Sustainability in commercial laundering processes

Module 1
Usage of water

Chapter 3a

Fresh water supply

Content

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- Water
- Water hardness
- Effect of water hardness on washing process and textiles
- Heavy metals
- Effect of heavy metals on washing process and textiles

Learning targets

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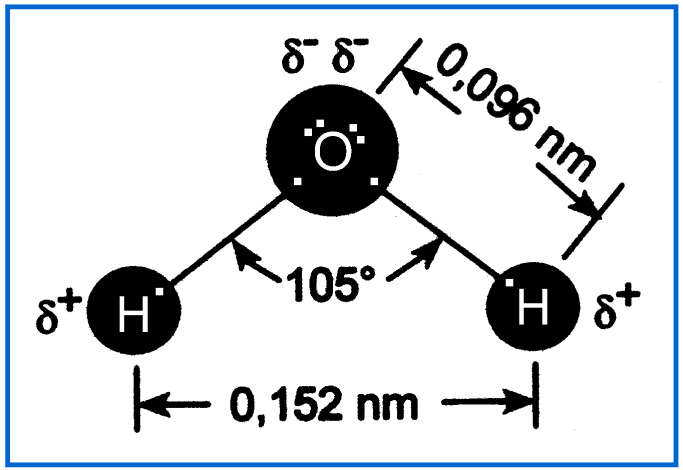
After finishing the chapter, you will

- be able to explain the properties of water
- know and be able to explain the role of the water during the washing process
- know what water hardness means
- know and be able to point out effects of water hardness on washing process
- know and be able to explain the effect of water hardness on textiles
- Know the origin of heavy metals in washing process
- be able to argue the effects of heavy metals on washing performance

Water – properties

- Sequence swapped – chart 5 to 4
- colourless liquid
- chemical formula H_2O
- angular ordered molecule



- irregular distribution of charge
- dipole
- interaction with other dipoles or ions
- hydrogen bonds
- polar solvent

Here is a text deleted

Role of water

- Solvent
  - for water-soluble soil
  - for detergent
- Energy transfer to the textiles
  - mechanical energy (liquor flow)
  - thermal energy (liquor heating)
- Transportation
  - detergents to the textiles
  - soil from the textiles

Water – substances

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- Natural water contains dissolved substances in variable quantities, such as

  - carbon dioxide
  - nitrogen and sulphur dioxide from the air
  - calcium, magnesium and iron salts
  - traces of other alkaline
  - chlorides, sulphates, phosphates, silicates
  - acid compounds from earth
  - germs

- They may cause harmful effects in laundry processes

Water – substances

- Calcium and magnesium salts destroy structure of soaps and inactivate surfactants
- Oxygen and carbon dioxide cause corrosion in boilers and pipes
- iron compounds discolour fabric
- These substances must therefore be removed as far as possible
  - careful analysis of water supply is necessary to decide the most appropriate method of removal in each case
- Probably the greatest problem is **water hardness**

Laundry water - requirements

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- clear water, odorless
- zero hardness or hardness nearing zero
- minimum metal content / Fe, Mn, Cu, e.g.
  - Fe < 0,1 mg/l
  - Mn < 0,03 mg/l
  - Cu < 0,05 mg/l
  - Fe max. 0,1 mg/L, which means “no” Fe
- pH between 6 – 9,5

Definition of water hardness
chart before is removed

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Water Hardness - amount of alkaline earth ions in mmol per liter of water

What are alkaline earth (metals) ?

Metals of second group of the table of the elements

- Beryllium
- Magnesium
- Calcium
- Strontium
- Barium
- Radium

} most important elements

Measurement of water hardness

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Hardness degrees

1 mmol CaO/l = 56 mg CaO/l = 5.6 °d
1 °d = 10 mg CaO/l = 0.18 mmol CaO/l

°d = German hardness degree
°e = English hardness degree
°f = French hardness degree

} 1 °d = 1.25 °e = 1.79 °f

Hardness scale

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Sequence! Chart no 17

	mmol/L	° d	°e	°f
WH I	0 - 1,3	0 - 7	0 - 5.6	0 - 3.9
WH II	1,3 - 2,5	7 - 14	5.6 - 11.2	3.9 - 7.82
WH III	2,5 - 3,8	14 - 21	11.2 -16.8	7.82 - 11.73
WH IV	> 3,8	> 21	> 16.8	> 11.73

also see chart 10

Relation of water hardness and origin of water

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- **Sequence! Chart no 17**

Origin	hardness scale
lake	→ soft
river	→ soft
spring water	→ soft to hard
ground water	→ soft to hard
tap water	→ soft to hard

Origin of water hardness

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- Water hardness is caused by dissolved inorganic salts

  - calcium and magnesium salts
  - iron and manganese
  - acid standard carbonates, sulphates and chlorides

- There are two types of hardness

  - Temporary (carbonate) hardness

  - Permanent (non-carbonate) hardness

Total Hardness =

Temporary Hardness + Permanent Hardness

Temporary (carbonate) hardness

- caused due to presence of acid carbonates
- dissociated carbonic acid $H_2CO_3/HCO_3^- + H^+$
- removable by heating
- due to the heating process
  - part of the carbon dioxide evaporates
  - acid carbonates (HCO_3) react with Ca^{2+}/Mg^{2+}-ions to poorly soluble standard carbonates
  - those coagulate as flakes (scale)

Water hardness

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Permanent (non-carbonate) hardness

- remaining anions (chlorides, sulphates)
- no heavily soluble compounds accumulation
- no removal by heating
- kind of anions have no impact on water hardness

Temporary and permanent hardness

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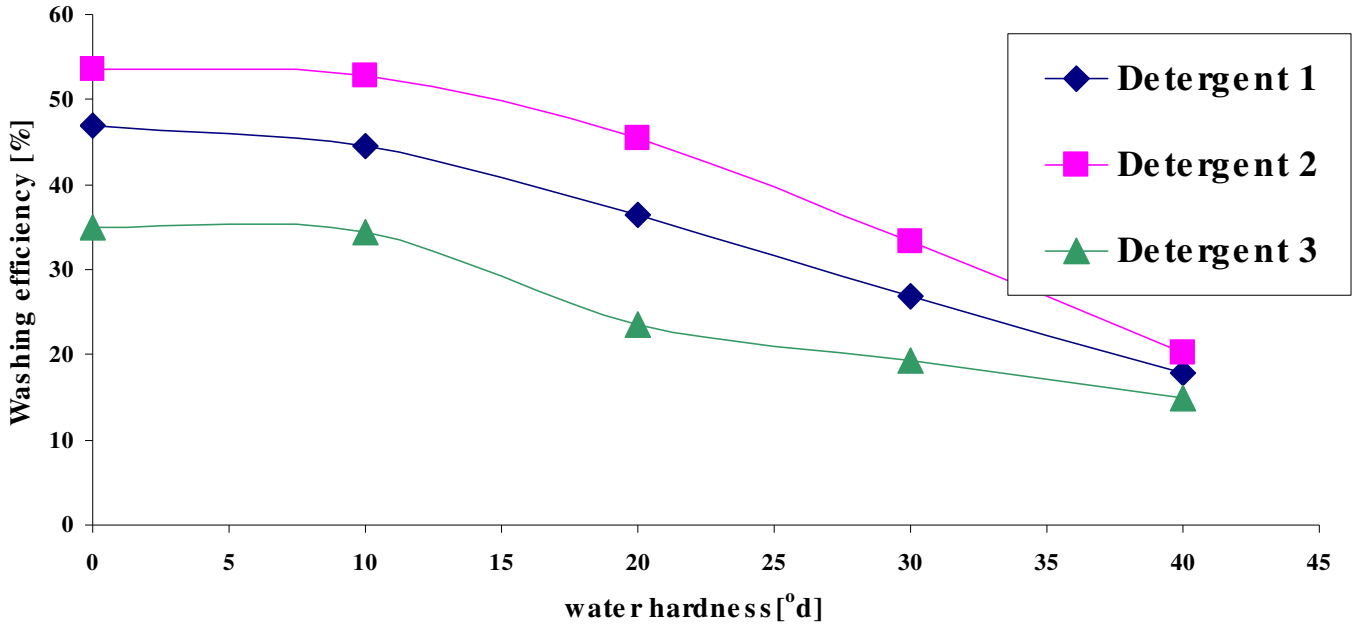
- Temporary hardness (Carbonate hardness)
  - Ca-/Mg-hydrogen carbonates
  - T > 60 °C: precipitation of hydrogen carbonates as carbonates
  - $Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2$
- Permanent hardness (Non-carbonate hardness)
  - Ca-/Mg- sulfates
  - Ca-/Mg- chlorides
  - Ca-/Mg- nitrates

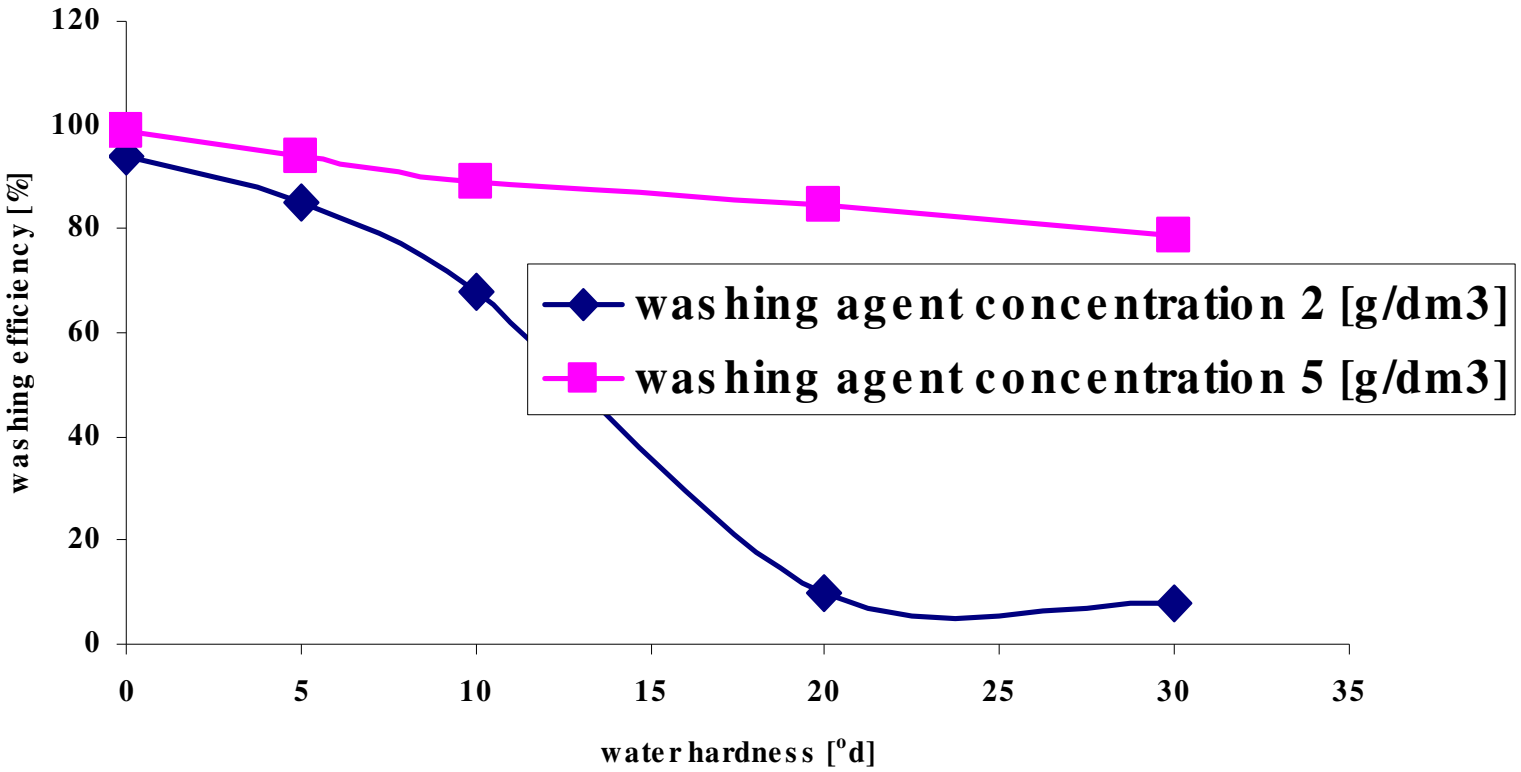
Water hardness
influence on washing efficiency



Washing efficiency decreases in relation to increasing water hardness – independent from applied type of detergent

Water hardness

detergent`s dosage



at higher water hardness values, higher detergent dosage application is necessary

Inorganic incrustation

If T > 60 °C
calcium and magnesium carbonate precipitate

$$Ca(HCO_3)_2 \rightarrow \underbrace{CaCO_3}_{\text{Calcium carbonate}} + H_2O + CO_2$$

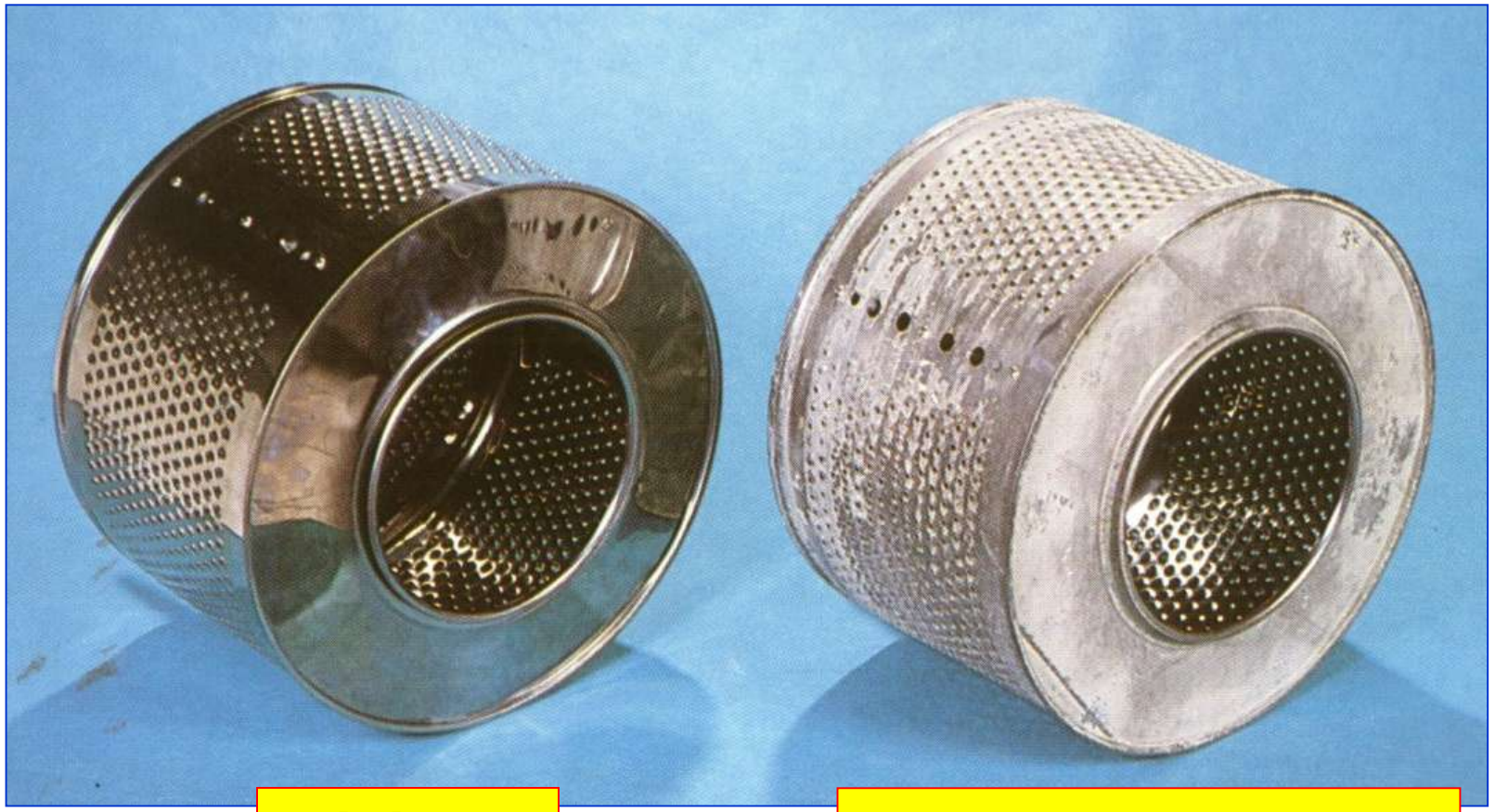
Inorganic incrustation

- Calcium and magnesium precipitate lead to

  - residues on the laundry
  - greying
  - high ash content/textile incrustation
  - mechanical fibre damage (due to sharp edges of micro-crystals)
  - sediments on the tube walls and electrical heating coils (Scale depositions)
  - cog-up of tubes, damage of heating coils

see illustrations on following charts

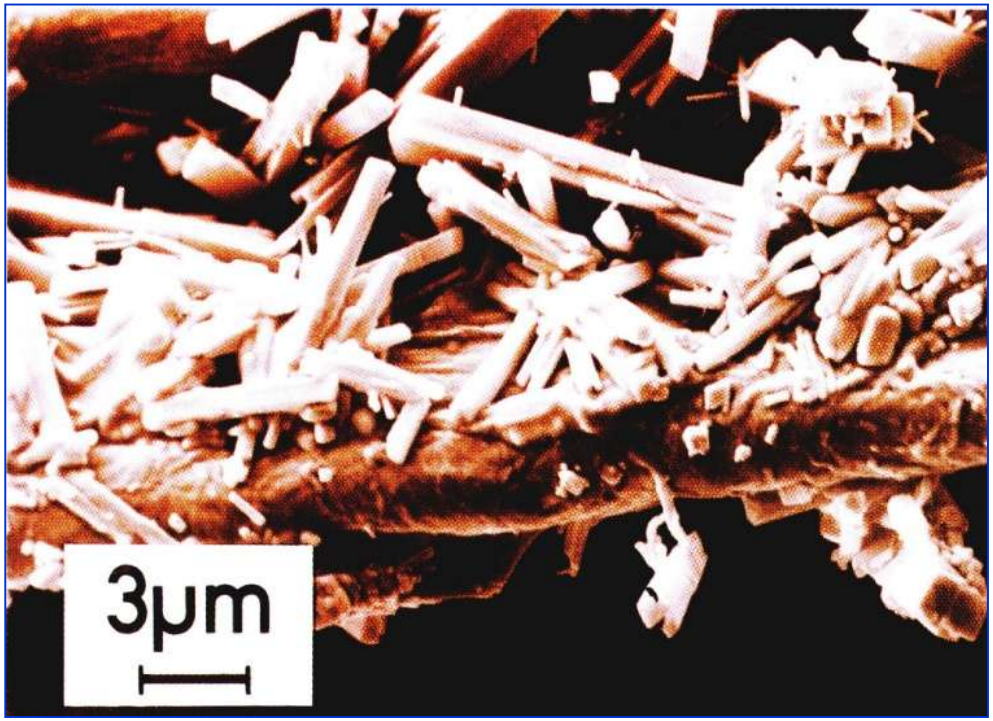
Inorganic incrustation



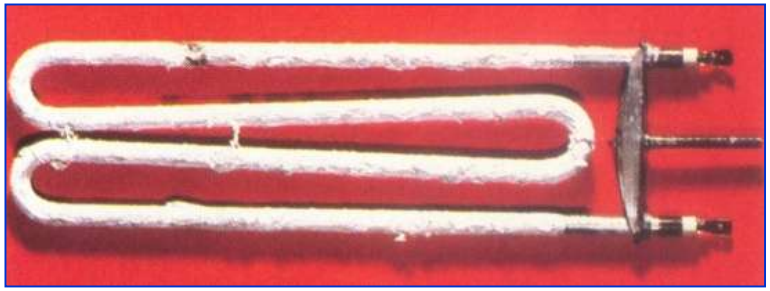
originally

with scale depositions

Inorganic incrustation IV



micro-crystals



heating coil with scale depositions

Inorganic incrustation

In presence of soaps/soap-based detergents, calcium and magnesium ions compose insoluble soap salts

⇨ insoluble soap salts precipitate
⇨ wash-active substances concentration in liquor decreases
⇨ detergent consumption arises therefore

Precipitated soap salts build a hydrophobic film on the fibre surfaces

⇨ greying of fibres
⇨ hydrophobic film on fibre surface
⇨ reduced up-take of water by textile

Heavy metals

There exists no common definition about what heavy metals are.

- **Talking about heavy metals, we usually mean:**

  Iron (Fe), copper (Cu), lead (Pb), stannous (Zn),nickel (Ni), Cadmium (Cd), Chrome (Cr)
- Degradation of heavy metals means environmental burden

Sources of heavy metals

- Water
- corrosion of pipes and tanks
- steam pipes
- textile goods
- accumulation of heavy metals in textiles

→ remove commas and dots

Presence in water supply

- heavy metals concentration in surface waters can diversify by several orders of magnitude within short time intervals
- particularly harmful for the washing process are Fe^{2+}, Mn^{2+}, Cu^{2+} ions
- the only satisfactory method is to treat the water for removal of iron and manganese ions
  - usually involves aeration and filtration
  - possibly with chemical dosage after aeration

Corrosion of pipes and tanks

- Very soft water from municipal supply or water after softening is relative corrosive
- It tends to attack iron pipes and tanks, particularly if the water contains dissolved gases

Prevention

- the tanks and piping may be treated with sodium silicate (water glass) to avoid rust flaking
- equivalent to 15 mg/dm^3

Iron from steam pipes

- iron spots may be caused by specks of iron rust blown from corroded steam pipes onto the textiles
- this trouble is sometimes experienced after an old system has been disturbed by installing a new machine

Solution

- replacing the old system is probably the only cure for this trouble

Heavy metals in textile goods

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- Textile goods sometimes contain heavy metals which are, therefore, carried into the wash

- disturb the washing and bleaching process

- presence of heavy metals in
  - soil and falling dust (Cd, Pb, Zn, Mn, Fe, and Ni)
  - dyestuffs (Cr, Ni, Cu, and Co)

- Some un-dyed wools contain sometimes iron when first obtained
- Wool is more susceptible to minute traces of iron in water than cotton and linen
- Wool has the property of accumulating iron from wash to wash

Consequenses on washing and bleaching

- deposition on textiles
- yellowing of textiles
- catalytic decomposition of peroxides
  (destruction of bleaching activity)
- depolymerization of cellulose

Consequenses on washing and bleaching

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Deposition of **heavy metals** on textiles

- Heavy metal ions ($Fe^{2}+$, $Mn^{2}+$) in presence of alkalis are oxidised and deposited on textiles

$$2\ Fe(HCO_3)_2 + H_2O + \tfrac{1}{2}\ O_2 \rightarrow 2\ Fe(OH)_3 \downarrow + 4\ CO_2 \uparrow$$

$$2\ Mn\ (HCO_3)_2 + 2\ H_2O + O_2 \rightarrow 2\ Mn(OH)_4 \downarrow + 4\ CO_2 \uparrow$$

$$Mn(OH)_4 \rightarrow MnO_2 \downarrow + 2\ H_2O$$

Yellowing of textiles

- General yellowish discoloration can arise in the following ways:
  - presence of iron, manganese and copper in original water supply
  - iron from material washed
- Patchy yellow discoloration can arise from:
  - iron from steam pipes
  - flushes of iron rust in the water

Consequenses on washing and bleaching

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Catalytic decomposition of peroxides

- during bleaching in presence of transition metal ions particularly Fe^{3+}, Mn^{2+}, and Cu^{2+}

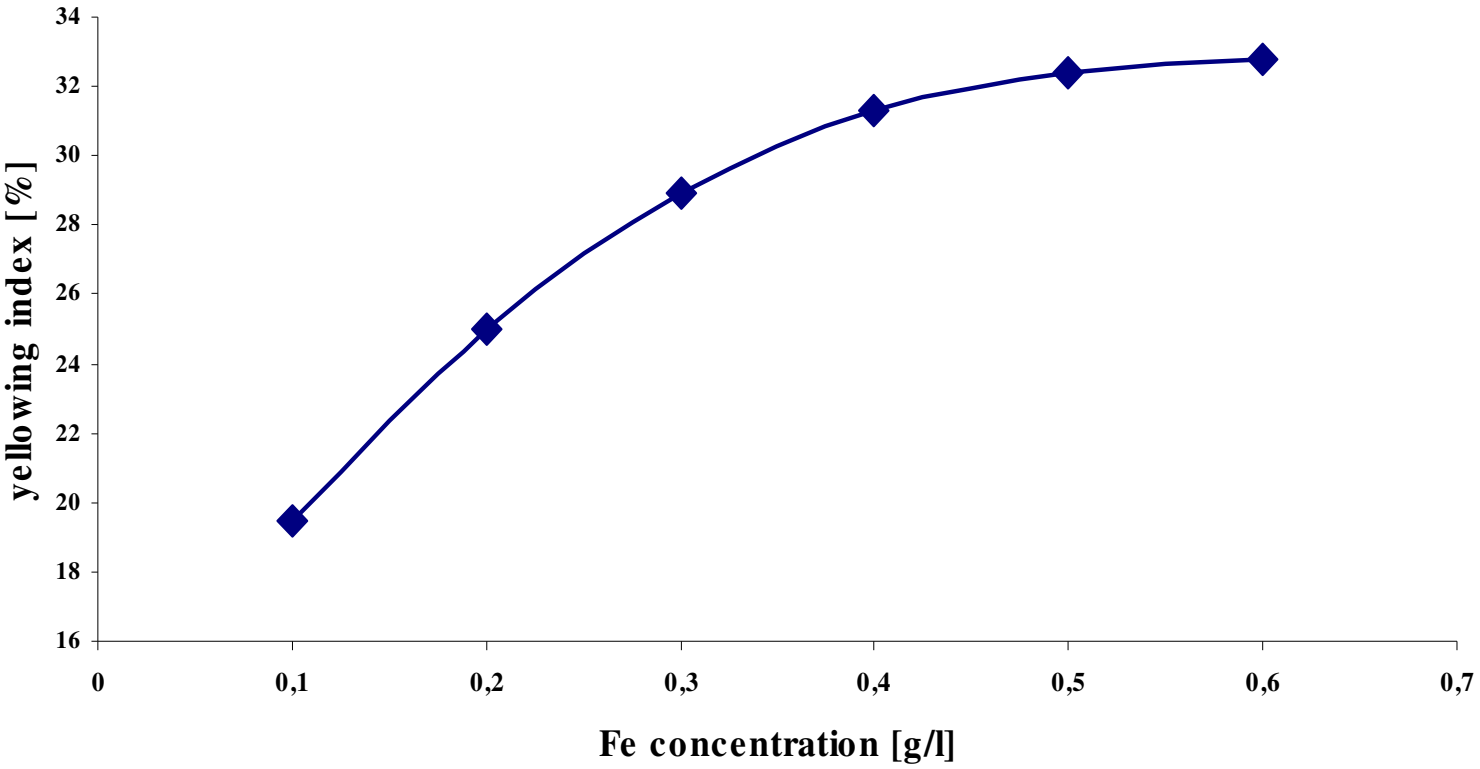
⇨ Prevention - aqueous hydrogen peroxide must be stabilized with complexing agents sequestering the transition metal cations

Depolymerization of cellulose

- presence of metal particles from the shuttle looms can lead to presence of oxycellulose,
- resulting later in textile damage

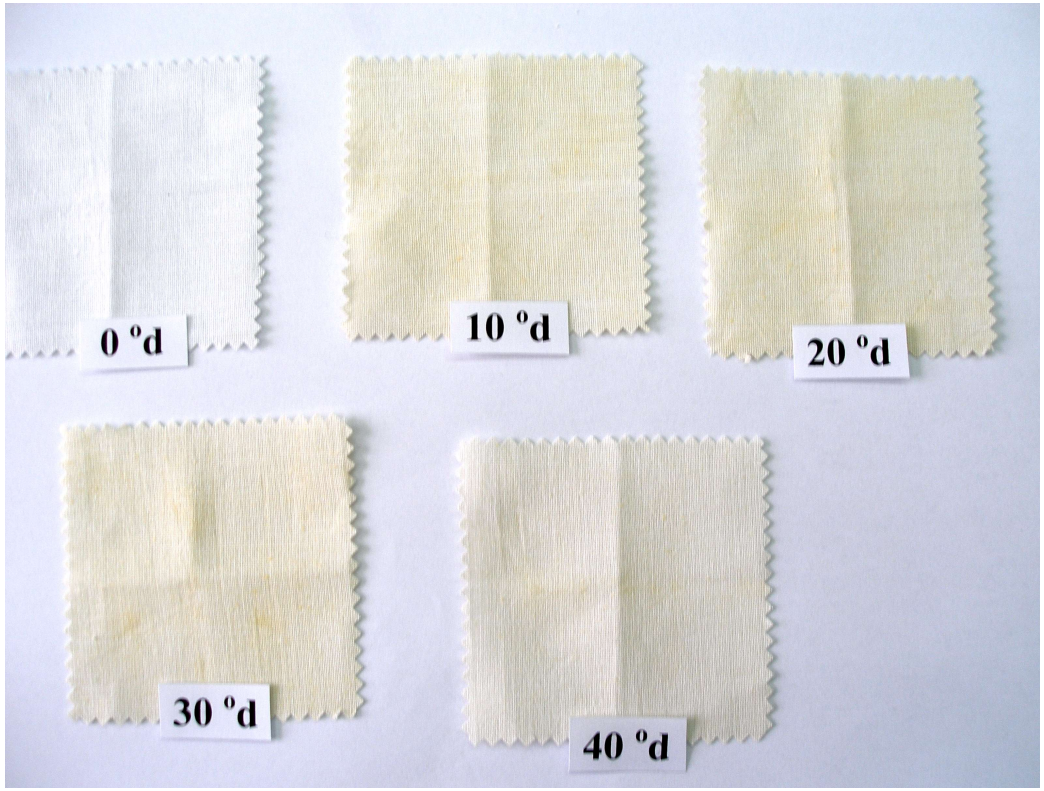
Effect of Fe ions in rinsing

yellowing of cotton fabric



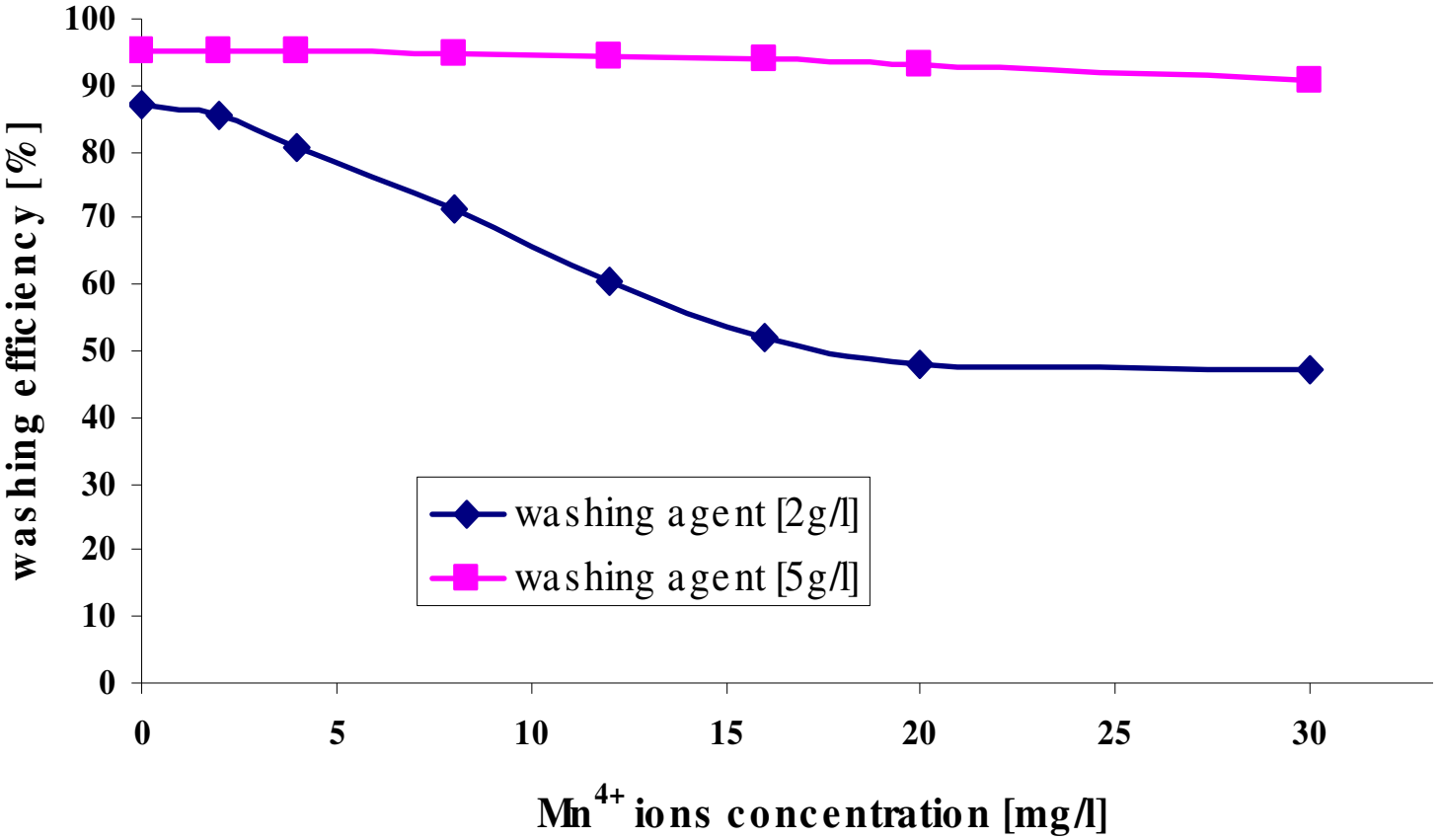
Yellowing of fabric is caused by higher concentration of Fe-ions in water

Effect of water hardness on yellowing



cotton after washing cycles with water of different hardness degrees

Influence of Mn-ions on washing efficiency



Presence of Mn-ions lead to decreasing washing efficiency. Constant results can only be kept by application of considerably heightening of detergents`dosage.