

# **Sustainable Use of Resources – Recycling of Sewage Treatment Plant Water in Concrete**

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**Second International Conference on  
Sustainable Construction Materials and Technologies  
June 28- 30, 2010  
Ancona, Italy**

# INTRODUCTION

- Concrete is the most widely used construction material in the world.
- Production of portland cement used in concrete produces over 2.5 billion tons of carbon dioxide (CO<sub>2</sub>) and other green-house gases (GHGs) worldwide.
- Sustainability of the concrete industry is of societal importance.

# INTRODUCTION

- Concrete is one of the largest water consuming industries.
  1. Approximately 150 liters of water is required per  $\text{m}^3$  of concrete mixture.
  2. Considering waste and washing out of equipment at the concrete mixing plant and trucks for transporting the concrete, water consumed is approximately 500 liters per  $\text{m}^3$  of concrete.
- Water is a critical environmental issue and water supplies and water quality are becoming more limited worldwide.

# INTRODUCTION

- The world population doubled from 1959 to 1999, increasing from three billion to six billion. According to the United States Census Bureau, the world population is projected to reach **nine billion by 2043**
- Thus, it is expected that the water demand will have an increasing trend; leading to **water recycling and conservation**

# INTRODUCTION

- **Freshwater** accounts for **only 2.5%** of the Earth's water, and most of it is frozen in glaciers and ice caps. The remaining unfrozen freshwater is mainly found as **groundwater**, with only a small fraction present above ground or in the air (UNESCO, WMO, and IAEA, 2006).

# INTRODUCTION

- In addition, the use of water for industrial purposes increases in proportion to a country's GDP (gross domestic product). From 10% in the low-income and medium-lower income countries, it increases to 59% in high-income countries (World Bank Group, 2000).
- Therefore it is essential to conduct **research of substitution of potable water by reclaimed water** partially or totally to produce concrete, especially in the U.S.

# INTRODUCTION

Some examples of successful water reuse projects are the use of reclaimed water in place of potable water:

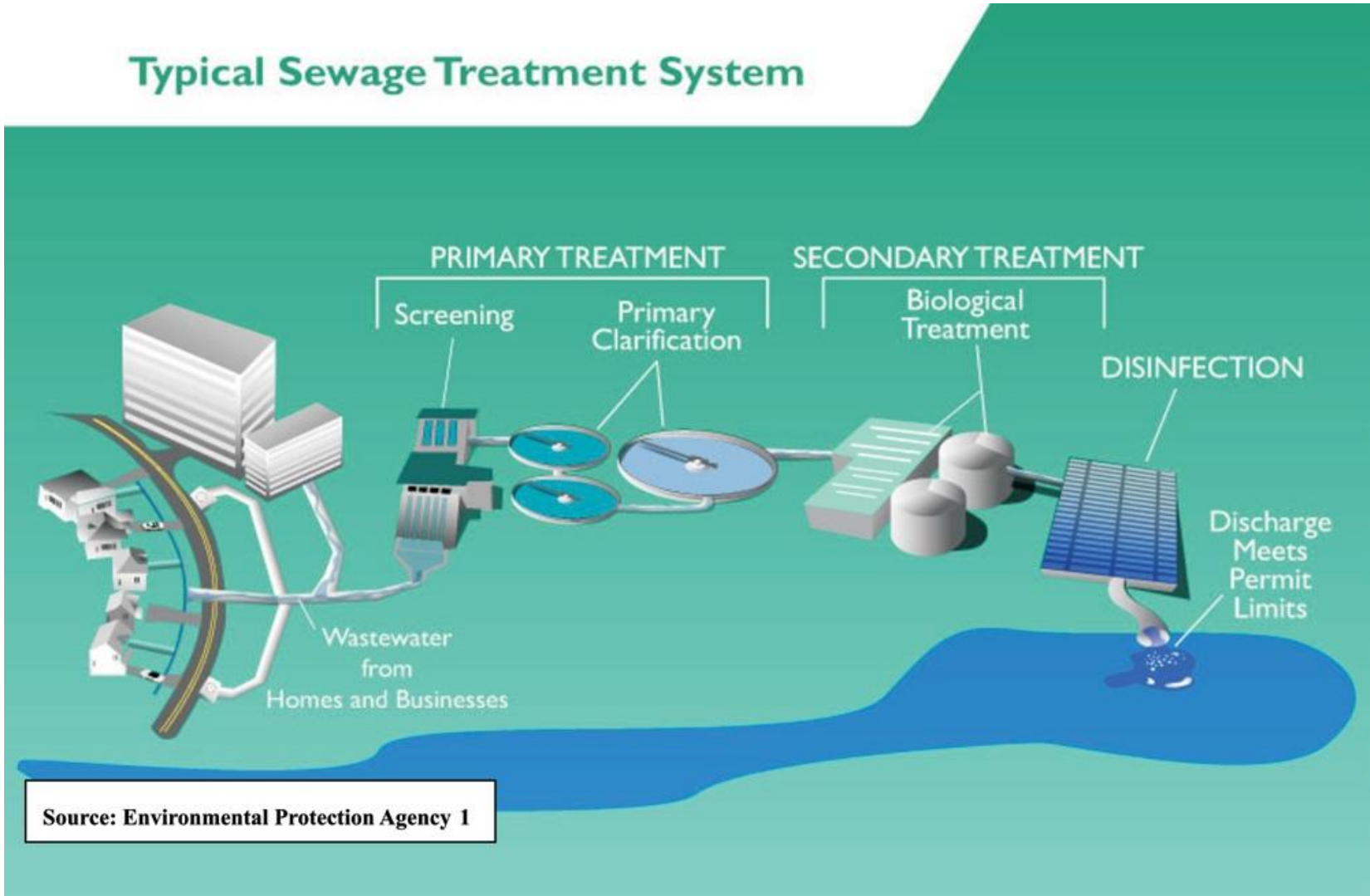
- Irrigation
- environmental restoration
- cleaning
- toilet flushing
- and industrial uses.

It has been shown that the basis for the success of such projects are:

- operational performance
- institutional arrangements
- conservative cost and sales estimates
- good project communication
- avoiding institutional obstacles, inadequate valuation of economic benefits, or a lack of public information

# CURRENT STATE OF KNOWLEDGE

## Typical Sewage Treatment System





# CURRENT STATE OF KNOWLEDGE

- Other researchers around the world have been investigating the use of reclaimed water in concrete.
- Not many have studied the use of sewage treatment plant effluent water in concrete.
- This research topic is also a challenge in terms of public health, when human contact with sewage treatment water is considered.
- Public education and close interaction with government agencies and policy makers is a key

# CURRENT STATE OF KNOWLEDGE

- The suitability of using treated wastewater for mixing concrete was evaluated in Kuwait (Al-Ghusain and Terro, 2003)
- Concrete cube specimens were cast using tap water, preliminary treated wastewater, secondary treated wastewater, and tertiary treated wastewater obtained from the local wastewater treatment plant.
- Concrete made with water from the primary and secondary treatment showed **lower strengths for ages up to the age of one year and the possibility of steel corrosion increased too.**
- Overall, **tertiary** treated wastewater was found to be **suitable** for mixing concrete without adverse effects

# CURRENT STATE OF KNOWLEDGE

- Cebeci and Saatci (1989) also reported that treated wastewater was not shown to have an adverse effect on concrete.
- **Raw sewage** reduced the 3- and 28-day compressive strength by 9%.
- The results (setting time, and mortar and concrete strength tests) showed that **biologically treated average domestic sewage** is similar from distilled water when used as mixing water.

# CURRENT STATE OF KNOWLEDGE

- In Malaysia, researchers carried out two tests to determine the feasibility of using **treated effluent** for concrete mixing (Lee et al, 2001). Their results showed that treated effluent **increases the compressive strength and setting time** when compared with potable water and that treated effluent could be used as mixing water in concrete.

# CURRENT STATE OF KNOWLEDGE

- **Health Assessment of Water Reuse**
- There are certain aspects that should be taken into consideration for water reuse:
  - (a) expected degree of human contact with the reclaimed water;
  - (b) what concentration of microbiological and chemicals of concern are expected;
  - (c) which treatment processes is necessary to achieve the required reclaimed water quality;
  - (d) what are the sampling/monitoring protocols to assure water quality needed.
- The states of Arizona, California, Florida, Hawaii, Nevada, Texas, and Washington have their own regulations for water reuse in several industrial sectors (EPA, 2004).

# METHODS AND MATERIALS

Samples of wastewater were collected from the Milwaukee Metropolitan Sewerage District (MMSD) and analyzed.

	Total Suspended Solids TSS, mg/l	BOD <sub>5</sub> mg/l	Ammonia Nh <sub>4</sub> -N, mg/l	Phosphorous P, mg/l	Fecal Coliform MPN/100 ml	pH
Influent primary at Influent Plant	231	257	11.5	3.85		
Primary effluent	86	183				
Aeration effluent	2400					
Secondary effluent					50000*	
Plant effluent (after disinfection)	6	5	0.2	0.3	40	7.2

The value above is the average of the daily monitoring data for the year of 2006

\* Average based on modeling

# METHODS AND MATERIALS



Mixer and Mixing Bowl



Specimen Molds

ASTM C109 Compressive Strength of Hydraulic Cement Mortars

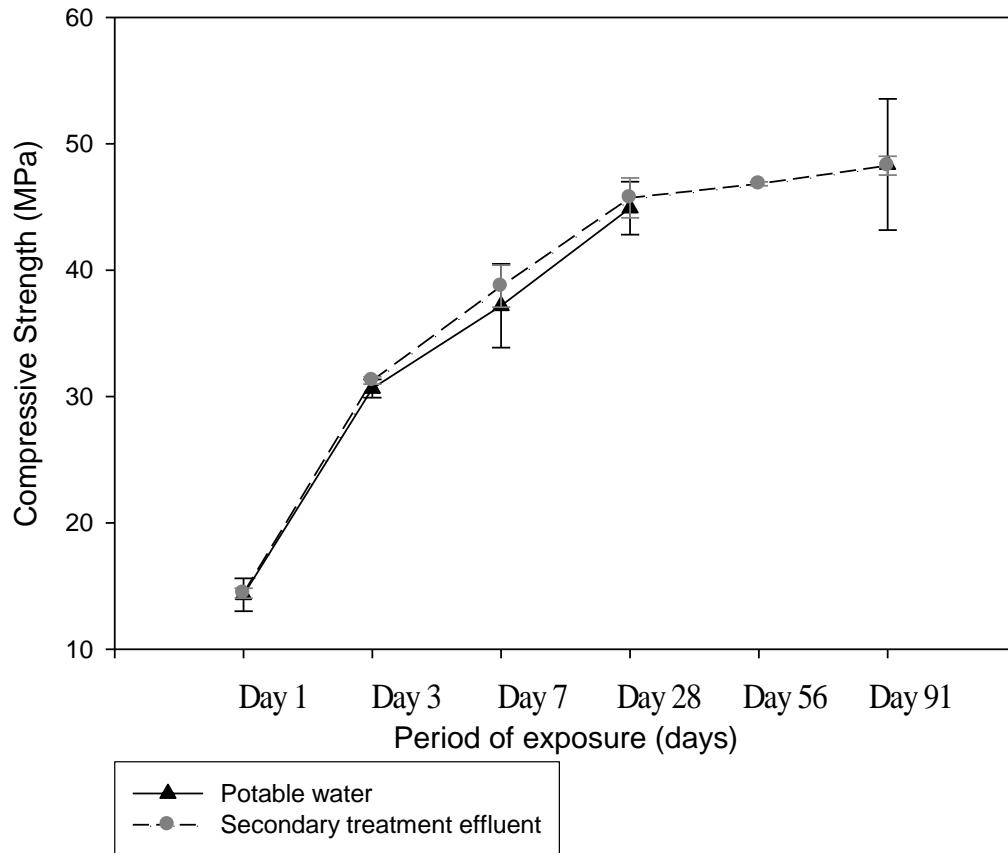
ASTM C778 Specification for Standard Sand

ASTM C150 Specification for Portland Cement

ASTM C305 Mechanical Mixing of Hydraulic Cement Pastes & Mortars of Plastic Consistency

ASTM C230 Specification for Flow Table for Use in Tests of Hydraulic Cements

# RESULTS



The average flow for mortar cubes made of potable water and reclaimed water was 98.1% and 89.5%, respectively. These results suggest that even though there was reduced flowability/workability of the mortar with reclaimed water, negative impact of the use of reclaimed wastewater on the mortar cubes was not noticeable.

Compressive strength → mortar cubes had similar results between mortars cubes made of the two water sources, Fig. 1. Again, these results suggest that negative impact was not observed on compressive strength of mortar cubes due to the use of reclaimed wastewater.

**Comparison of compressive strengths of mortar cubes made with potable water and wastewater.**



# CONCLUSIONS

1. Significant differences do not exist between mortar cubes made of potable water versus sewage treatment plant water.
2. Further research is needed
3. Some of the possible outcomes and contributions of this research are:
  - minimize the need for the use of potable water;
  - eliminate the need to expand potable water supply for use in the concrete industry;
  - minimize the need to construct more water treatment facilities due to population growth;
  - save potable water for drinking purposes;
  - make sewage treatment plants become more economically attractive by reusing water before its final treatment

# FUTURE WORK

- Prepare mortar cubes with sewage treatment plant water from different stages of the treatment process and different percentage in the formulation of mortar mixtures.
- Development of classes for use of reclaimed water, according to different applications and human exposure.

# ACKNOWLEDGMENTS

- Rudolph N. Kraus and Yoon-moon Chun from UWM- Center for By Products Utilization for lab arrangements
- Sidharta Arora of the United Water for providing samples from different stages of the treatment process and technical information about the samples.
- Aderiano da Silva for his insight about this issue of recycling water for concrete production.

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