

Sustainability in commercial laundering processes

Module 1
Usage of water

Chapter 3a

Fresh water supply

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

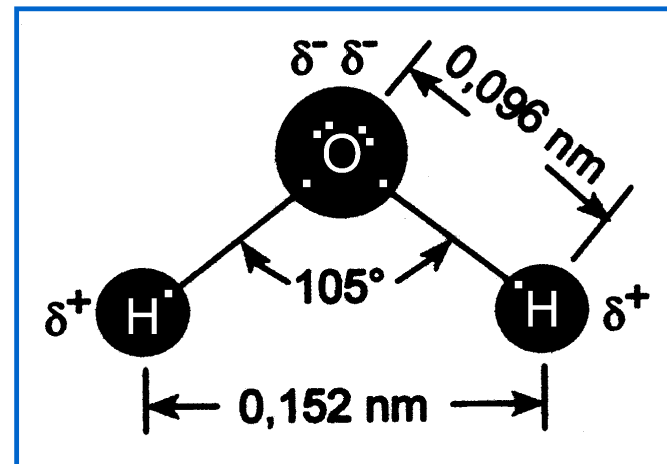
Learning targets

After finishing this 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

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

- 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

- 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

- clear water, odorless
- zero hardness or hardness near 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

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

Hardness degrees

$$1 \text{ mmol CaO/l} = 56 \text{ mg CaO/l} = 5.6 \text{ }^\circ\text{d}$$

$$1 \text{ }^\circ\text{d} = 10 \text{ mg CaO/l} = 0.18 \text{ mmol CaO/l}$$

$^\circ\text{d}$ = German hardness degree

$^\circ\text{e}$ = English hardness degree

$^\circ\text{f}$ = French hardness degree

$$\left. \begin{array}{l} \\ \\ \end{array} \right\} 1 \text{ }^\circ\text{d} = 1.25 \text{ }^\circ\text{e} = 1.79 \text{ }^\circ\text{f}$$

Hardness scale

	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

Relation of water hardness and origin of water

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

- 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 water hardness

Total Hardness =

Temporary Hardness + Permanent Hardness

Temporary (carbonate) hardness

- caused due to presence of acid carbonates
- dissociated carbonic acid $\text{H}_2\text{CO}_3/\text{HCO}_3^- + \text{H}^+$
- removable by heating
- due to the heating process
 - part of the carbon dioxide evaporates
 - acid carbonates (HCO_3^-) react with $\text{Ca}^{2+}/\text{Mg}^{2+}$ -ions to poorly soluble standard carbonates
 - those coagulate as flakes (scale)

Permanent (non-carbonate) hardness

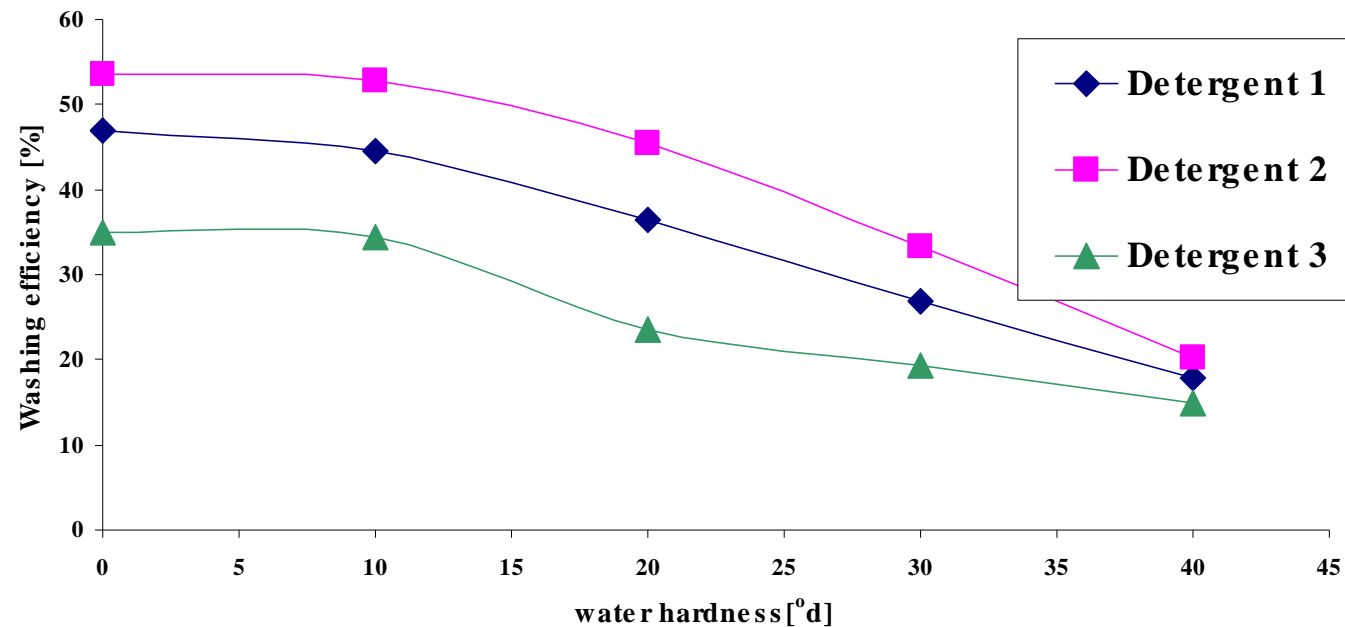
- remaining anions (chlorides, sulphates)
- no heavily soluble compounds accumulation
- no removal by heating
- kind of anions have no impact on water hardness

Temporary and permanent hardness

- Temporary hardness (Carbonate hardness)
 - Ca-/Mg-hydrogen carbonates
 - $T > 60\text{ }^{\circ}\text{C}$: precipitation of hydrogen carbonates as carbonates
 - $\text{Ca}(\text{HCO}_3)_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2$

- Permanent hardness (Non-carbonate hardness)
 - Ca-/Mg- sulfates
 - Ca-/Mg- chlorides
 - Ca-/Mg- nitrates

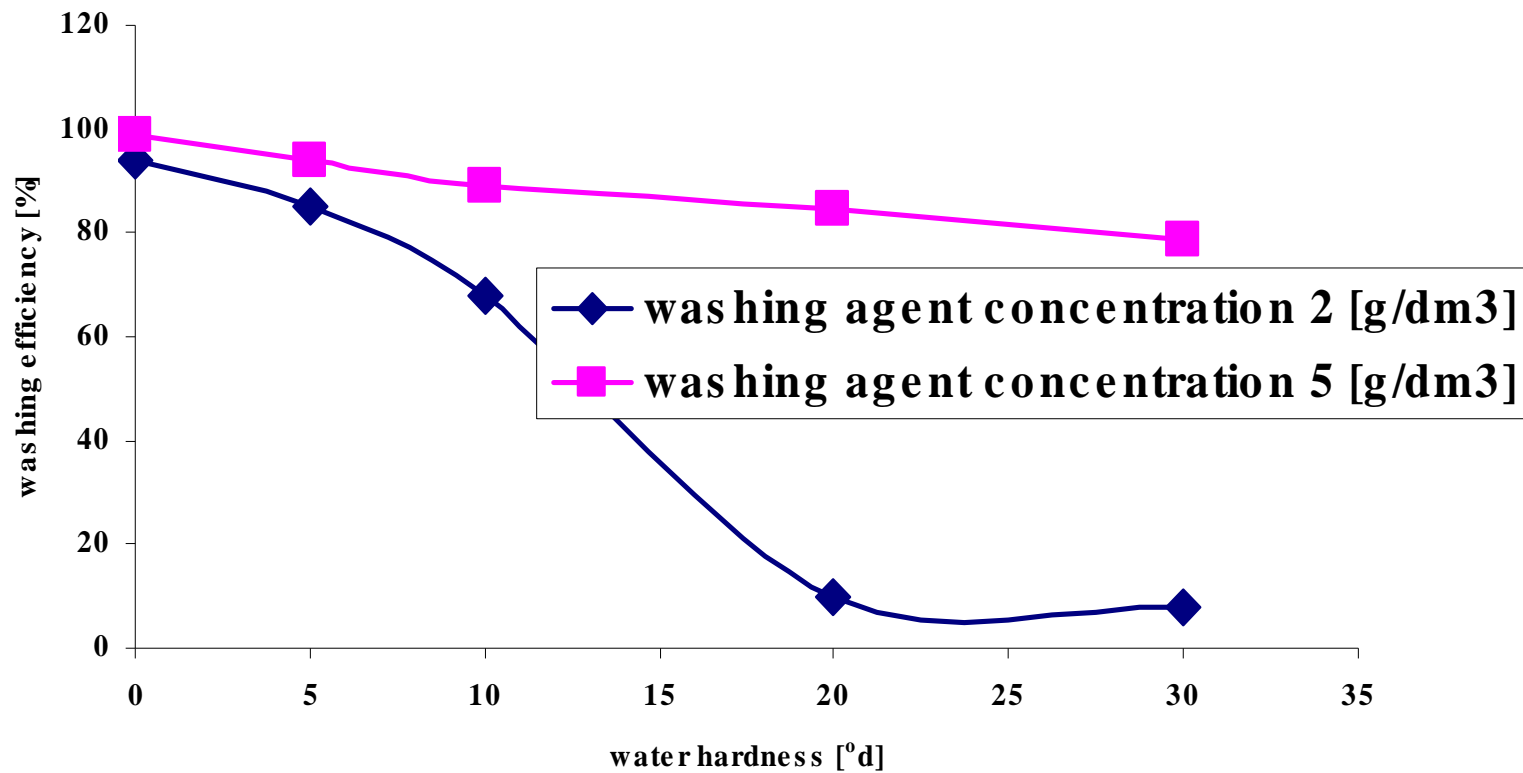
Water hardness influence on washing efficiency



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

If $T > 60\text{ }^{\circ}\text{C}$

calcium and magnesium carbonate precipitate



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

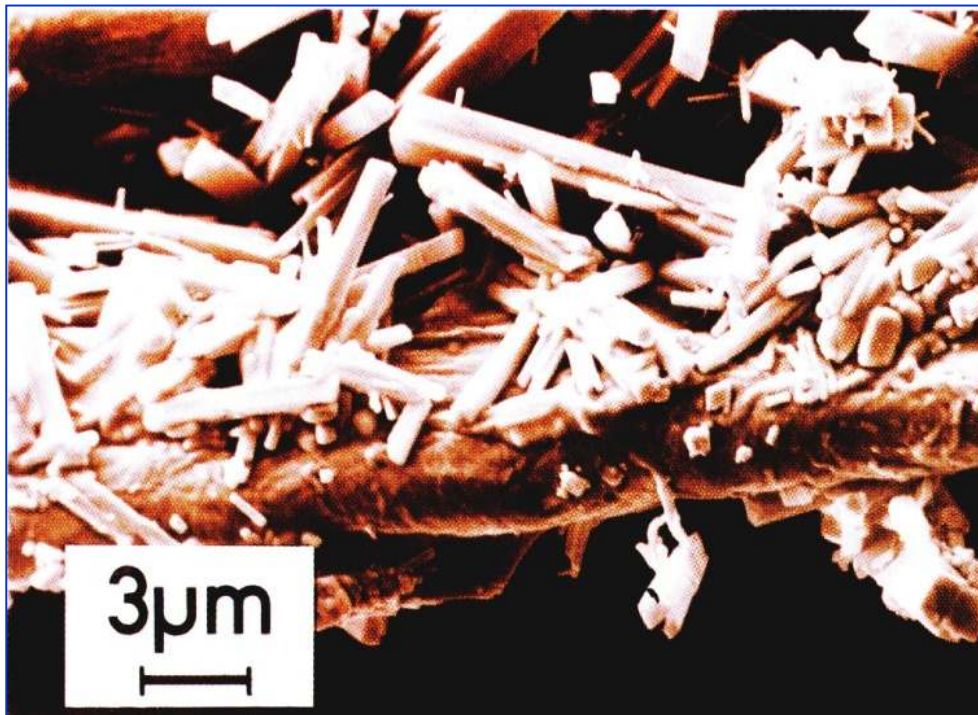
Inorganic incrustation



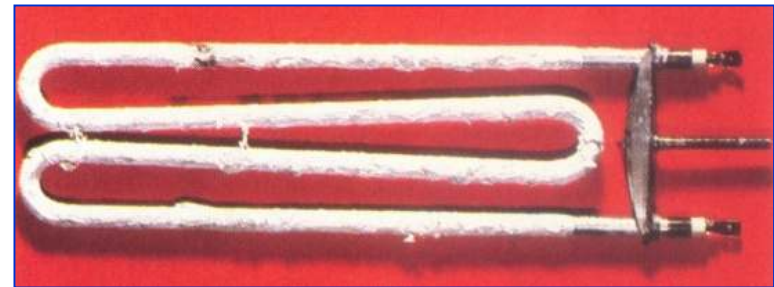
originally

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

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/dm³

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

- 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

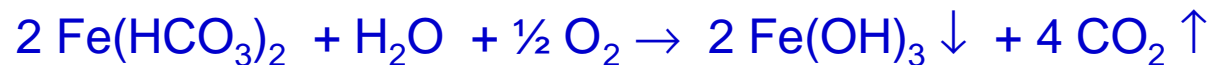
Consequenses on washing and bleaching

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

Consequenses on washing and bleaching

Deposition of **heavy metals** on textiles

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



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

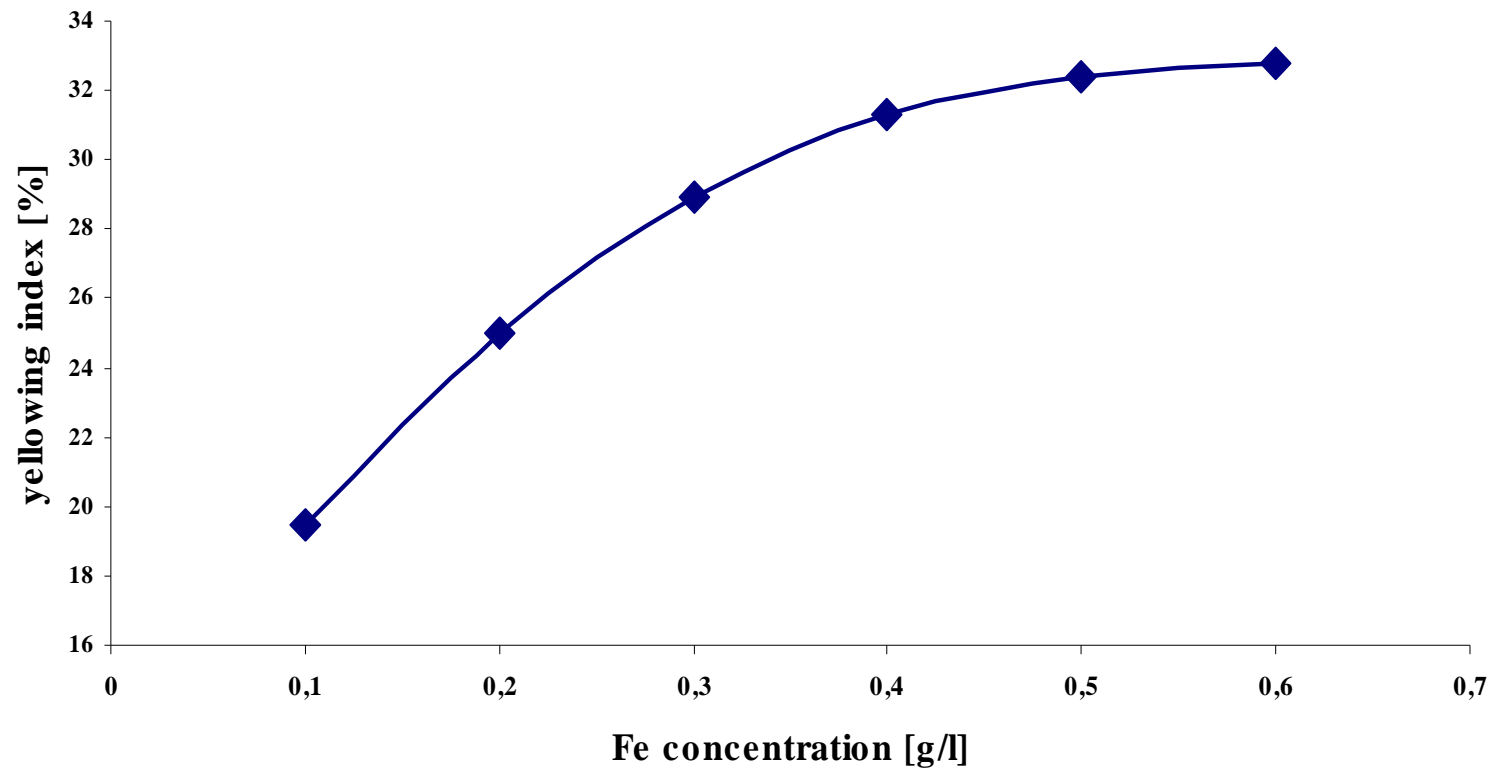
Catalytic decomposition of peroxides

- 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

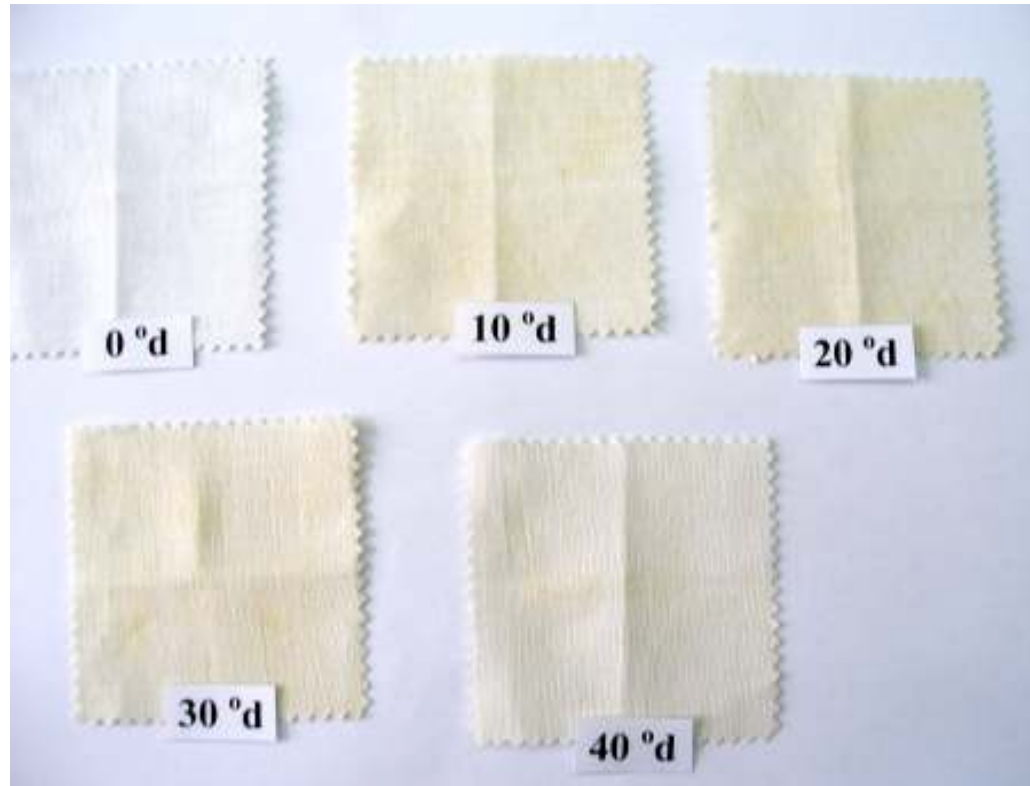
- presence of metal particles from the shuttle looms can lead to presence of oxycellulose,
- resulting later in textile damage

Effect of Fe ions in rinsing yellowing of cotton fabric



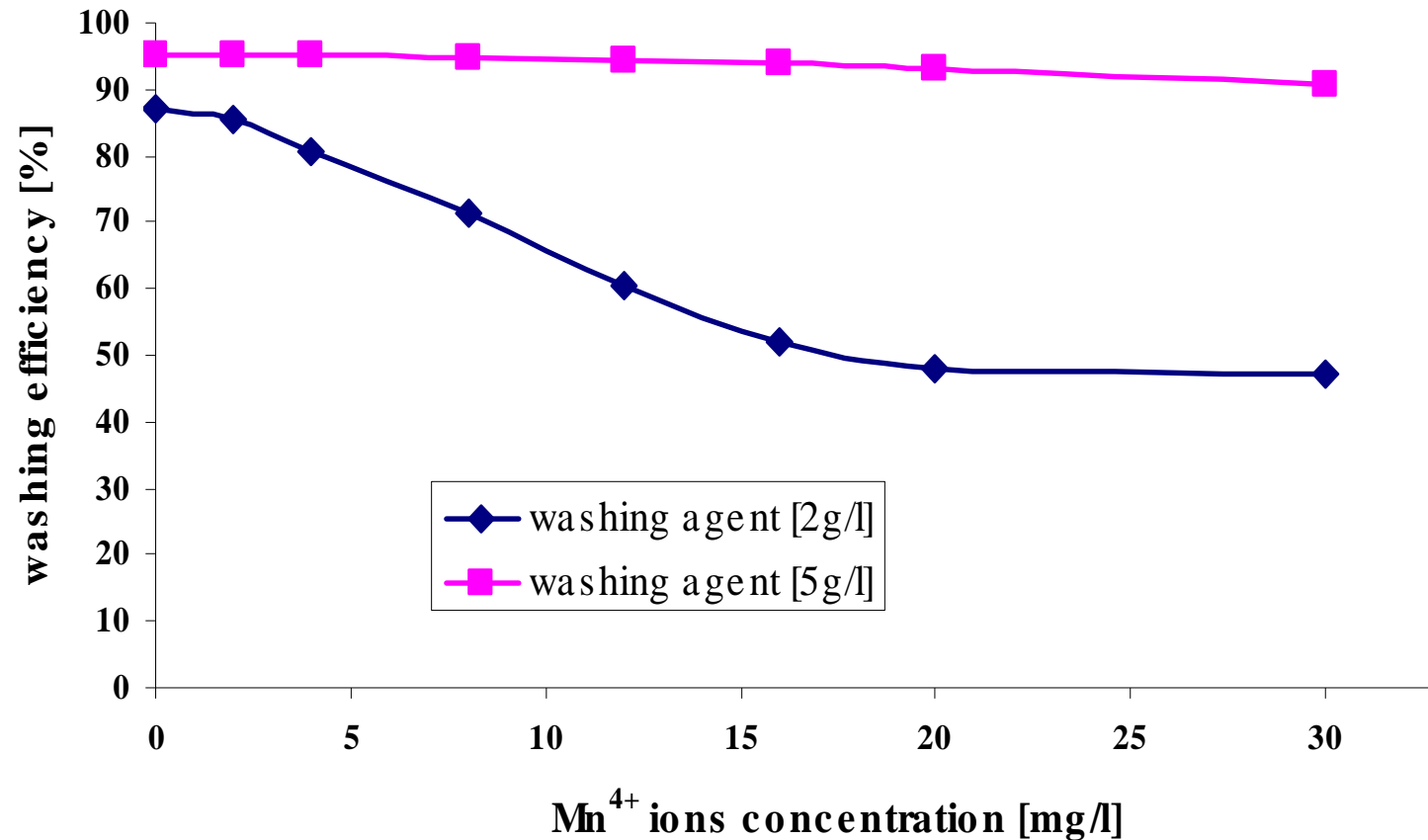
Yellowing of fabric is caused by higher concentration of Fe-ions in water

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 increase of dosage of detergent