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Brown Stock Washing Optimization and Research Studies Field Results

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Content

1. Personal history
2. Publications
3. Results of brown stock washing studies
4. Conclusion
5. Example of the waste water case

Personal history

- **Engineer of Paper technology, Tampere University of Applied sciences, 2000**
- Practical training -97, Metsä-Rauma
- **Master of Science in Industrial Environmental Technology, University of Oulu 2004**
- Master thesis: Study of pulp washing in five different kraft pulp mill
- **Researcher LUT, Savonlinna, 9/2004 – 10/2005**
- **Researcher MAMK, Savonlinna 11/2005 →**
- **Postgraduate, Aalto University 2006 →**
- Academic dissertation: Kraft pulp wash loss and its reliable measurement at pulp mill, 2012

Publications

1) **Refractive index measurements for brown stock washing loss - laboratory investigations,** APPITA JOURNAL vol 61(5), 2008.

- Usability of Refactometer to Measure Washing Loss in Chemical Pulping

2) **Refractive index measurements for brown stock washing loss - mill investigations,** APPITA JOURNAL vol 63(2), 2010 and 63rd APPITA CONFERENCE

- Usability of Refactometer to Measure Washing Loss in Chemical Pulping
- Different measurement methods in determining brown stock washing loss were compared, Washing efficiency E_{10} was calculated, refractometer measurement in the oxygen delignification feed

3) **Optimization of pressure filter performance by refractometer - Mill investigations,** APPITA JOURNAL vol 64(1) and 64th APPITA CONFERENCE

- Optimization of different variables which affect to pressure filters performance, Refractometer measurement in the all filtrate fractions of single washer

Publications

4) **Improving brown stock washing by using on-line measurement – mill investigations,** ABTCP-TAPPI 2010 CONFERENCE and O'PAPEL (under review)

- Optimisation of brown stock washing, digester washing, pressure diffuser washing, double filter washing, the effect of the washing to oxygen delignification

5) **Optimization of wash water usage in brown stock washing,** TAPPI PEERS 2010 CONFERENCE

- Utilization of Real-time Refractometer Measuring Results in Chemical Pulping

6) **Refractometer and its ability to measure dissolved dry solids at low concentrations,** 65th APPITA CONFERENCE

- Investigation of Real-time Refractometer Measurement Applied in an Activated Sludge Plant

<u>Master thesis</u>

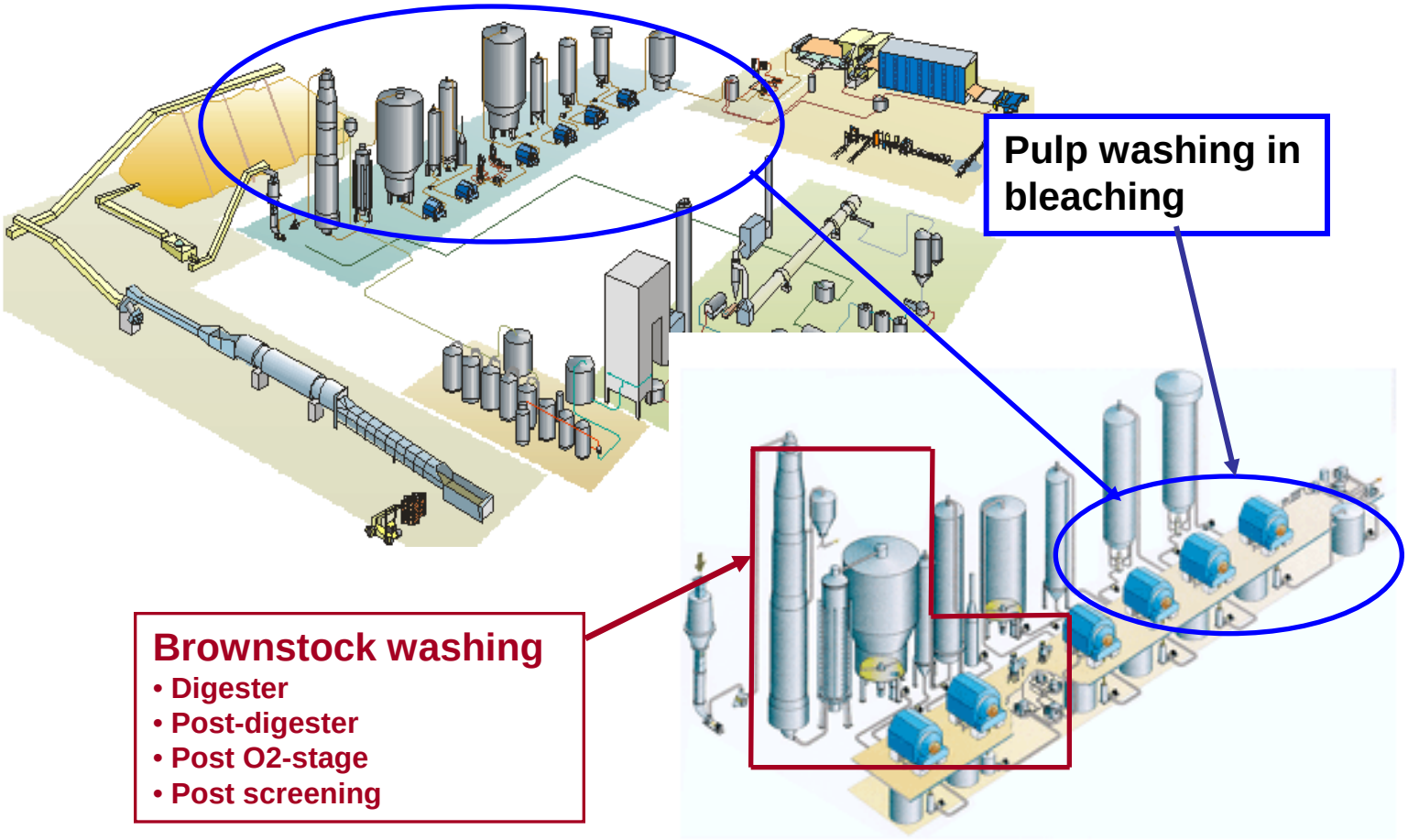
- Helttunen Jukka: **Washing loss on-line measurement in kraft pulping**
- Karjalainen Simo: **The optimization of the DD-washer**
- Kari Erkki: **Improving the efficiency of brown stock washing by utilizing real-time measurements**

Content of mill studies

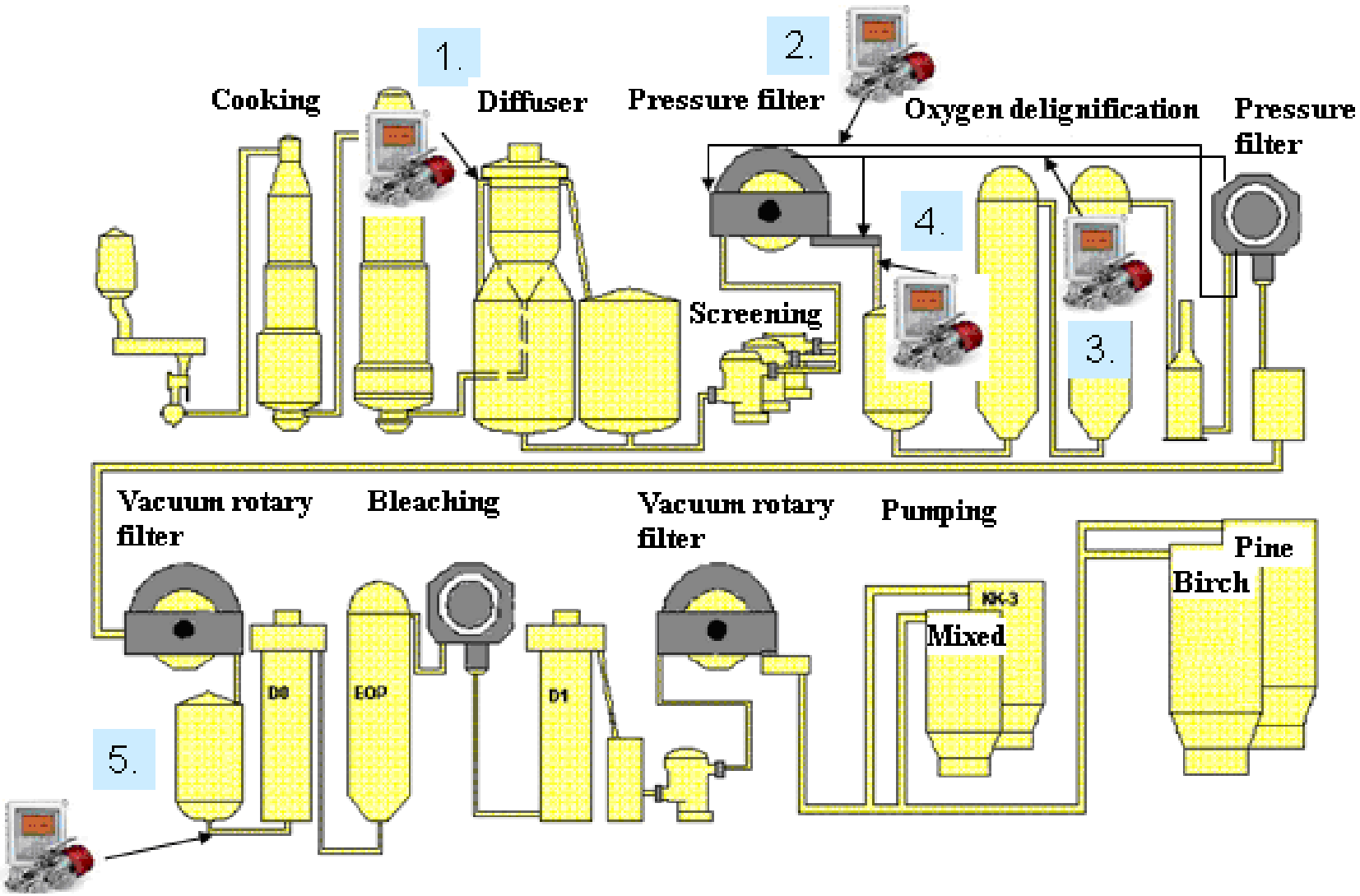
1) **Target**
2) **Arrangement of mill tests**
3) **Comparison of different measurement methods**
4) **The effect of pulp consistency to washers operation**
5) **The effect of wash liquor amount to washers operation**
6) **The effect of the brown stock washing to performance of oxygen delignification and to economy of pulp mill**
7) **Washer operation**
8) **Conclusions**

Target

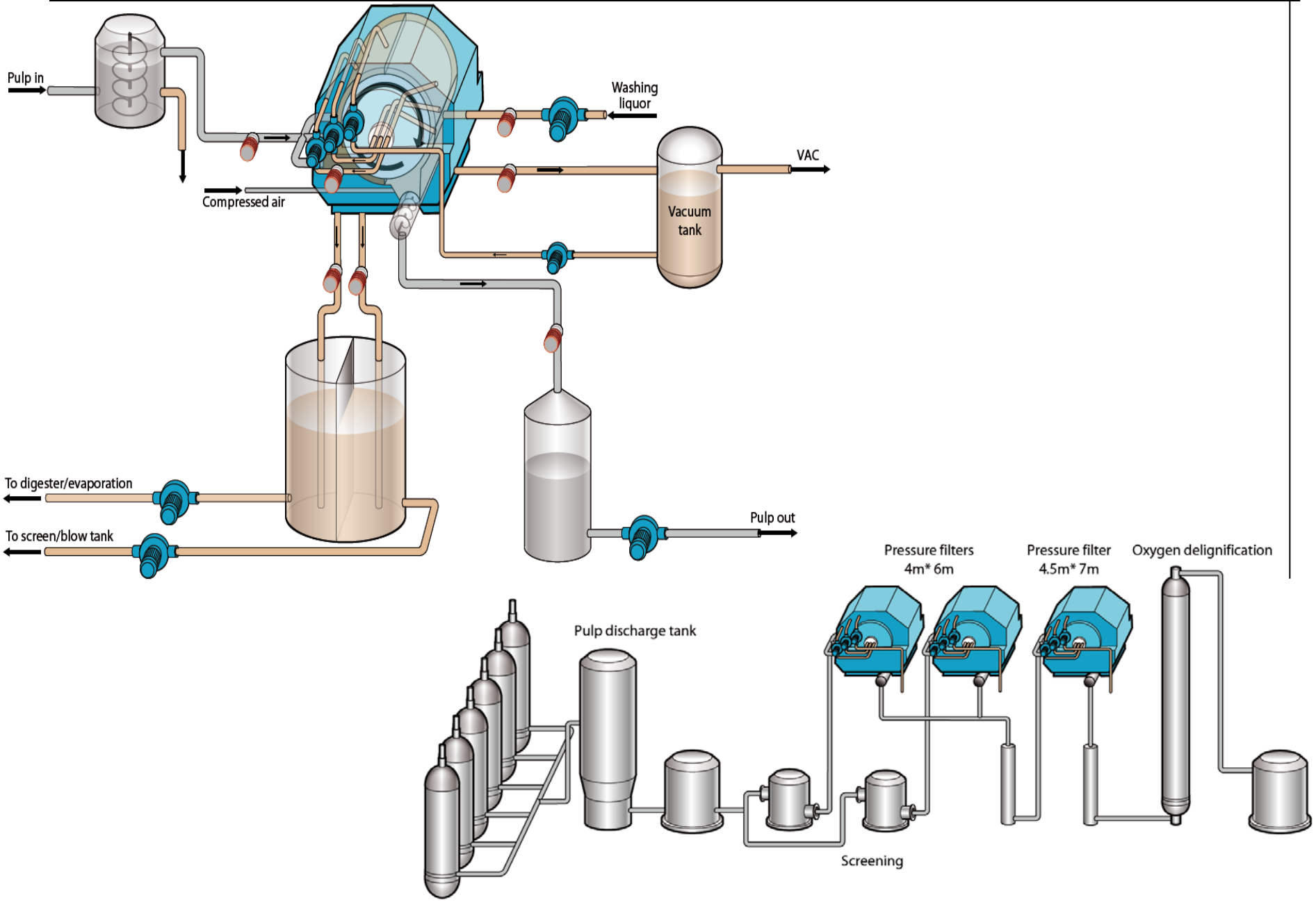
- **Series of investigations to find solutions that minimize washing loss and consume less energy, water and chemicals**



Arrangement 1



Arrangement 2



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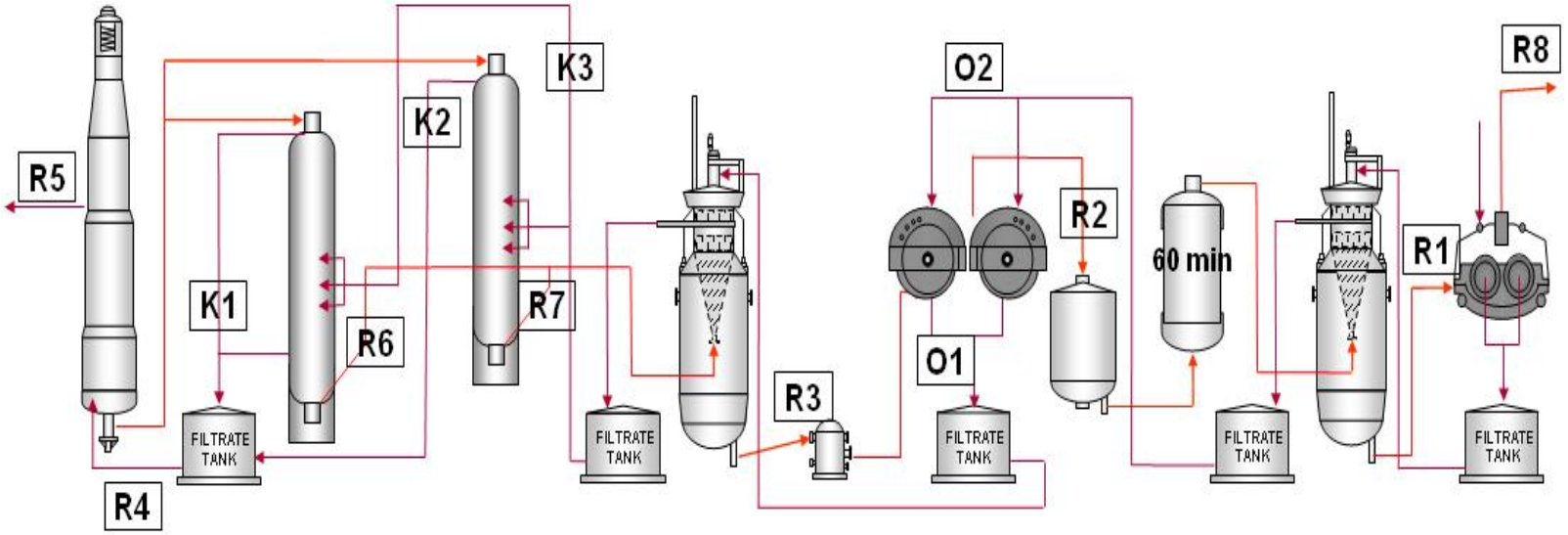


HI-HEAT

PRESSURE DIFFUSER 1

PRESSURE DIFFUSER 2

DIFFUSER WASHER

SCREENING & KNOT SEPARATION

DOUBLE FILTER

O_2-STAGE

O_2 -DIFFUSER WASHER

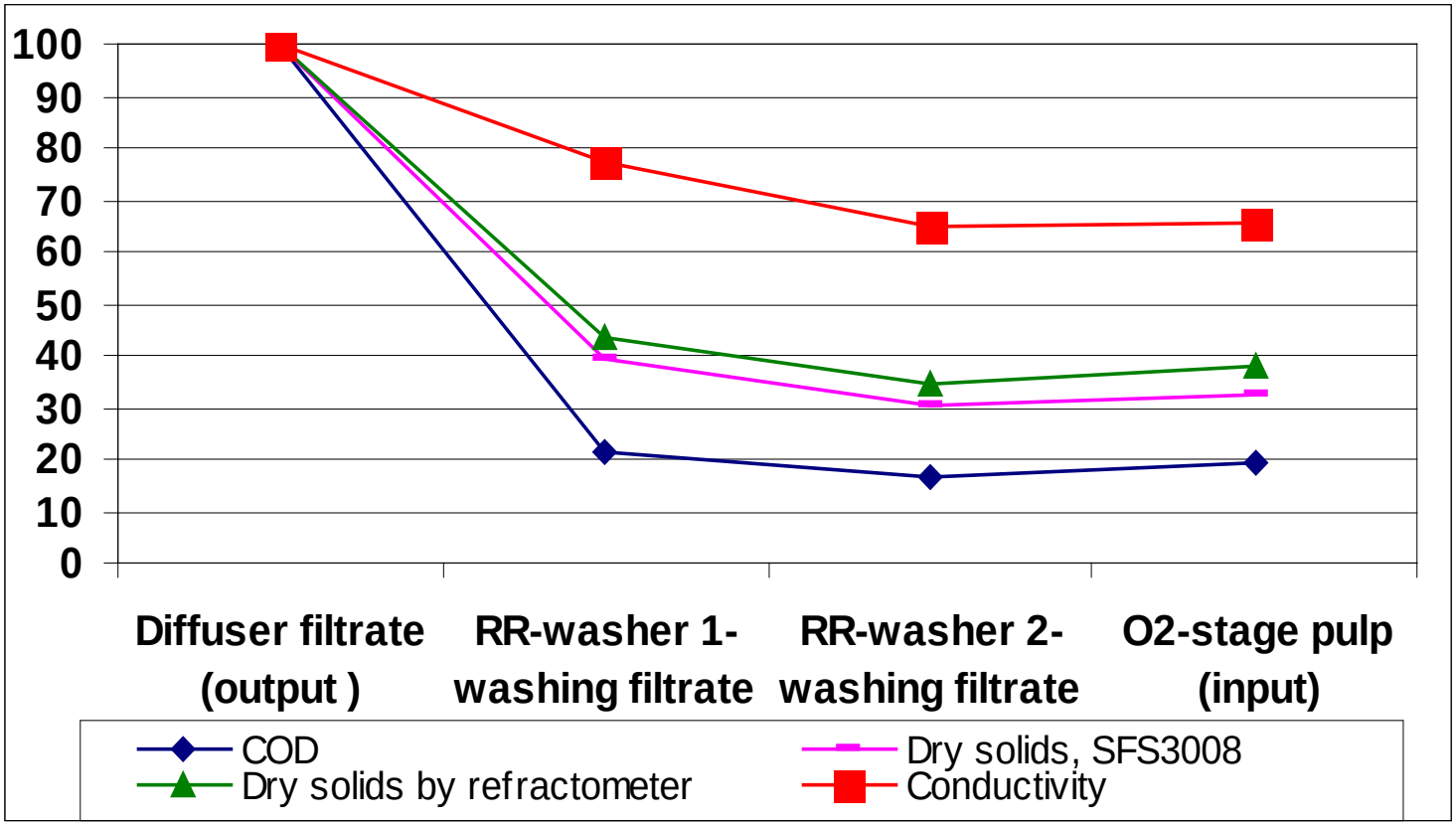
PRESS WASHER

Results

- **Comparison of different measurement methods**

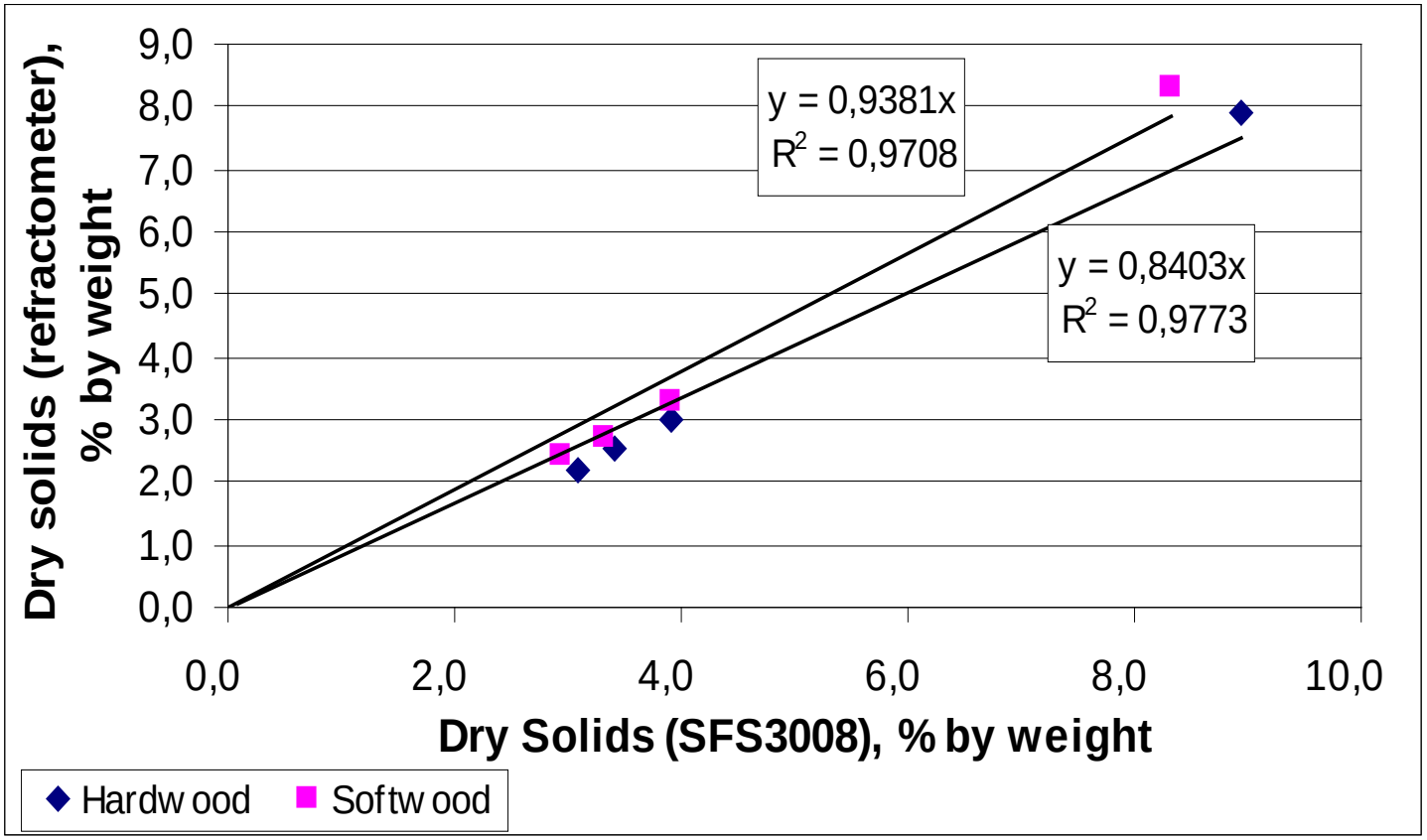
Normalized wash losses

- **All devices detect wash loss**
- **Proportional variances are constant**



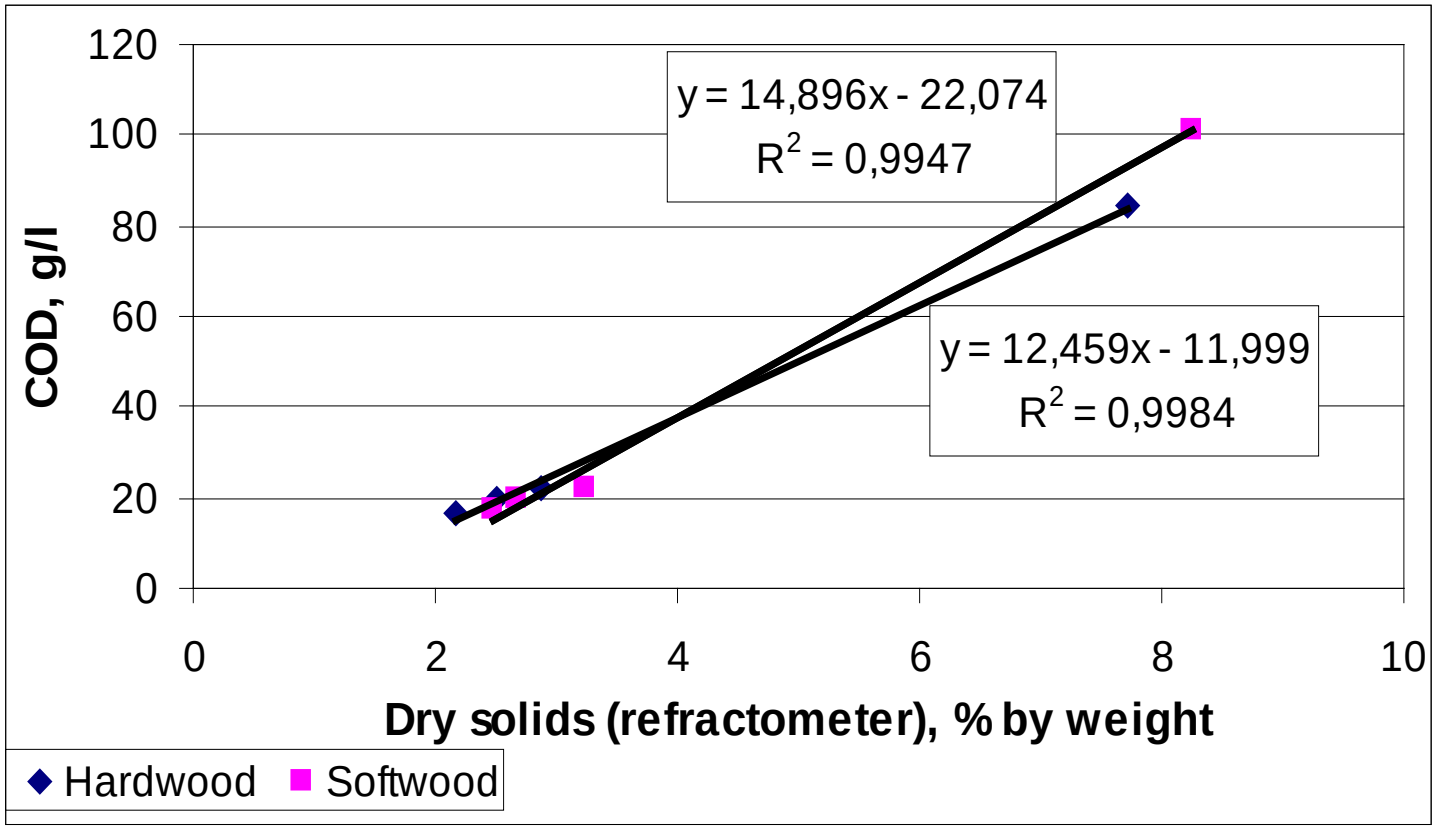
SF-3008 vs. Refractometer in filtrates

- **Correctly calibrated refractometer measures exactly DDS.**
- **The wood species had resonance for the measuring result**



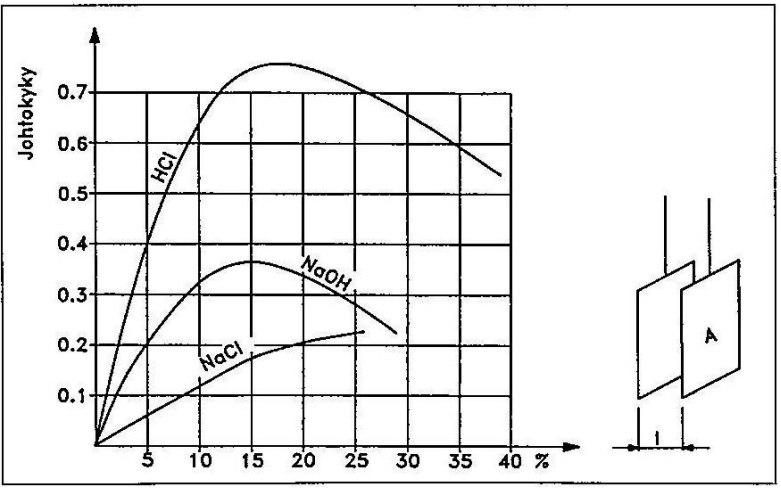
Refractometer vs. COD in filtrates

- **The correlation between COD and dissolved dry solid content measured by the refractometer**

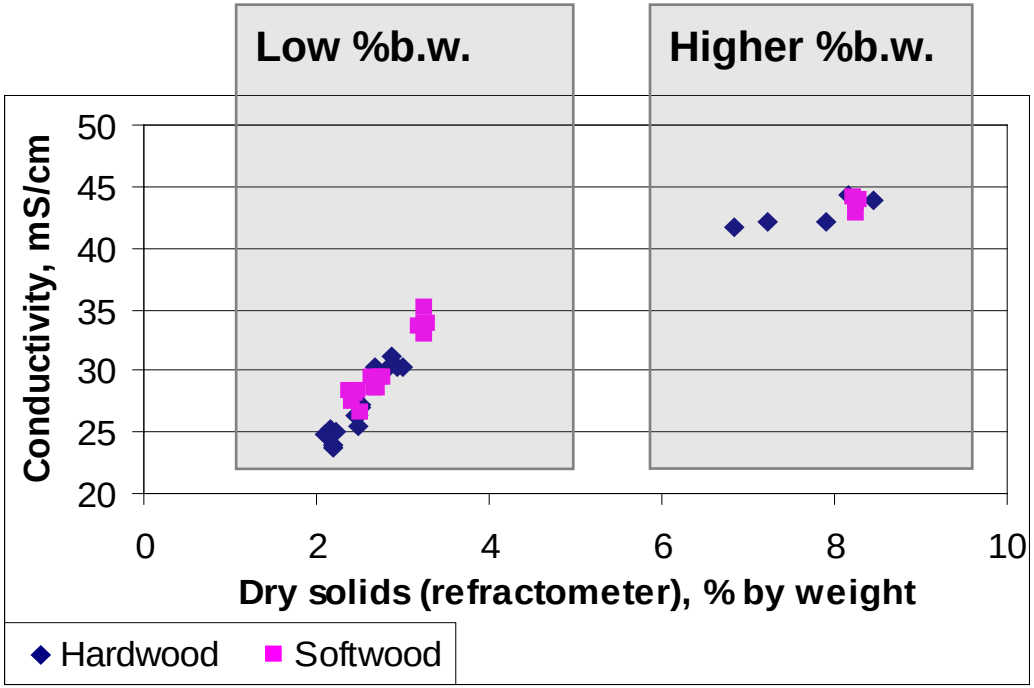


Conductivity vs. refractometer in filtrates

- The correlation is not linear
- Conductivity increase begins to slow down with a rise in dry solids concentration

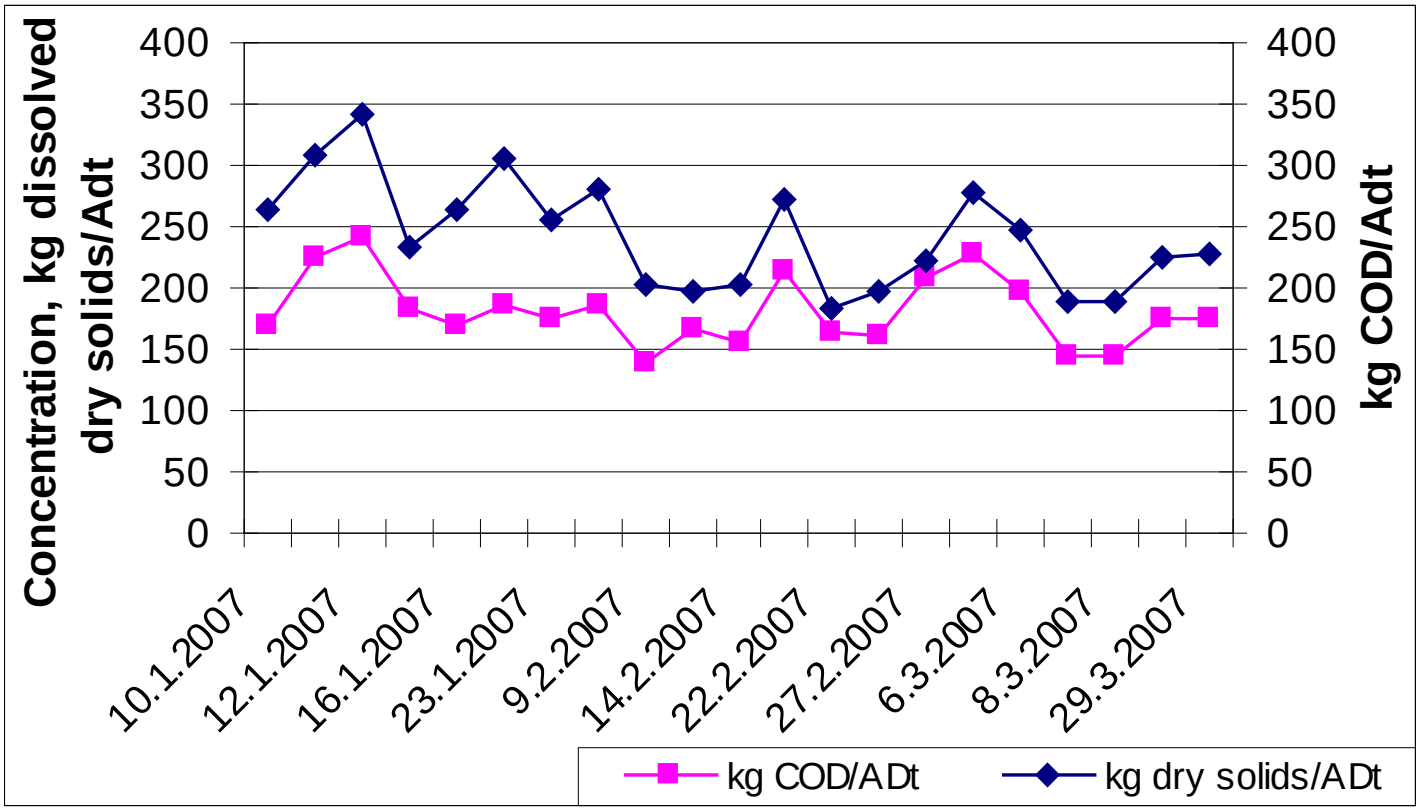


Conductivity vs. Liquid concentration
Source: Pihkala, J.



Filtered results of Refractometer and COD-analysis

- Refractometer measurement follows the mills COD-laboratory analysis considering level differences

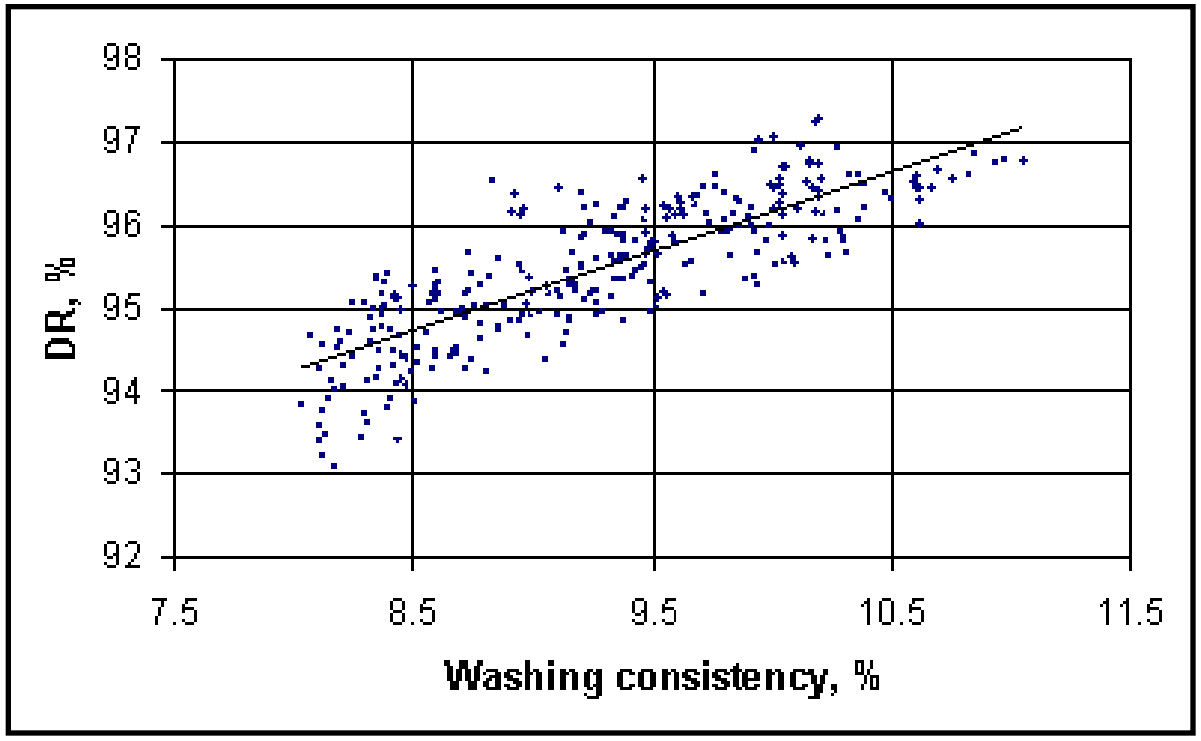


Results

- **The effect of pulp consistency to washers operation**

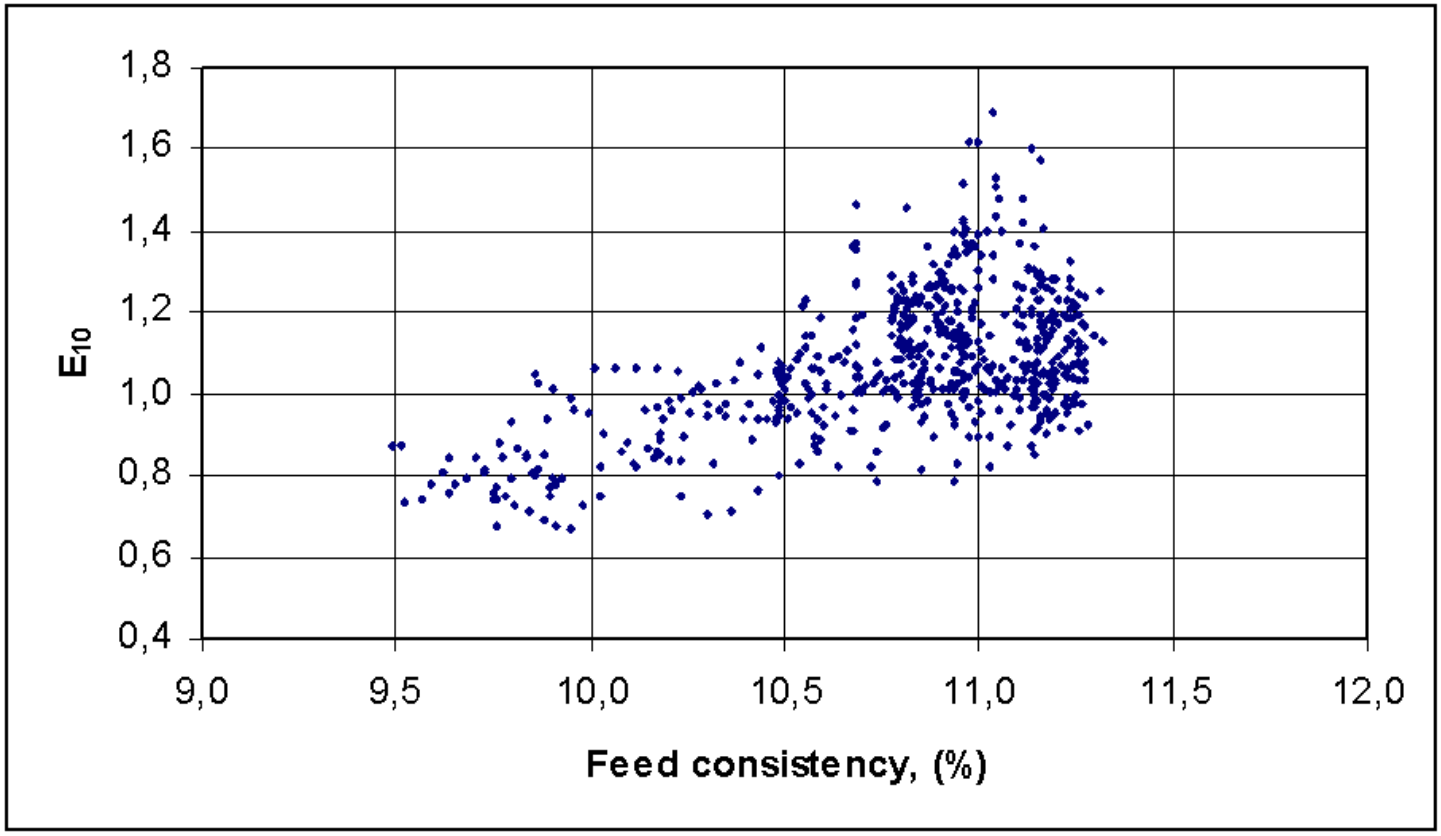
Effect of washing consistency on washing results

- **A sufficiently high consistency of feed pulp to the washer enabled high washing consistency → is an essential requirement for effective and economical washing of pulp**



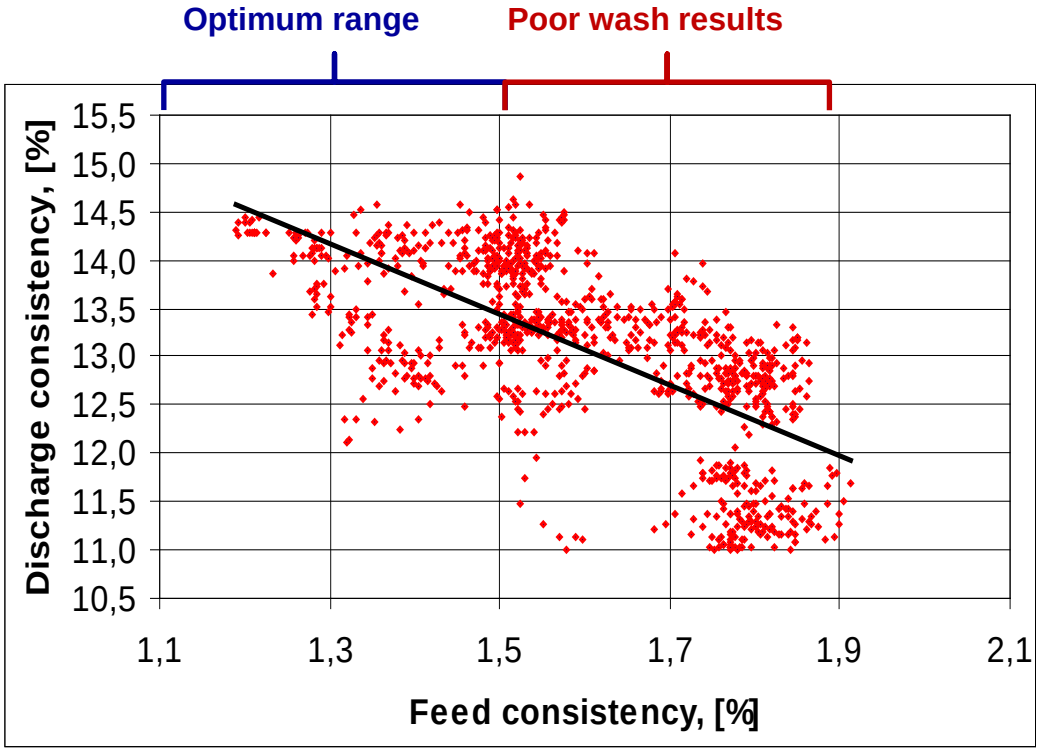
Pressure Diffuser's Feed Consistency Effect

- **With a higher feed consistency, the washing efficiency is increased**



Effect of Feed Consistency on Discharge Consistency (Hardwood)

- **Too high feed consistency harmfully affects the double filter's washing performance**
- **In the literature: "When the washer operates at design capacity the optimum feed consistency is between 1.0 and 1.25% for softwood and 1.1 and 1.5% for hardwood"**

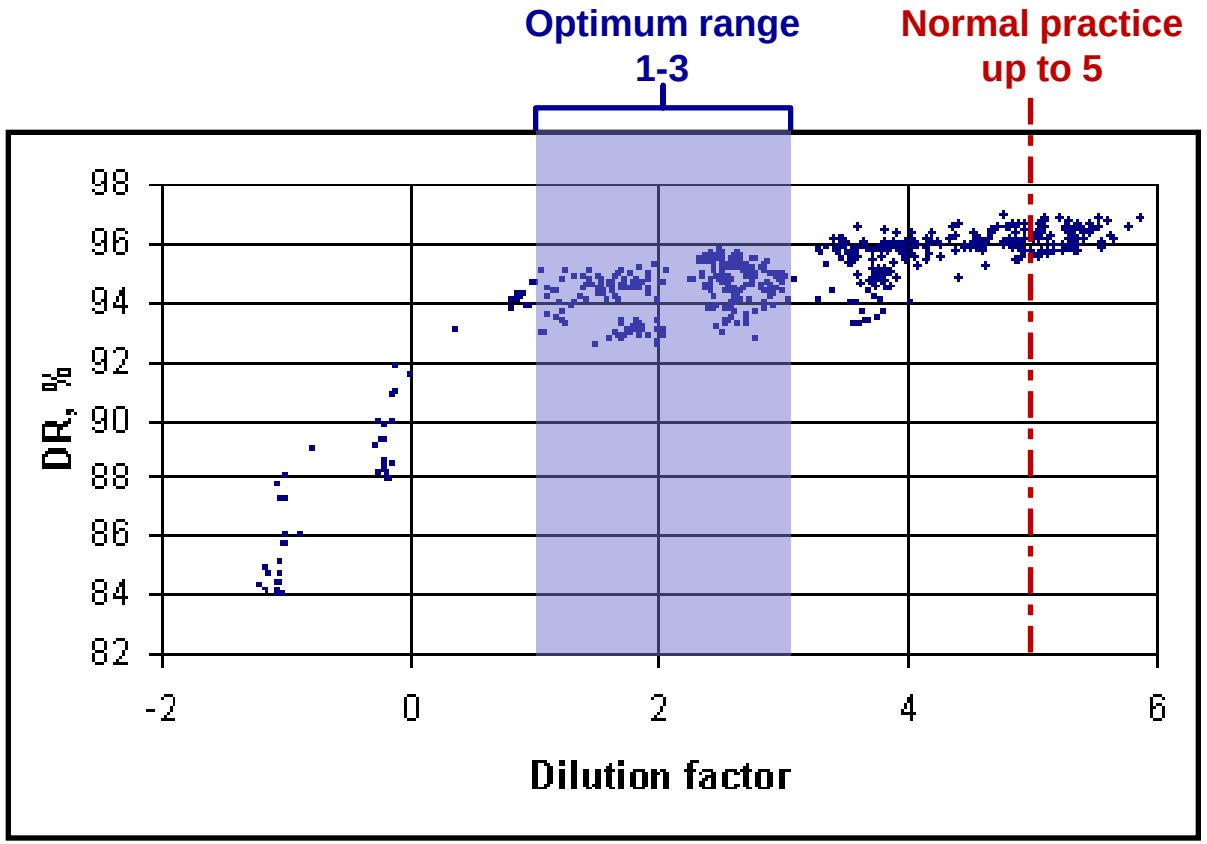


Results

- **The effect of wash liquor amount to washers operation**

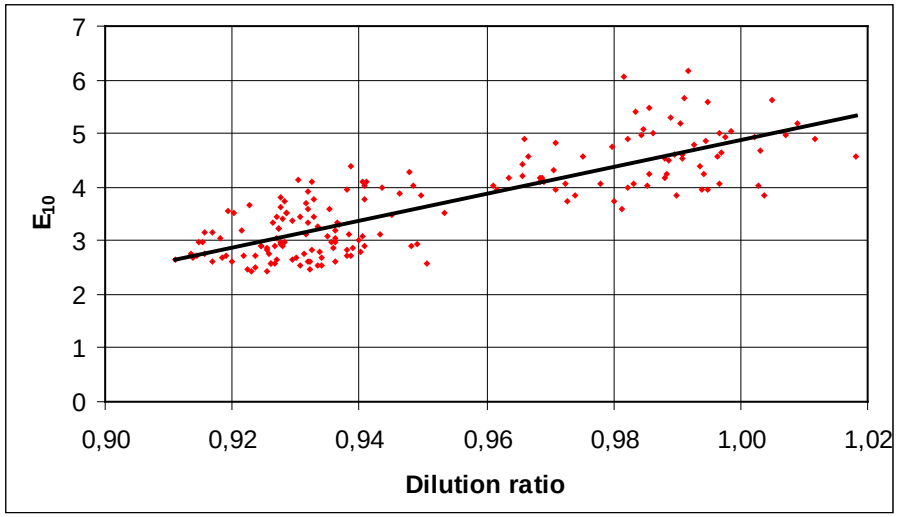
Effect of dilution factor on washing results

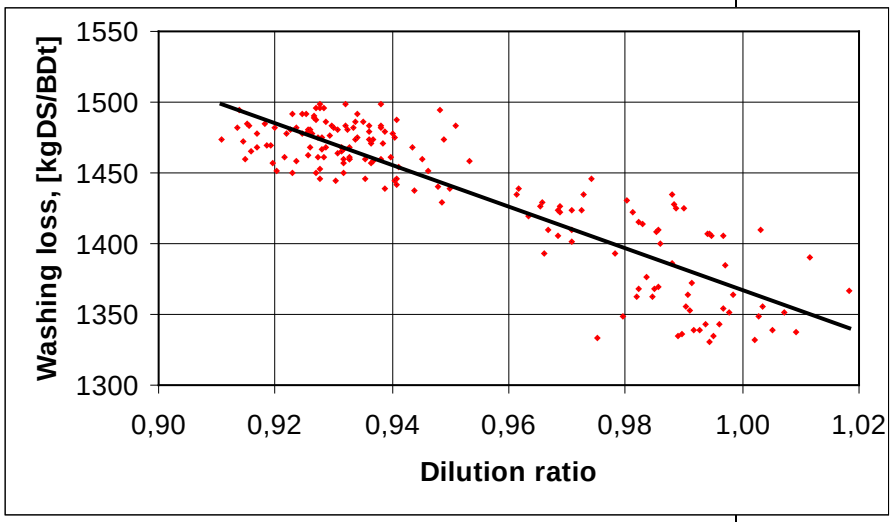
- **Dilution factor should be above 1 to guarantee unobstructed washer performance**
- **The real-time results are similar to literature**



Effect of Dilution Ratio on E10 and on Washing Loss

- **The dilution ratio notably affects the pressure diffuser's washing result**

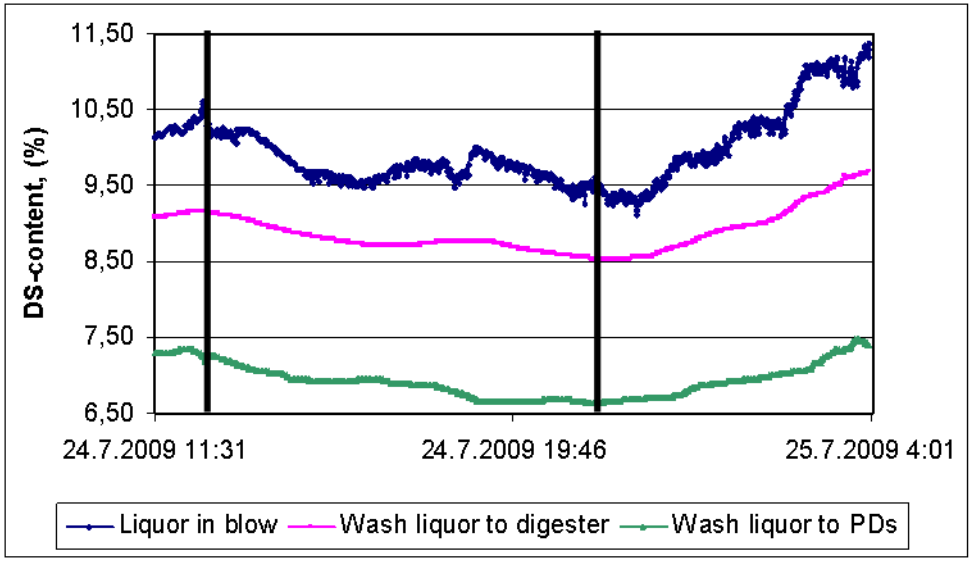




$$Dilution\ ratio = \frac{wash\ \ filtrate(out), \left[l/s\right]}{wash\ liquor(in), \left[l/s\right]}$$

Utilising radial displacement washing in the digester

- **Bypass was decreased and the amount of wash liquor fed into the digester was increased (into the central distribution chamber). The same amount of filtrate from the wash circulation was extracted.**
- **The digester's washing result can be increased by utilising radial displacement washing.**

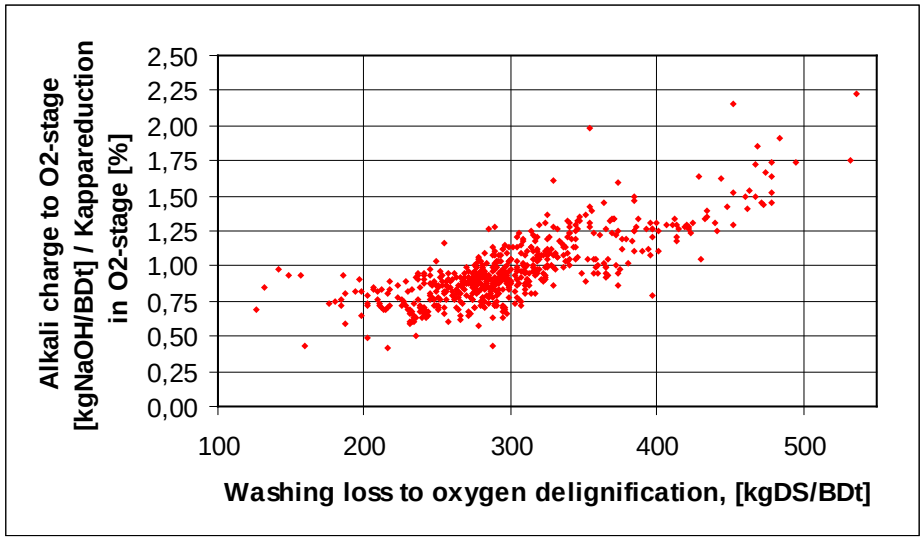


Results

- **The effect of the brown stock washing on the performance of oxygen delignification and on the economy of pulp mill**

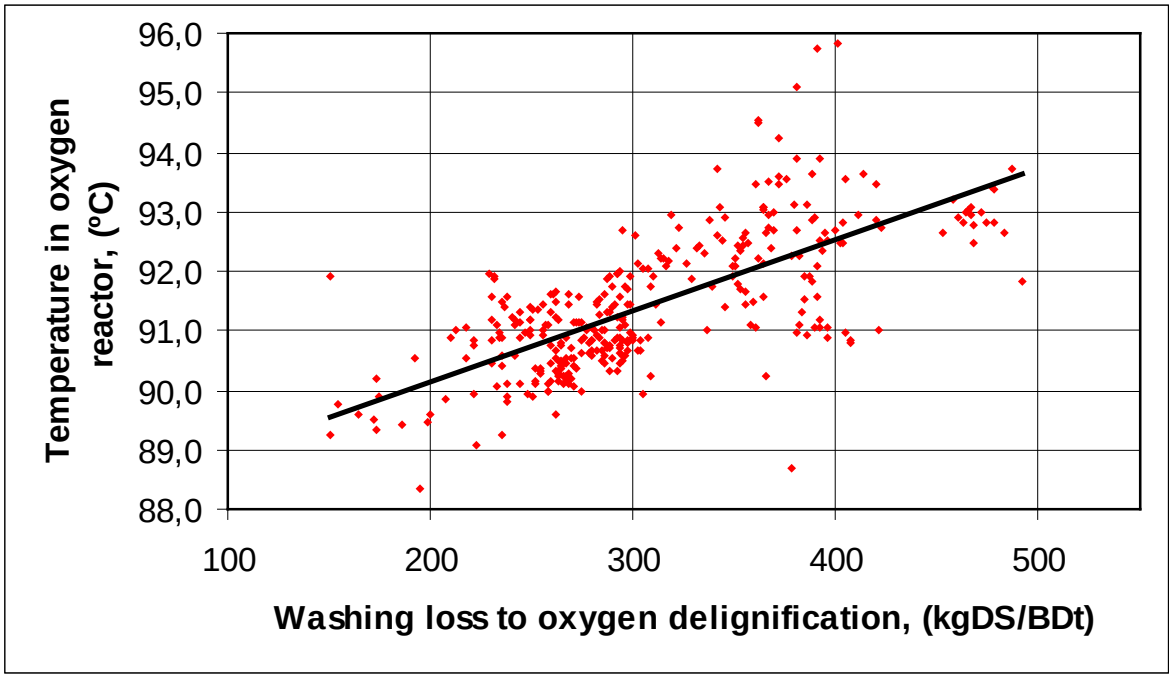
Effects of Washing Loss on Oxygen Delignification (Hardwood)

- When the amount of the washing loss increases more alkali is consumed in oxygen delignification
- The reason for this is that e.g. alkali is consumed in the neutralization reactions of the acids originated from the cooking



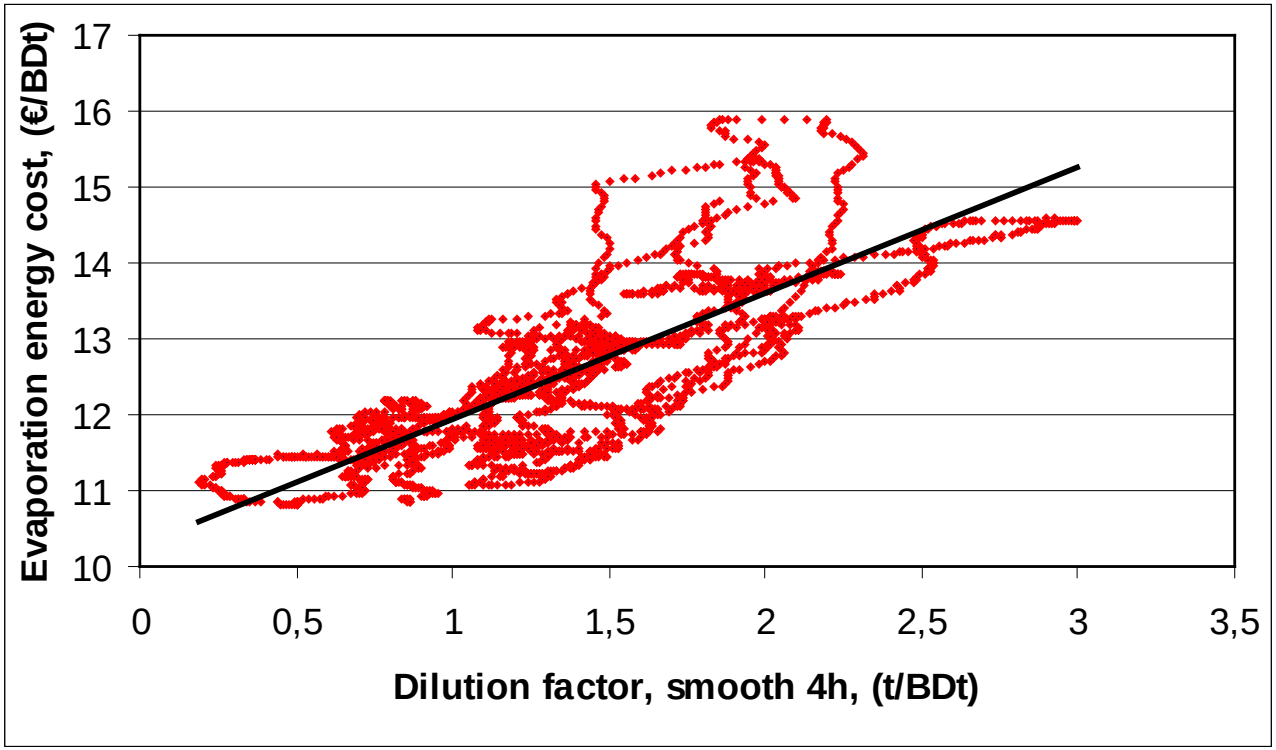
The Effect of Washing Loss on Oxygen Reactor's Temperature (Softwood)

- **The temperature in the oxygen reactor correlates with the amount of washing loss**



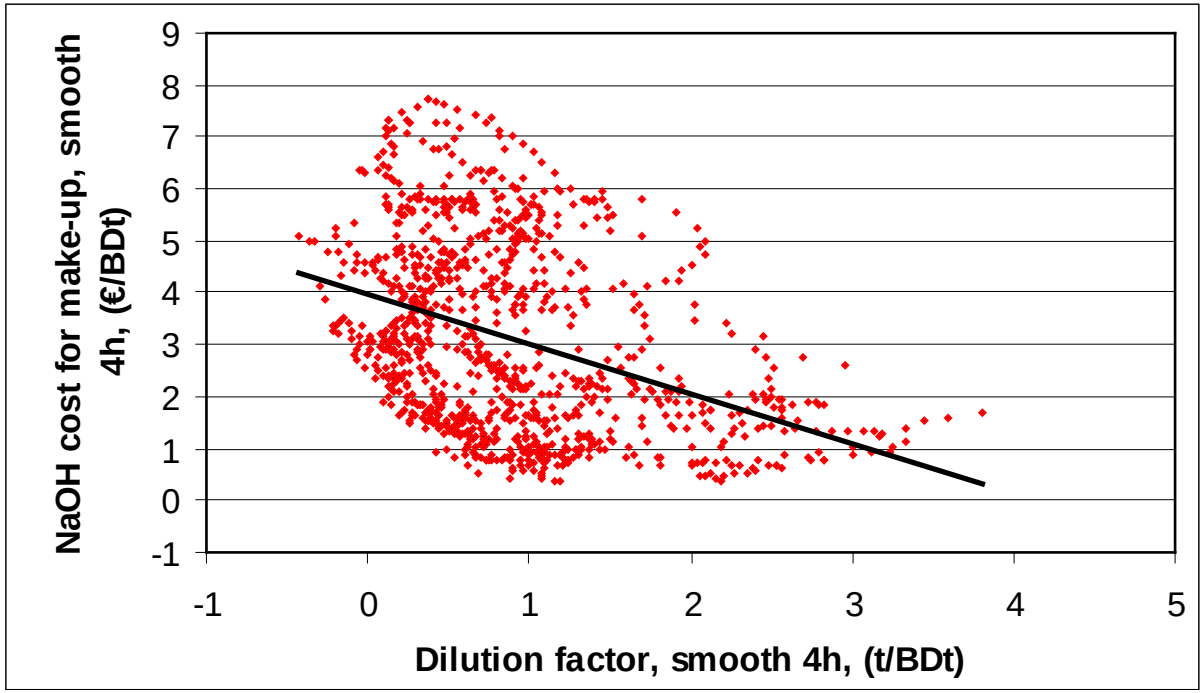
The Effect of Dilution Factor on Evaporation Energy Costs

- **At this mill experiment increasing the dilution factor by 1 unit, evaporation costs increase on an average by 1.5 €/BDt.**



The Effect of Dilution Factor on NaOH Make-Up Costs

- **At this mill experiment increasing the dilution factor by 1 unit, the make-up chemical cost as NaOH decreases on an average by 1.0 €/BDt.**



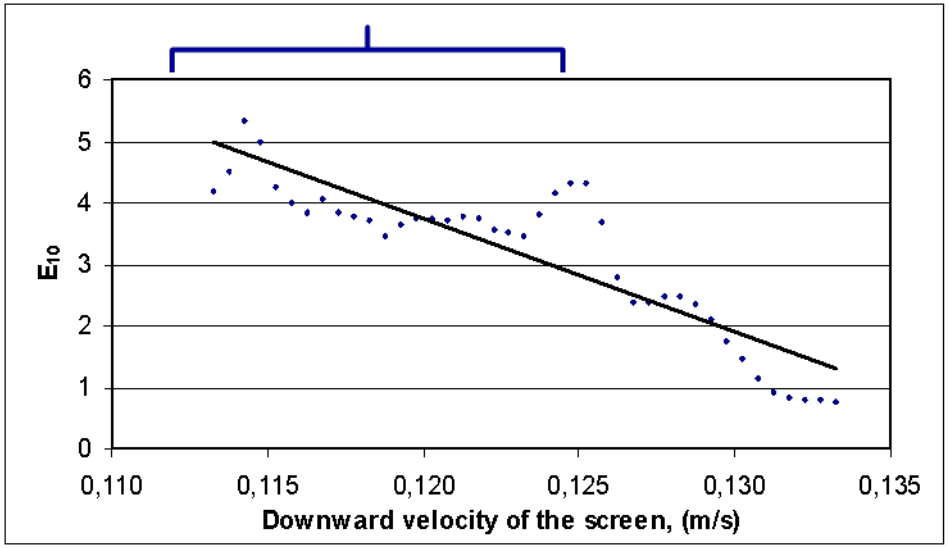
Results

- **Washer operation**

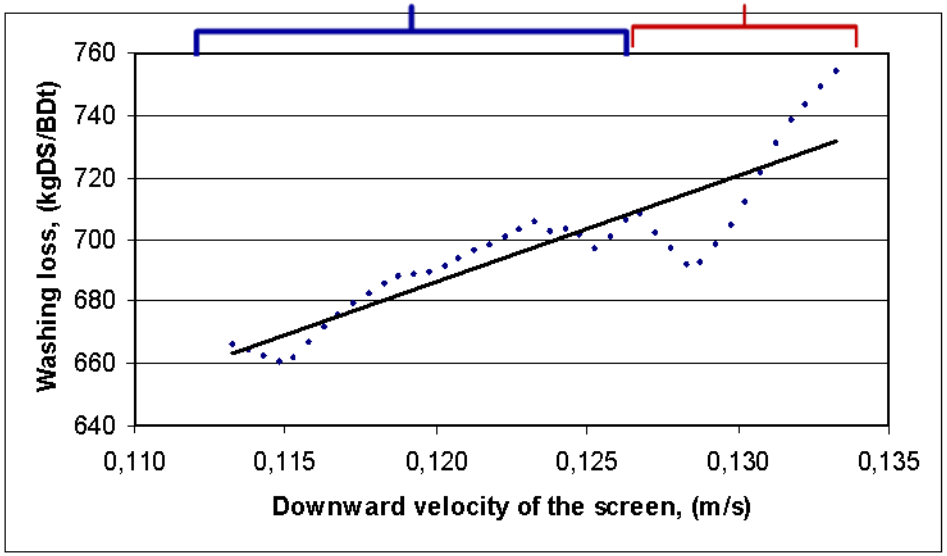
Effect of the Downward Velocity of the Pressure Diffuser Screen

- The downward velocity of the screen notably affects the pressure diffuser's washing result
- In literature: "The optimum velocity ratio should be slightly higher than one being from 1.1 to 1.3."

Optimum range

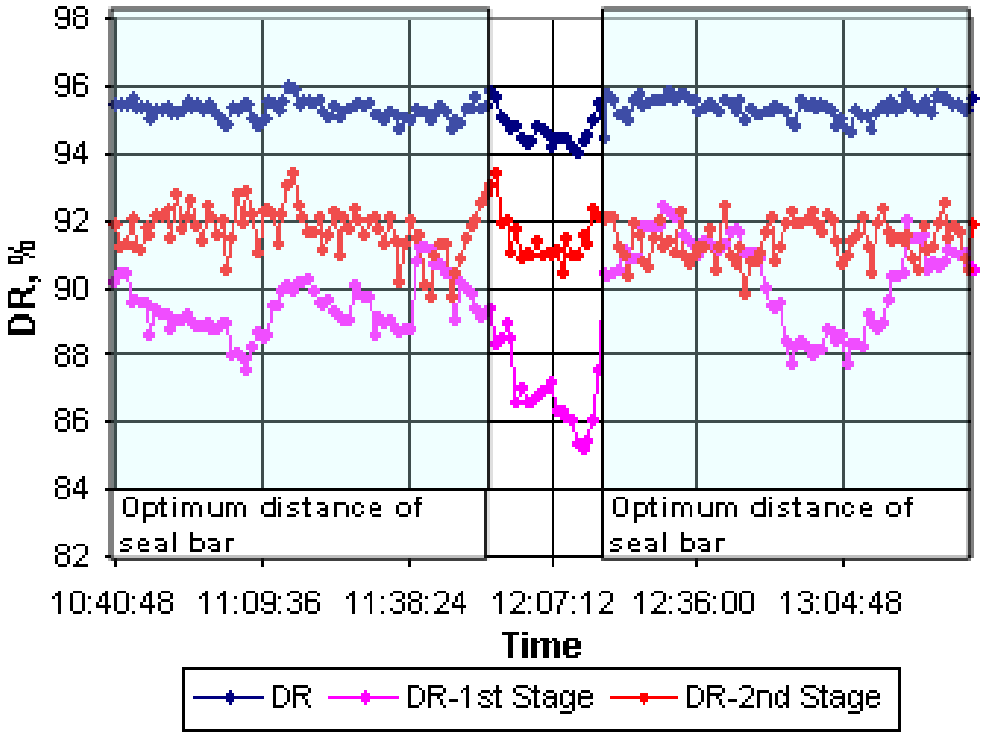


Optimum range Poor wash results



Effect of seal bars distance on washing results

- The distance of the seal bar from the drum has fundamental effect on the DR-value
- An unbalanced seal bar caused wash liquid to escape from the 1st stage to the 2nd stage



Conclusions

- **By controlling the performance of washers (cleanness of the screens, velocity of the screens, seal bars distance, rotation speed of drum etc.) and by changing process conditions (temperature, pH, consistency, wash water amount) it is possible to improve the effectiveness of washing line.**

→ Continuous measurements are needed for monitoring

- **By using refractometer measurements, TDS changes in the incoming washer flows (liquid and pulp suspension) can be detected immediately and reliably**

Conclusions

- **By using refractometers and data-analyses tools, it is possible to discover the black spots of the washing line and to evaluate the washing result continuously**
- **This allows for improved washing efficiency and reduced water consumption, which had clear effect on economy of other sub process like evaporation, bleaching and waste water treatment.**
- **Refractometers provide whole new possibilites for implementing higher level process optimization, e.g. at the whole washing department**

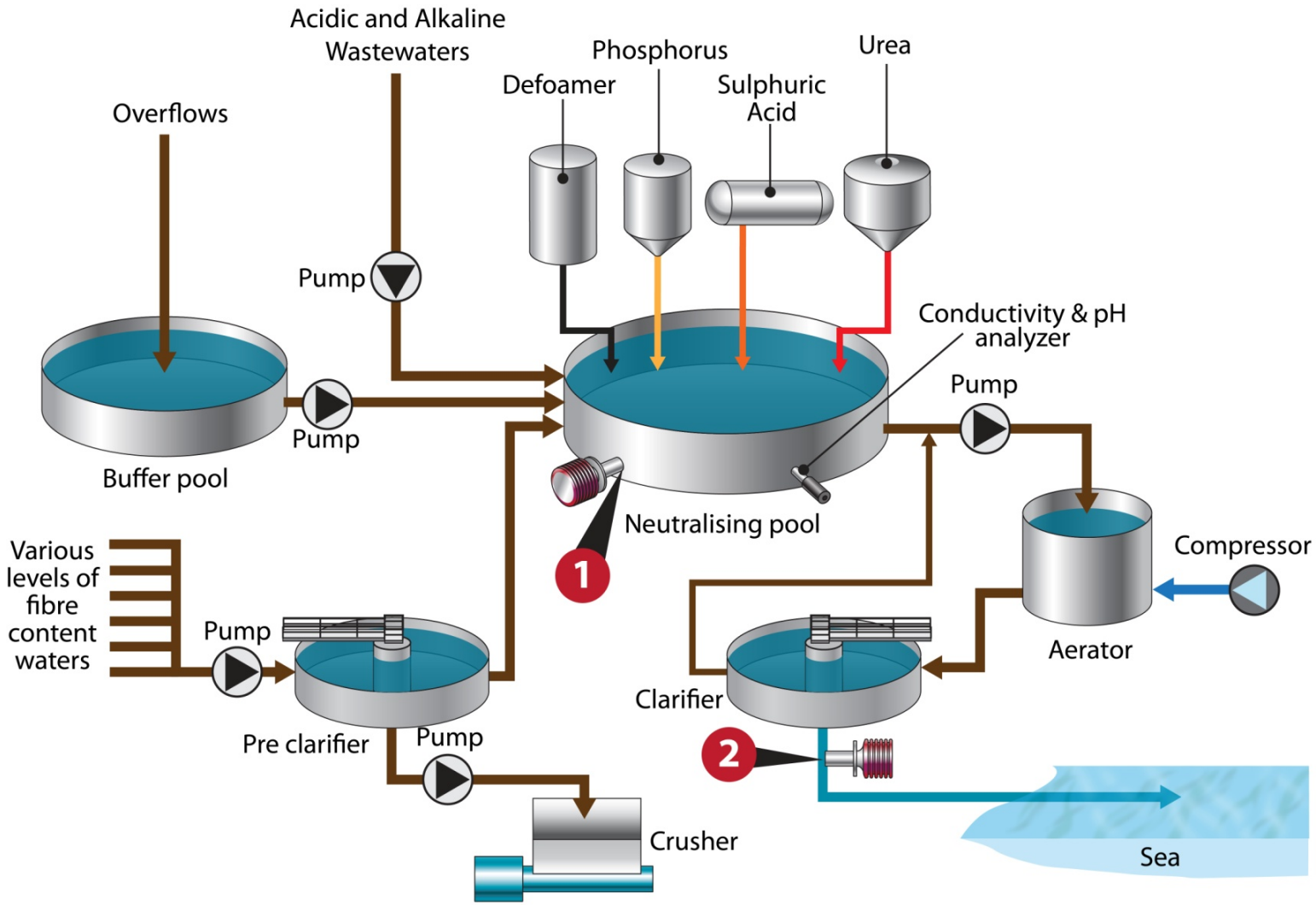
Example of the waste water case

- **Investigation of Real-time Refractometer Measurement Applied in an Activated Sludge Plant**

Target

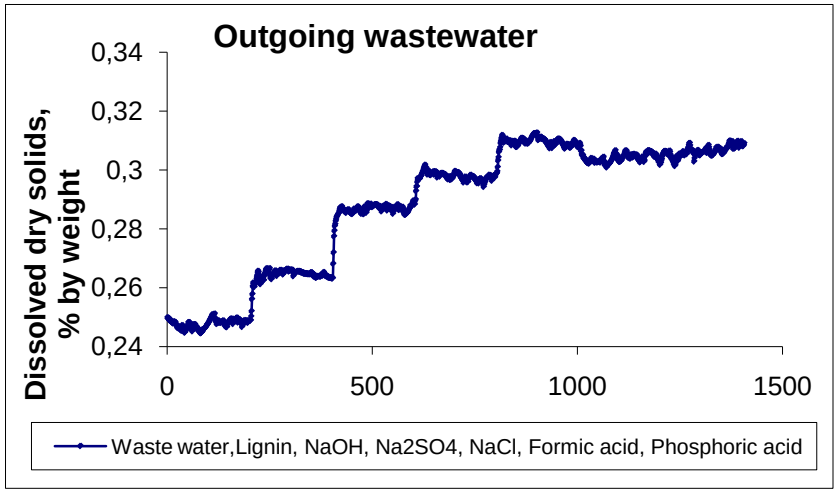
- Identify concentration level changes, as well as compositional changes in wastewater.
- Find a new way to measure wastewater parameters' limit values.

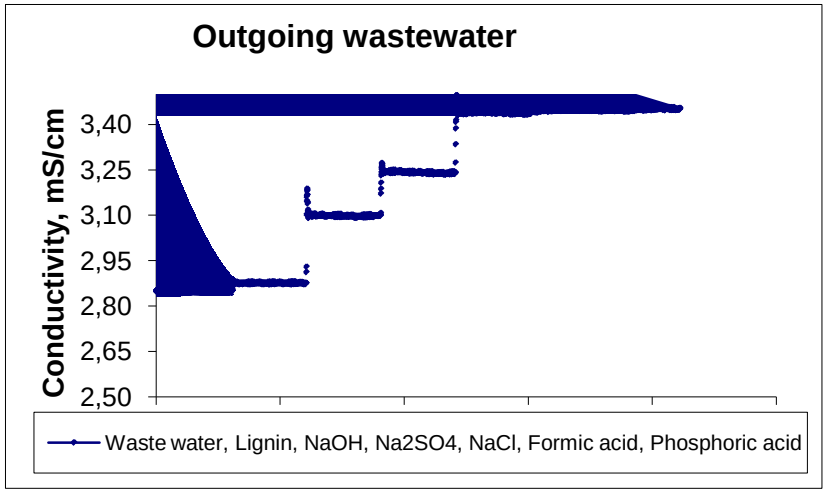
Refractometer Installation Points in an Activated Sludge Plant (Mill Tests)



The Effects of Adding Six Different Chemicals on TDS_{ref} and Conductivity

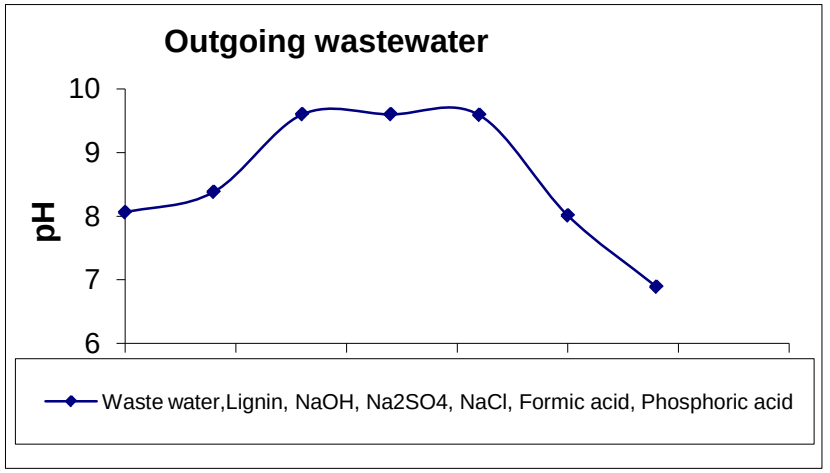
- **Refractometer detects organic and inorganic compounds, while conductivity meter detects only inorganics**





Added chemicals in adding order:

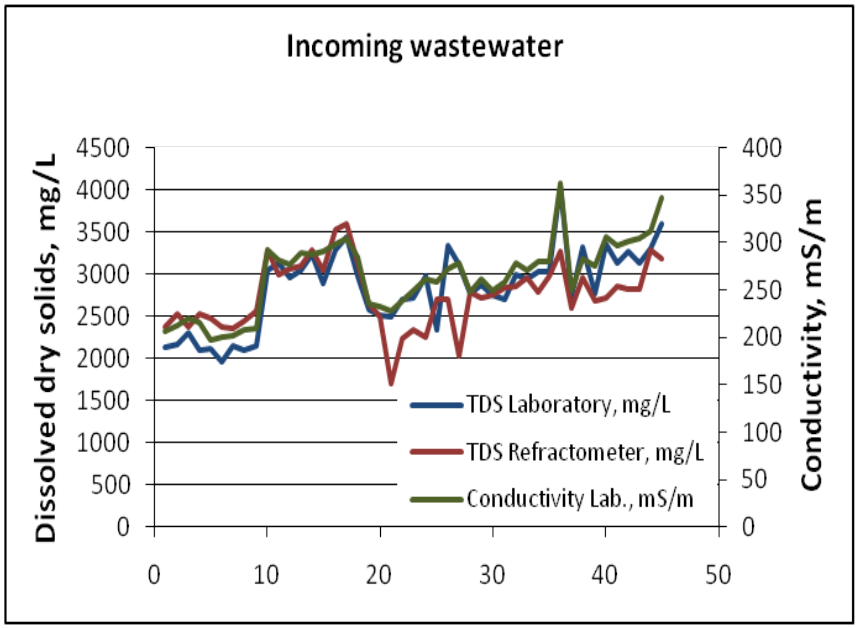
Wastewater, Lignin, NaOH, $NaSO_4$, NaCl, Formic Acid and Phosphoric Acid.

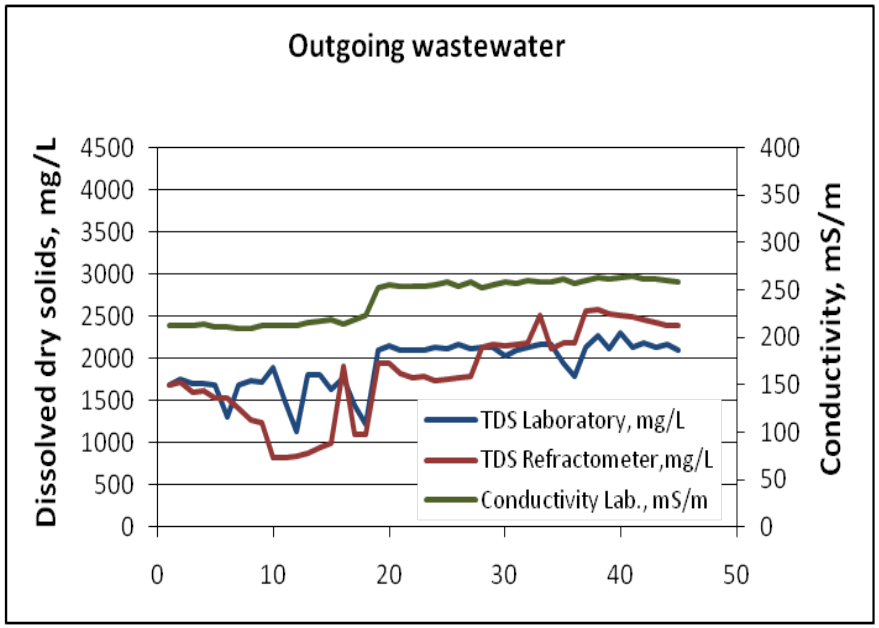


On-line TDS_{ref} and Conductivity Monitoring of Effluents in an Activated Sludge Plant

- **Both measurements indicate changes well in the incoming wastewater but conductivity only shows level changes in the outgoing streams.**

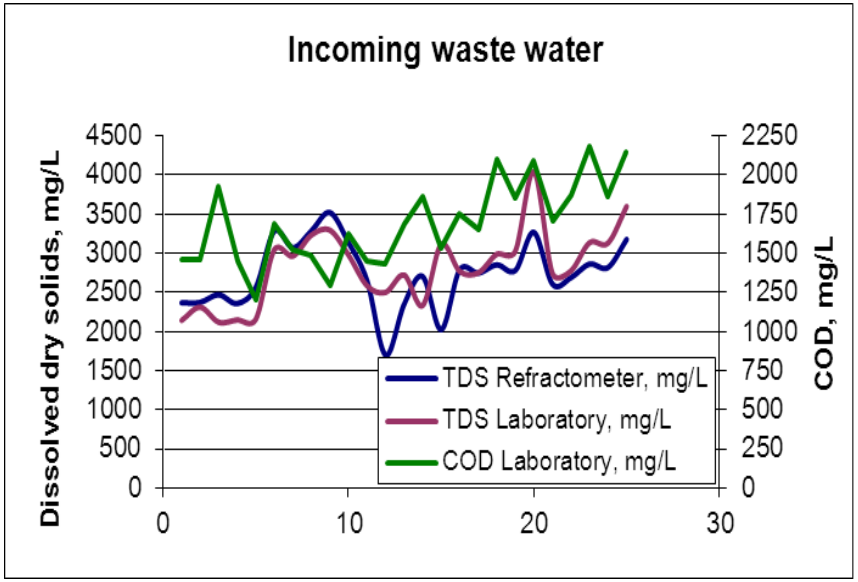
- **Dissolved dry solids decreases and conductivity remains the same → Changes occur mainly in the organic load.**

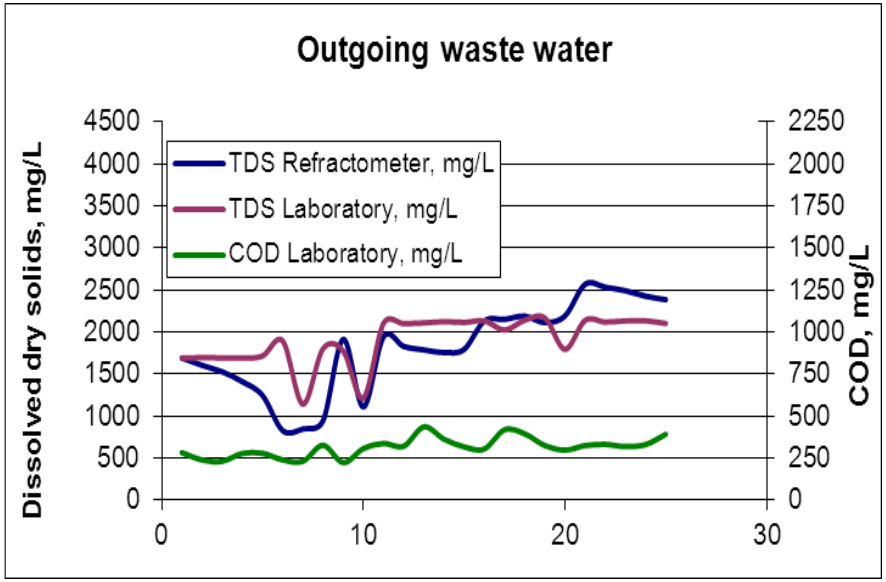




On-line Monitoring of Effluents with TDS_{ref}, Laboratory Analyses of TDS_{lab} and COD

- **COD load from organic substances decreases dramatically in wastewater treatment plant, while dissolved solids decrease along with the organic compounds.**





Conclusions

- **Refractometer measures low, dissolved, dry solids in wastewater treatment accurately.**

- **Different compounds cause different changes, e.g. pH changes cause sedimentation / dissolving. These phenomena should be better understood.**

- **In the wastewater treatment organic substances are removed efficiently, COD decreases. Inorganic substances are not removed so efficiently, conductivity does not decrease remarkably → amount of TDS approximately becomes halved**

- **For on-line control of wastewater treatment efficiency we need simultaneous measurements, refractometer, conductivity and pH.**

Thanks

Thank you for your attention!
Questions?