Quds University treated wastewater respectively. The permeability was 3, 2, 2, 3 mm for potable water, Al-Bireh treated wastewater, Al-Tireh treated wastewater, and Al-Quds University treated wastewater respectively. And 3, 1, 2, 2 mm for potable water, biologically treated wastewater, MBR treated wastewater, and the effluent respectively. The specific gravity values were 2.40, 2.40, 2.42, 2.41 for potable water, Al-Bireh treated wastewater, Al-Tireh treated wastewater, and Al-Quds University treated wastewater respectively. And 2.40, 2.42, 2.42, 2.41 for potable water, biologically treated wastewater, MBR treated wastewater, and the effluent respectively. Finally the percent of air content was measured, values were 1:30%, 1:50%, 1:40%, 1:20% for potable water, Al-Bireh treated wastewater, Al-Tireh treated wastewater, and Al-Quds University treated wastewater respectively, and 1:30%, 1:10%, 1:10%,

1:40% for potable water, biologically treated wastewater, MBR treated wastewater, and the effluent respectively.

Comparing test results of the treated waste water with potable water, the results were all within the tolerable limits, according to ASTM standards. The research shows that treated waste water can be used successfully in preparing concrete at various used treating techniques or either treating stages.

المخلص

يشكل الاستهلاك الحالي للمياه المحلاة لإنتاج الخرسانة عبئا كبيرا من حيث التكلفة ، وخاصة في الوقت الراهن في ظل أزمة المياه العالمية، والتي تتلخص في الطلب الكبير على المياه مقابل مصادر المياه المحدودة. تم إجراء هذا البحث لدراسة جدوى استخدام مياه الصرف الصحي المعالجة في إنتاج الخرسانة، في محاولة لتوفير المياه المحلاة لأغراض أخرى وذلك للحد من التكلفة الإجمالية لإنتاج الخرسانة على الدول.

في هذا البحث، تم أخذ عينات المياه من محطة الطيرة، محطة البيرة، ومحطة جامعة القدس لمعالجة المياه العادمة، بالإضافة إلى عينات مياه الصرف الصحي المعالجة بمراحلها المختلفة من محطة الطيرة لمعالجة المياه العادمة كفصل اضافي في البحث، تم فحص جميع العينات ومن ثم استخدامها كميها خلط في إنتاج الخرسانة. وتمت مقارنة نتائج جميع عينات المياه المعالجة مع نتائج مياه الشرب. أجريت الفحوصات التالية على الخرسانة: قوة الضغط، الهبوط في الكتلة، زمن الشك الابتدائي و النهائي، ومحتوى الهواء، النفاذية، والوزن النوعي لجميع الخلطات الخرسانية جميع الاختبارات في هذا البحث تمت مع مراعاة معايير ومتطلبات المواصفات القياسية لل ASTM.

عند قياس قوة الضغط للخرسانة كانت النتائج كالتالي 281, 299, 286, 288 كجم/سم² عند الكسر على 7 ايام, 394, 392, 380 كجم/سم² عند الكسر على 28 يوم, 417, 413, 416, 402 كجم/سم² عند الكسر على 56 يوم للعينات التالية على الترتيب : مياه الشرب, محطة معالجة البيرة, محطة معالجة الطيرة, محطة معالجة جامعة القدس. في حين كانت النتائج 258, 311, 288, 282 كجم/سم² عند الكسر على 7 ايام, 358, 410, 391, 390 كجم/سم² عند الكسر على 28 يوم, 377, 425, 408, 403 كجم/سم² عند الكسر على 56 يوم وذلك لمياه الشرب, المياه المعالجة بيولوجيا قبل الاغشية, المياه المعالجة بالاغشية, و المياه الخارجة من المحطة على التوالي. كانت نتائج فحص الهبوط 123, 119, 127, 125 مم للعينات التالية على الترتيب : مياه الشرب, محطة معالجة البيرة, محطة معالجة الطيرة, محطة معالجة جامعة القدس. في حين كانت 137, 132, 132 مم وذلك لمياه الشرب, المعالجة بيولوجيا قبل الاغشية, المياه المعالجة بالاغشية, و المياه الخارجة من المحطة على التوالي. زمن الشك الابتدائي كان 4:50, 4:50, 5:00, 5:50 ساعة للعينات التالية على الترتيب : مياه الشرب, محطة معالجة البيرة, محطة معالجة الطيرة, محطة معالجة جامعة القدس. و أعطى النتائج التالية لمياه الشرب, المعالجة بيولوجيا قبل الاغشية, المياه المعالجة بالاغشية, و المياه الخارجة من المحطة على التوالي 4:50, 4:50, 8:30, 8:40, 8:35 ساعة لمياه الشرب, محطة معالجة البيرة, محطة معالجة الطيرة, محطة معالجة جامعة القدس على التوالي. في حين كانت النتائج 8:50, 9:30, 9:00, 8:35 ساعة لمياه الشرب, المعالجة بيولوجيا قبل الاغشية, المياه المعالجة بالاغشية, و المياه الخارجة من المحطة على التوالي.

اما بالنسبة لفحص النفاذية فكانت القيم 3, 2, 2, 3 مم لمياه الشرب, محطة معالجة البيرة, محطة معالجة الطيرة, محطة معالجة جامعة القدس على التوالي و 3, 1, 2, 2 مم لمياه الشرب, المعالجة بيولوجيا قبل الاغشية, المياه المعالجة بالاغشية, و المياه الخارجة من المحطة على التوالي. الوزن النوعي كان 2:40, 2:40, 2:42, 2:41 لمياه الشرب, محطة معالجة البيرة, محطة معالجة الطيرة, محطة معالجة جامعة القدس على التوالي.. و 2:40, 2:42, 2:41 لمياه الشرب, المعالجة بيولوجيا قبل الاغشية, المياه المعالجة بالاغشية, و المياه الخارجة من المحطة على التوالي. أخيرا تم فحص محتوى الهواء و أعطى النتائج 1:30%, 1:50%, 1:40%, 1:20% لمياه الشرب, محطة معالجة البيرة, محطة معالجة الطيرة, محطة معالجة جامعة القدس على التوالي. و 1:30%, 1:10%, 1:10%, 1:40% لمياه الشرب, المعالجة بيولوجيا قبل الاغشية, المياه المعالجة بالاغشية, و المياه الخارجة من المحطة على التوالي. بمقارنة نتائج الفحص باستخدام المياه العادمة المعالجة مع مياه الشرب كانت النتائج جميعها ضمن الحدود المسموح بها, وفق ما جاء بمعايير ال ASTM.

أظهرت نتائج البحث أن المياه العادمة المعالجة على اختلاف مراحل المعالجة او التقنيات المستخدمة صالحة للاستعمال كميها خلط في الخرسانة.

Key words

Treated wastewater; Concrete production; Impurities in concrete; Self-healing; Compressive strength; Setting time; Permeability; Air content; Specific gravity

DEDICATION

This work is dedicated to the following;

My parents, my grandfather and grandmother, my everything Sawsan

My husband Moath

My sisters Thanaa, Reem, Reham, and Siwar

My brothers Tareq and Zaid

My daughters Zeina, Maram, and Lucein

My friends

Dr. Nidal Mahmoud and all my doctors in the department

ACKNOWLEDGMENT

The financial support for the project was submitted by Middle East Desalination Research Center (*MEDRC*).

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LIST OF ABBREVIATIONS

PW	Potable Water
PTWW	Primary Treated Waste Water
STWW	Secondary Treated Waste Water
TTWW	Tertiary Treated Waste Water
COD	Chemical Oxygen Demand
BOD	Biological Oxygen Demand
DO	Dissolved Oxygen
TS	Total Solids
TDS	Total Dissolved Solids
MBR	Membrane Bioreactor
EA	Extended Aeration
RO	Reverse Osmosis
ASTM	American Standard Testing Methods
WCED	World Commission on Environment and Development
UNEP	United Nations Environmental Programme
USAID	U.S. Agency for International Development
EPA	U.S. Environmental Protection Agency
PCA	Portland Cement Association
OPC	Ordinarily Portland Cement
WHO	World Health Organization
EC	Electrical Conductivity