PIPE SERVICE AGE EFFECT ON WATER QUALITY IN DRINKING-WATER TRANSMISSION AND DISTRIBUTION SYSTEMS

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INTRODUCTION

However, chlorine concentration decreases with time due to consumption.

Ccaused by chemical reactions of the chlorine with water constituents and with both the biofilm and tubercles formed on the pipe wall, as well as reaction with the pipe wall material itself.

Pipe Wall Demand

INTRODUCTION

Chlorine consumption classified as occurring in two phases

- 1 to 2 hours, or 4 hours
- long-term chlorine consumption   Slower

INTRODUCTION

- Wall Decay

- Some authors concluded that a zero-order overall kinetic model was well suited for describing the overall chlorine decay in a heavily tuberculated cast iron pipe, whereas,

- First-order overall kinetic model was found suitable for new cement-lined ductile iron pipe.

INTRODUCTION

The overall chlorine decay constant during the second phase to be the sum of the first-order bulk decay constant, k_b, and the effective chlorine wall decay constant, k_w,

INTRODUCTION

- Wall Decay:

Previously assumed first-order chlorine, and

been found to be characterized by first-order kinetics.

INTRODUCTION

A zero-order wall decay kinetic reaction was effective for characterizing the wall decay, but also indicated that the first-order model might be better.

INTRODUCTION

This manuscript assumes the overall, bulk, and wall chlorine decay constants will be of first-order kinetics.

INTRODUCTION

- Relatively few studies have been conducted concerning the determination of the chlorine disappearance rate in distribution systems.
- These studies have been conducted either in the field or in the laboratory.

INTRODUCTION

- Field Studies

- Isolating the pipe under study from the network

- Monitoring the chlorine concentration upstream and downstream.

- Chlorine may be injected upstream.

INTRODUCTION

- By knowing the time of passage (retention time), the first-order decay constant in the pipe, due to both the water and pipe consumption, can be determined using Equation 2. This constant is described as the apparent or total decay constant.

INTRODUCTION

Though on-site studies are considered directly applicable to the distribution system as they are performed under field conditions, large potential measurement errors are expected.

AIM

Determination of the influence of the service age of pipes of different materials and sizes on the effective first-order chlorine decay constant.

MATERIALS AND METHODS

- More than 185 pipe sections were collected.
- Out of these, 153 pipe sections were selected, prepared as described below, and used for performing the experimental work.

MATERIALS AND METHODS

- Either new (i.e. not used before), recently installed, or old pipes of different ages from an actual system.
- Collected from the local distribution system as part of repair or rehabilitation works on existing pipes.

MATERIALS AND METHODS

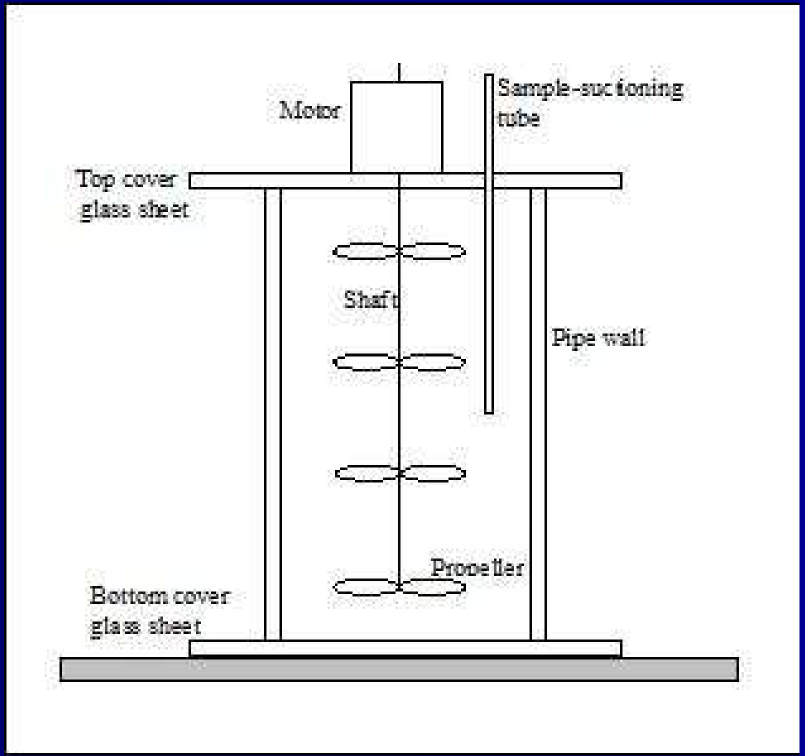
- Four different pipe materials:
  - steel
  - cement-lined ductile iron
  - unplasticized polyvinyl chloride (uPVC)
  - polyethylene pipes

MATERIALS AND METHODS

- Pipes Ages: New to 55 years old
- Pipes Diameters: 12.5 mm (0.5 inches) - 300 mm (12 inches)
- All pipes were cut to a length of 1 m

MATERIALS AND METHODS

Schematic of the experimental set-up



MATERIALS AND METHODS

- Pipe sections were randomly divided into 61 groups.
- Hach spectrophotometer model DR-2010 with the DPD method.
- The first-order kinetic constant for chlorine decay is equal to the negative value of the slope of the best fit of the plots drawn for Ln(C) versus time.

MATERIALS AND METHODS

- The chlorine wall decay constant, k_w, is determined as
- Overall Decay Constant - The Bulk Decay Constant.

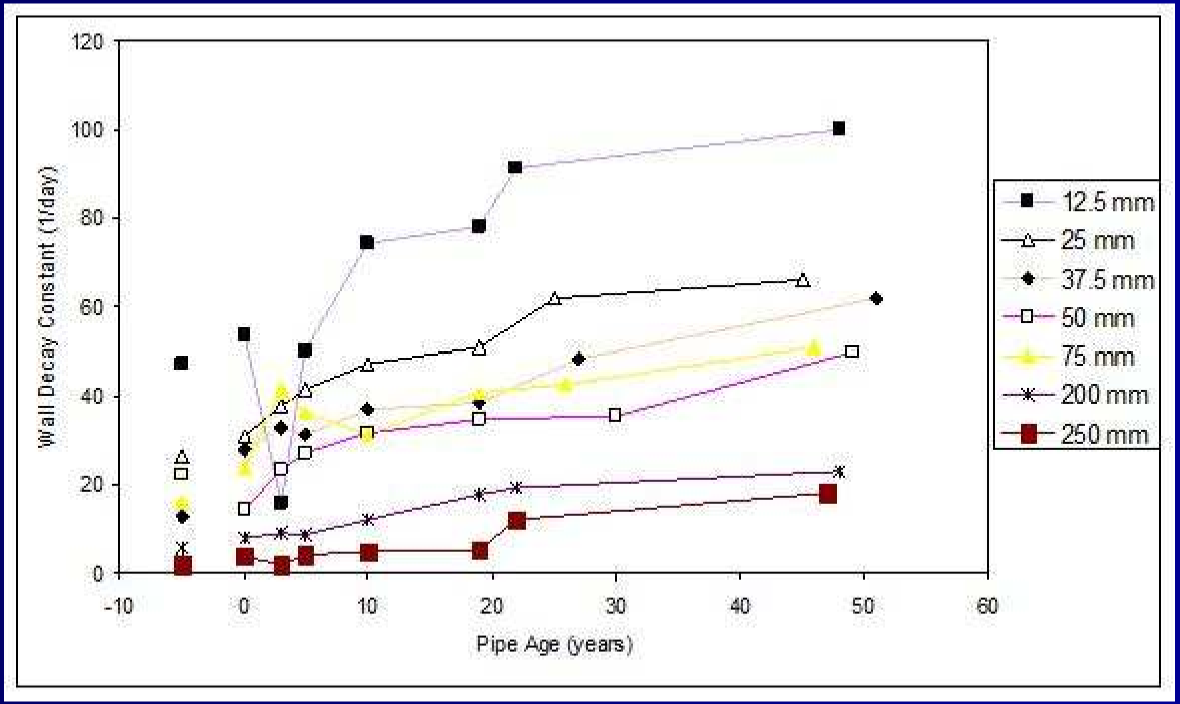
RESULTS

The laboratory effective chlorine wall decay constants, k_w, ranged from 0.11 day^{-1} to 100 day^{-1}

RESULTS

Effective first-order chlorine wall decay constants for

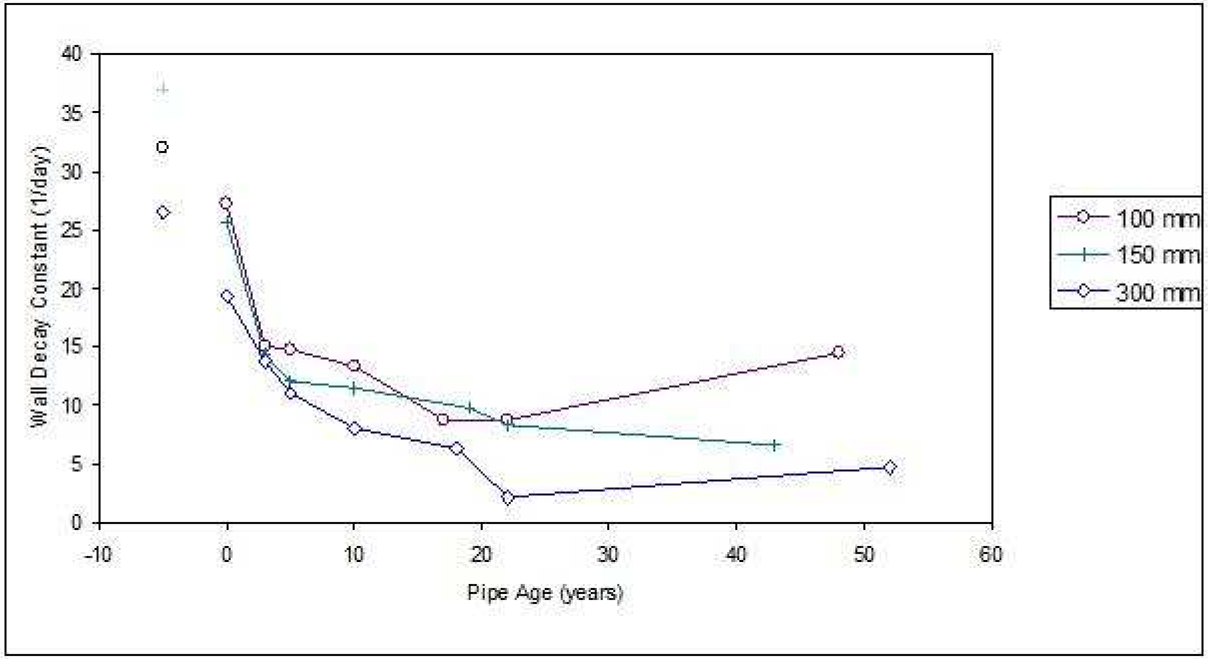
Steel Pipes



RESULTS

Effective first-order chlorine wall decay constants for

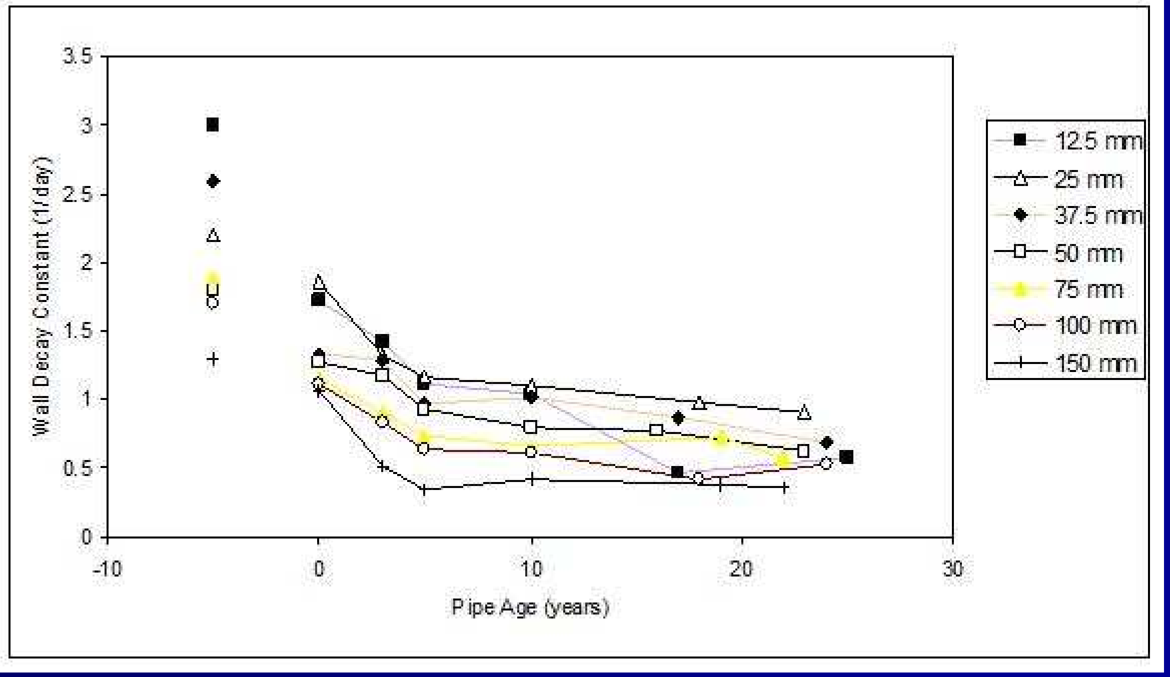
Cement–Lined Ductile Iron



RESULTS

Effective first-order chlorine wall decay constants for

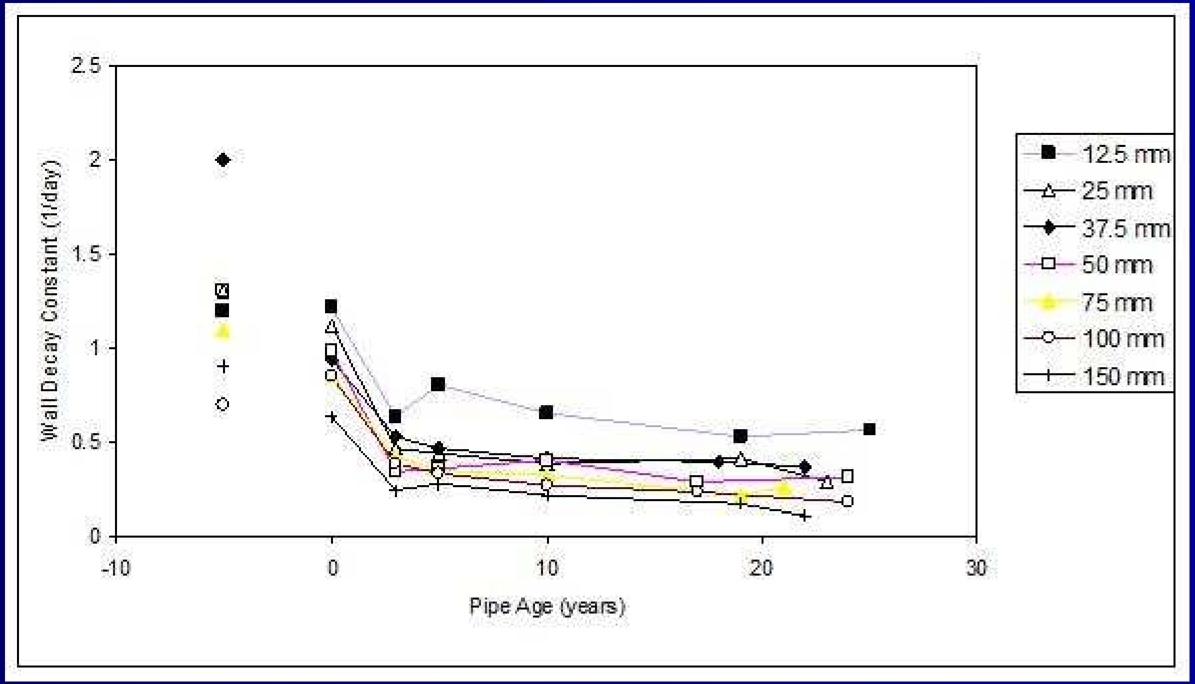
uPVC pipes



RESULTS

Effective first-order chlorine wall decay constants for

polyethylene pipes



CONCLUSIONS

- Pipe service age is an important factor that should be considered in the consumption of chlorine in some pipes such as steel, cement-lined ductile iron pipes.

CONCLUSIONS

- For the range of the 55 years of pipe service age used in this study, the change in the decay ranged from 8% to 531% of the corresponding values in the recently installed pipes.

CONCLUSIONS

- The positive effect of service age on the wall decay constant was the highest for steel pipes among the tested materials. Chlorine wall decay for cement-lined ductile iron pipes was less affected by service age as compared to steel pipes.

CONCLUSIONS

- Pipe service age is an important factor that should be considered in the consumption of chlorine in some pipes such as steel, cement-lined ductile iron pipes.

CONCLUSIONS

- The chlorine wall decay constants for uPVC, and polyethylene pipes were affected negatively by pipe service age. Age effect was relatively small. All sizes tested were affected by the pipe age with the same trend. (Pipe age effect did not show any effective relationship with pipe size).

CONCLUSIONS

- Variation in the long-term chlorine concentration in pipes is best described by a first-order equation.

- For all of the pipes tested, pipes not used before showed higher chlorine decay constants than those recently laid in the ground, whereas, this was the opposite for steel pipes.

CONCLUSIONS

- A wide variation in first-order chlorine wall decay constants was found ranging from 0.11 day^{-1} to 100 day^{-1}. Such a variation was due to the variation in pipe material, size, and service age.

CONCLUSIONS

- For pipe segments in the distribution system where the chlorine decay constant becomes high, it could be economical to replace it to avoid such a high chlorine demand and thus to meet water-quality goals.

CONCLUSIONS

- A standard method for determining chlorine wall decay constants in pipes should be used.

THANK YOU

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