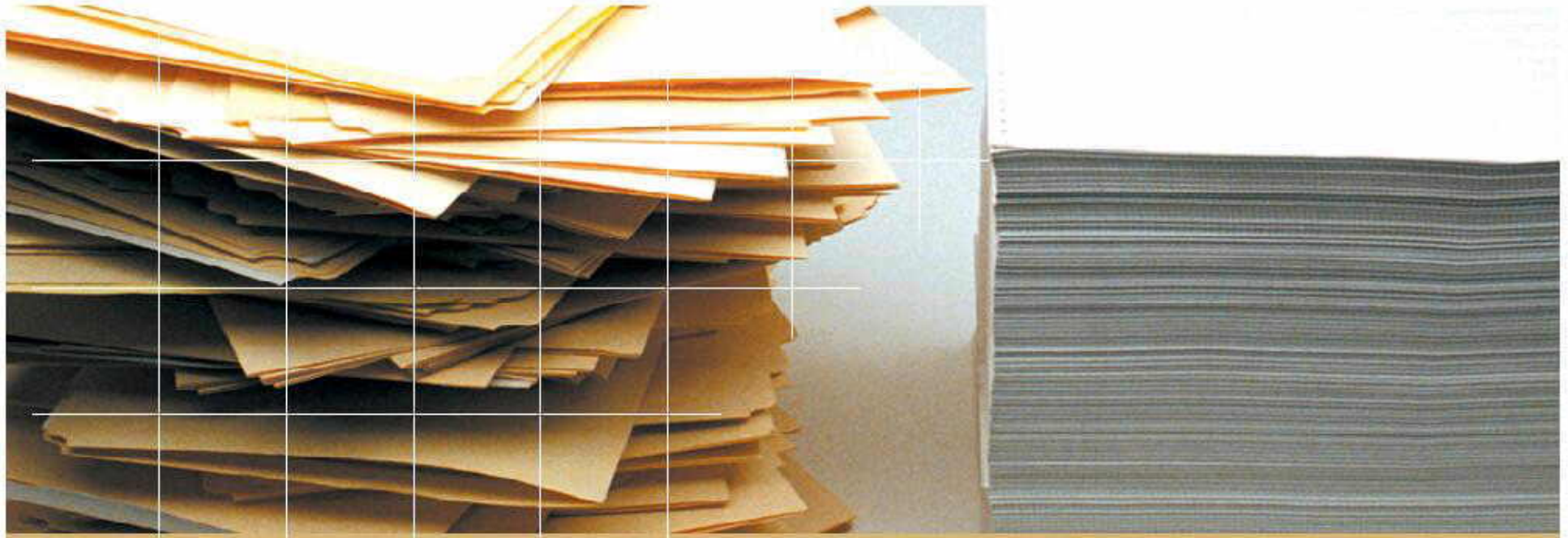

ABTCP CONFERENCE IN SAO PAULO

ADVANCED TECHNOLOGY FOR EFFLUENT TREATMENT AND SLUDGE DEWATERING

17 October, 2005

VEOLIA Water

Agenda

1.	Opening and introduction	at 9:00 – 9:30
2.	Effluent discharge from different P&P processes	at 9:30 – 11.00
	Coffee break	at 11:00 – 11:30
3.	Effluent treatment processes	at 11:30 – 13.00
	▪ Primary treatment	
	▪ Different secondary treatment solutions	
	▪ Tertiary treatment	
	Lunch	at 13:00 – 14.30
4.	Effluent treatment processes continue	at 14:30 – 15.00
5.	Sludge dewatering	at 15:00 – 16.00
	Break	at 16:00 – 16.15
6.	Bleach filtrate recycle in kraft pulp mills	at 16:15 – 16.45
7.	Zero liquid discharge, case presentation	at 16:45 – 17.30

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Introduction of VE, VW, VWS, HPD, AQF

VEOLIA Water

Veolia Environnement

VEOLIA
Water

VEOLIA Environnement : Turnover Partition

VEOLIA Environnement

+ Waste, civil work & water (FCC, Spain)

9 %

45%

20%

15%

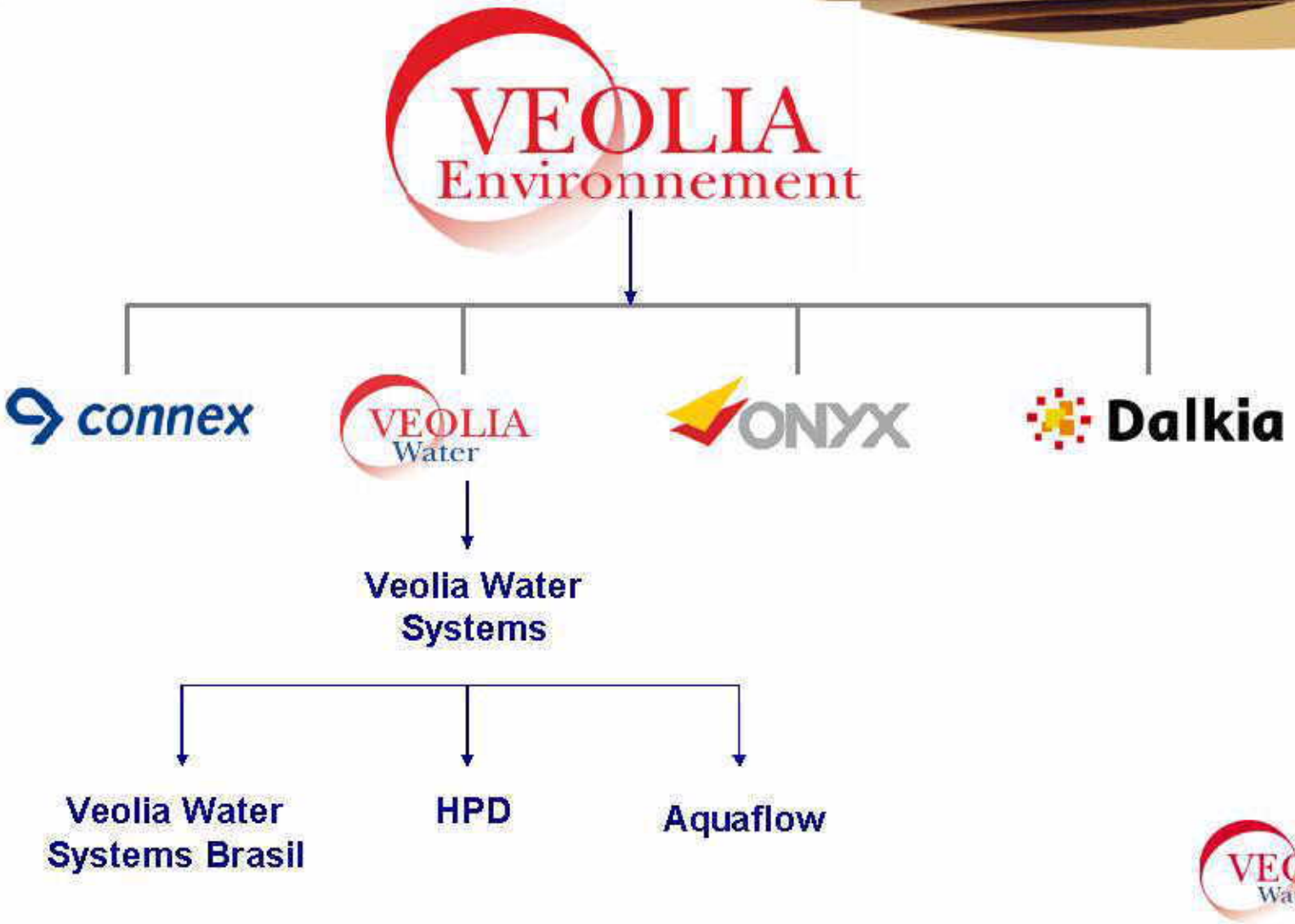
11%

Revenues : 28.6 billion € - 302,000 employees - Market cap.: 13.5 billion €

One Group ⇨ 4 Business Units

VEOLIA Water

Veolia Environnement Organization



Veolia Water : Key Figures (1/2)

11.3 billion euros in revenues for 2003

Presence in over 100 countries

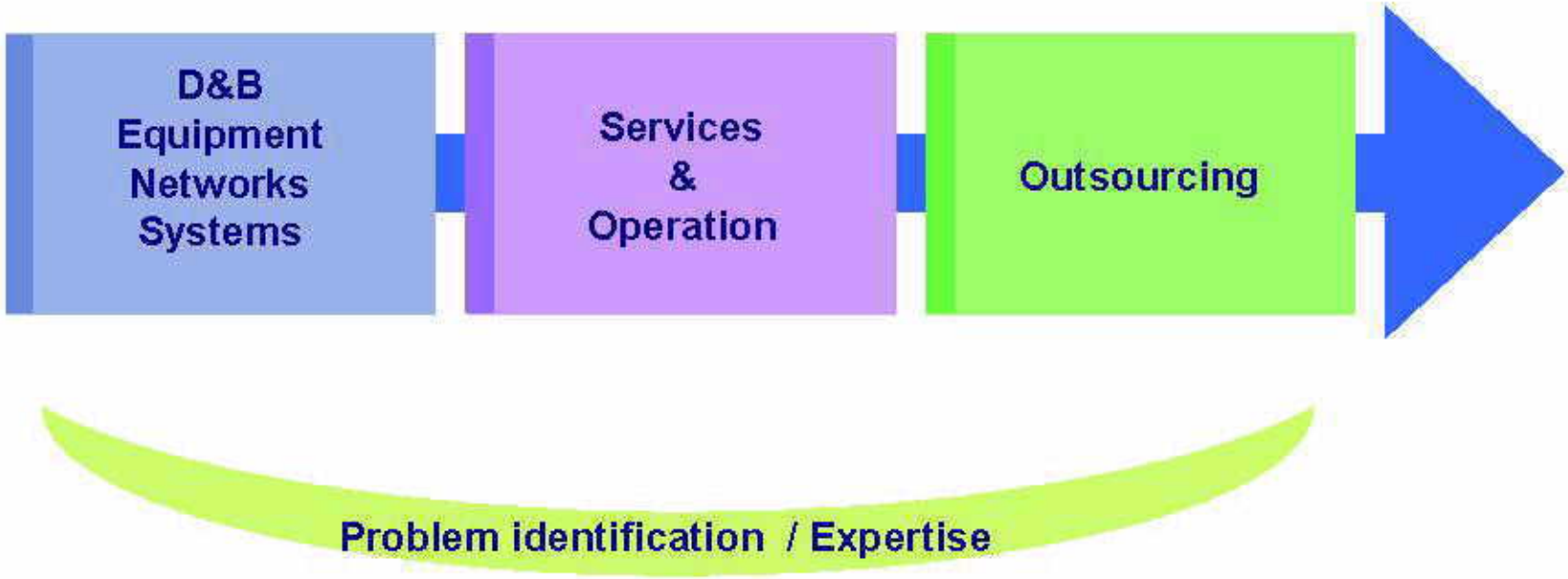
Over 110 million people served

77, 723 employees

Data source :VE results 2003

VEOLIA Water

Veolia Water: Industrial Offer



VEOLIA
Water

VEOLIA Water Systems

VWS: The Partner of Industrials

- **Pulp & Paper**
  - Aracruz, Veracel, Klabin, Cenibra, VCP, Champion (IP), Bahia Sul, Arauco, CMPC, Cartiere Burgo, Kimberly Clark, Stora Enso,
  - UPM-Kymmene, Myllykoski …

- **Others markets**
  - HPI/CPI
  - Metal treatment
  - Power
  - Microelectronics
  - Automobile
  - Pharmaceuticals, Cosmetics
  - Food & Beverage industry

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VEOLIA Water Systems Brasil

VEOLIA Water

Key Figures

- Present in LA since 1993
- Operational Merge of OTV Brasil and USF Brasil
- Two business lines:
  - D&B
  - Solutions
- 2003 revenue – Euros 44 million
- 304 employees (50% in Brazil)
- 40 engineers

VEOLIA Water

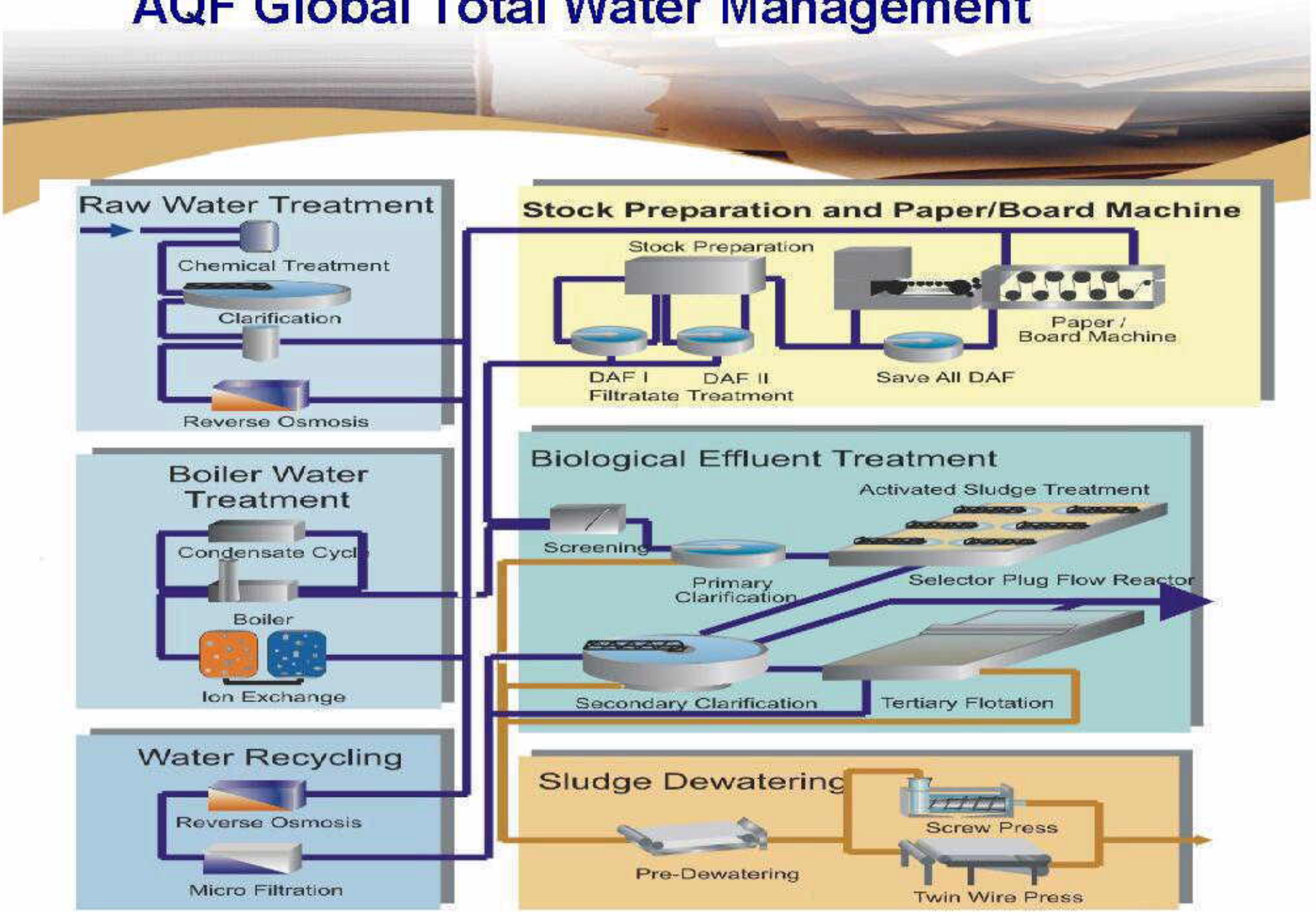
Veolia Water Systems Offer

Design-Build Capabilities

- Design-build solutions for municipalities and industrial customers
- Integrated water and wastewater systems, wastewater reuse, sludge treatment
- Engineering & Construction services for Turn-Key supplies:
    - Problem identification and treatability analysis
    - Process design
    - Basic and detailed engineering
    - Project Management
    - Local equipment manufacturing

VEOLIA Water

AQF Global Total Water Management



Business History

- Aquaflow Ltd. by VEOLIA Water Systems 1999
- USF Aquaflow Ltd. 1997
- Ahlstrom Aquaflow Ltd. 1989
- Ahlstrom Corporation 1987
- Enso-Gutzeit Oy (Stora Enso) 1962

AQUAFLOW

VEOLIA Water

Introduction

Mr Heimo TOIVIAINEN

- VWS BUSINESS DEVELOPMENT DIRECTOR IN THE P&P INDUSTRY
- 1989 – 2004: MANAGING DIRECTOR OF AQUAFLOW
- STARTED IN 1974 IN EFFLUENT TREATMENT IN THE P&P: ENSO-GUTZEIT (STORA ENSO)
  AHLSTROM
  AQUAFLOW

VEOLIA Water

Wastewater from Pulp and Paper Processes

VEOLIA Water

Wastewater from Pulp and Paper Processes

Worldwide Pulp and Paper Production

- **PRODUCTION**
  - 182 million ton pulp per year
  - 330 million ton paper per year

- **WASTEWATER TO TREATMENT**
  - About 30-35 billion m^3 wastewater generated per year
  - About 25-30 million ton COD generated per year

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Wastewater from Pulp and Paper Processes

Factors Impacting on Wastewater Composition and Characterists

1. Fibre raw material
2. Pulping and paper-making process
3. Process status
4. Process operation

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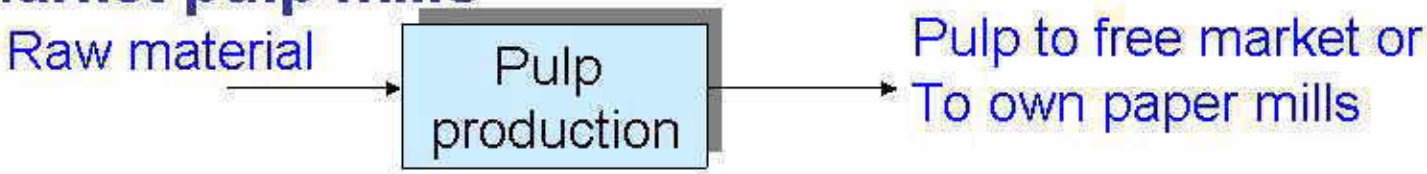
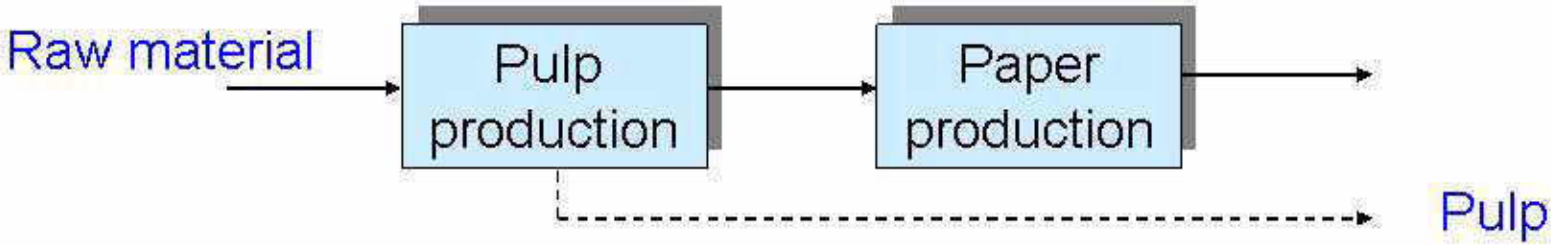
Wastewater from Pulp and Paper Processes

Pulping and Paper Mills

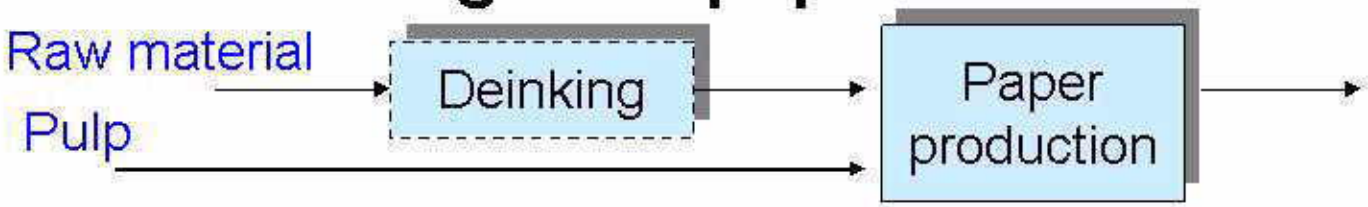
Market pulp mills



Integrated mills



Non-integrated paper mills



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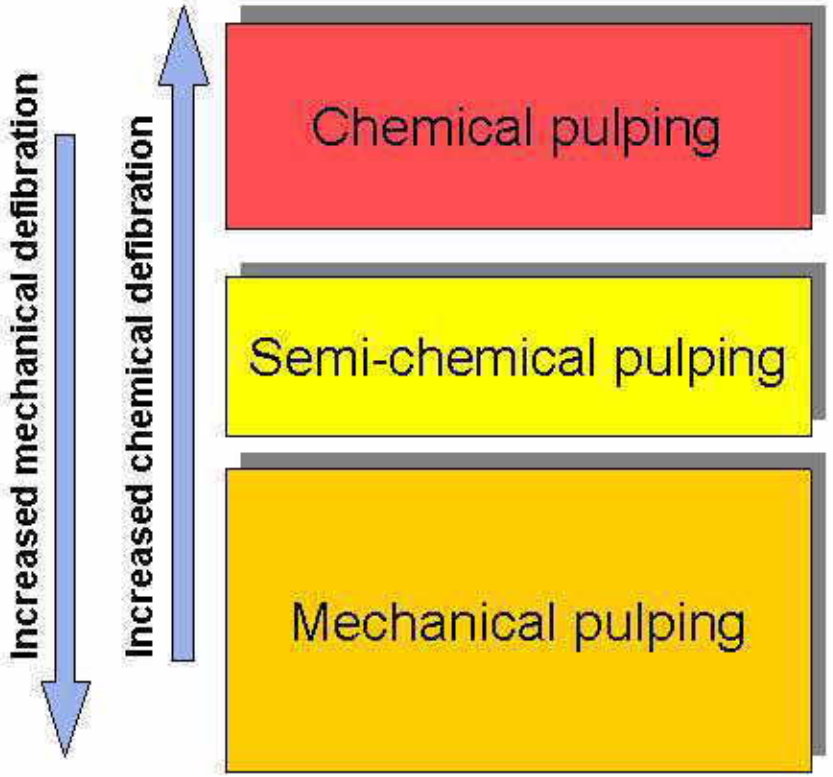
Wastewater from Pulp and Paper Processes

Pulping Processes



- Kraft or Sulphate, unbl./bleached
- Sulphite, unbl./bleached

- NSSC
- Soda
- CTMP, BCTMP
- TMP
- Groundwood

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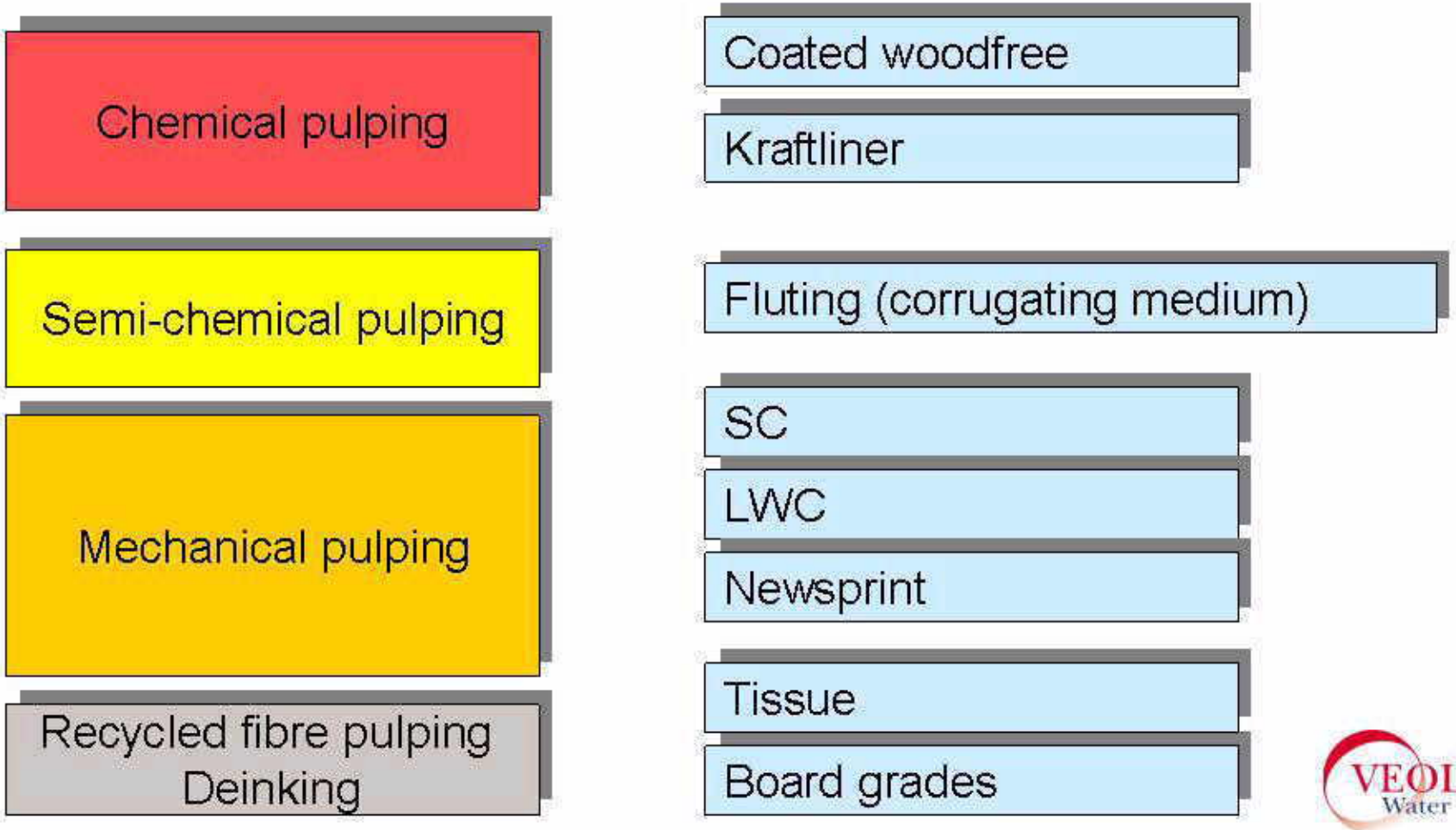
Wastewater from Pulp and Paper Processes

Paper Grades



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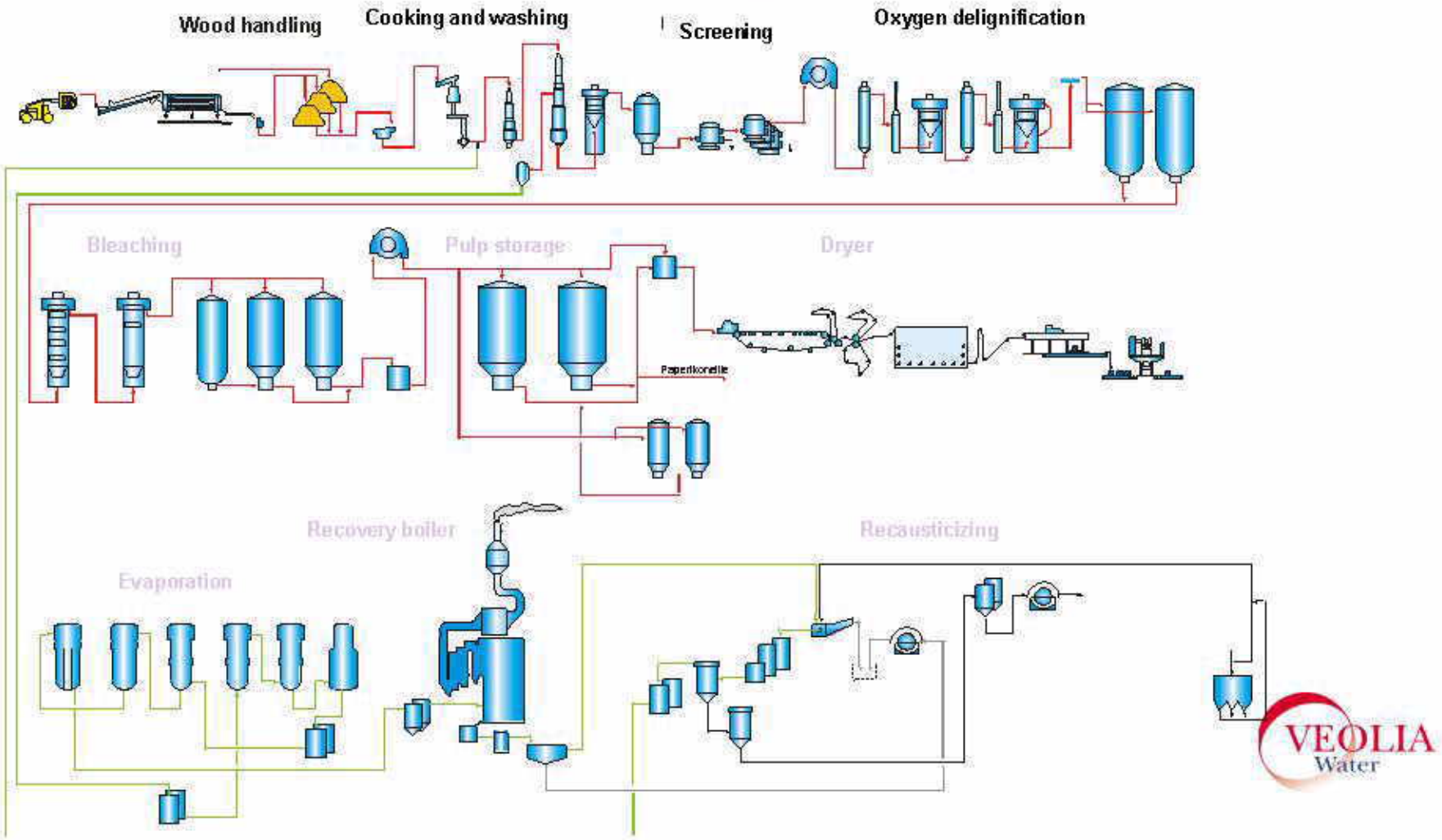
Wastewater from Pulp and Paper Processes

Bleached Kraft Pulping



Wastewater from Pulp and Paper Processes

Bleached Kraft Pulping Discharges

Process	COD kg/t pulp
Debarking	0 - 10
Brownstock area	0 - 7
Bleach plant	25 - 55
Evaporation condensates	3 - 15
Spills	3 - 8
Total	31 - 95

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Wastewater from Pulp and Paper Processes

Main Composition

	Organic	Inorganic
Suspended	Fibres Bark	$CaCO_3$ Soil
Dissolved	**Lignin derivatives (colour)** **Carbohydrates (sugars)** **Organic acids** **Chlorinated organics** **Nutrients (N, P)**	Na, K, Ca, P Sulphates Chlorate Chlorides

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Wastewater from Pulp and Paper Processes

Debarking

- **Wet vs. dry debarking process**
  - Wet debarking has higher discharge figures
- **Softwood higher – Hardwood lower loads**
- **Wastewater contains:**
  - TSS (bark residual, fibres, inorganic matter)
  - COD/BOD (dissolved and suspended material from logs)
  - Nutrients (P and N)
  - Toxic compounds (resin acids, fatty acids)

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Wastewater from Pulp and Paper Processes

Kraft Pulp Bleaching

GENERAL

- Objective to bleach pulp from brown to white with oxidation chemicals (Chlorine Dioxide, Peroxide, Ozone)
- Many processes, most typical is Elemental Chlorine Free (ECF) bleaching using Chlorine Dioxide.
- Total Chlorine Free (TCF) processes employ Peroxide, Ozone as oxidation chemicals.
- Bleach plant excess filtrate normally sewered since contains Chlorides, Heavy Metals and other inorganics that may accumulate in recovery cycle.

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Wastewater from Pulp and Paper Processes

Kraft Pulp Bleaching

BLEACHING WASTEWATER COMPOSITION AND LOADS ARE DEPENDENT ON:

- Washing loss (Amount of COD entering the Bleach plant)
- Kappa-factor (Amount of lignin in pulp)
  - Cooking process (Modified cooking)
  - Oxygen Delignification (OD)
- Bleaching process/Chemicals used
  - ”C-stage”
    - Elemental chlorine stage
    - Chlorine Dioxide
  - TCF bleaching

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Wastewater from Pulp and Paper Processes

Summary: Bleached Kraft Pulping

- Most common pulping process
- Main organic load originating from bleach plant
- About 50% of the COD is caused by lignin products that are non or slowly-biodegradable
- Chlorinated organic compounds in bleach plant effluents (AOX)
- Toxic compounds (resin and fatty acids) in debarking and bleach plant effluents

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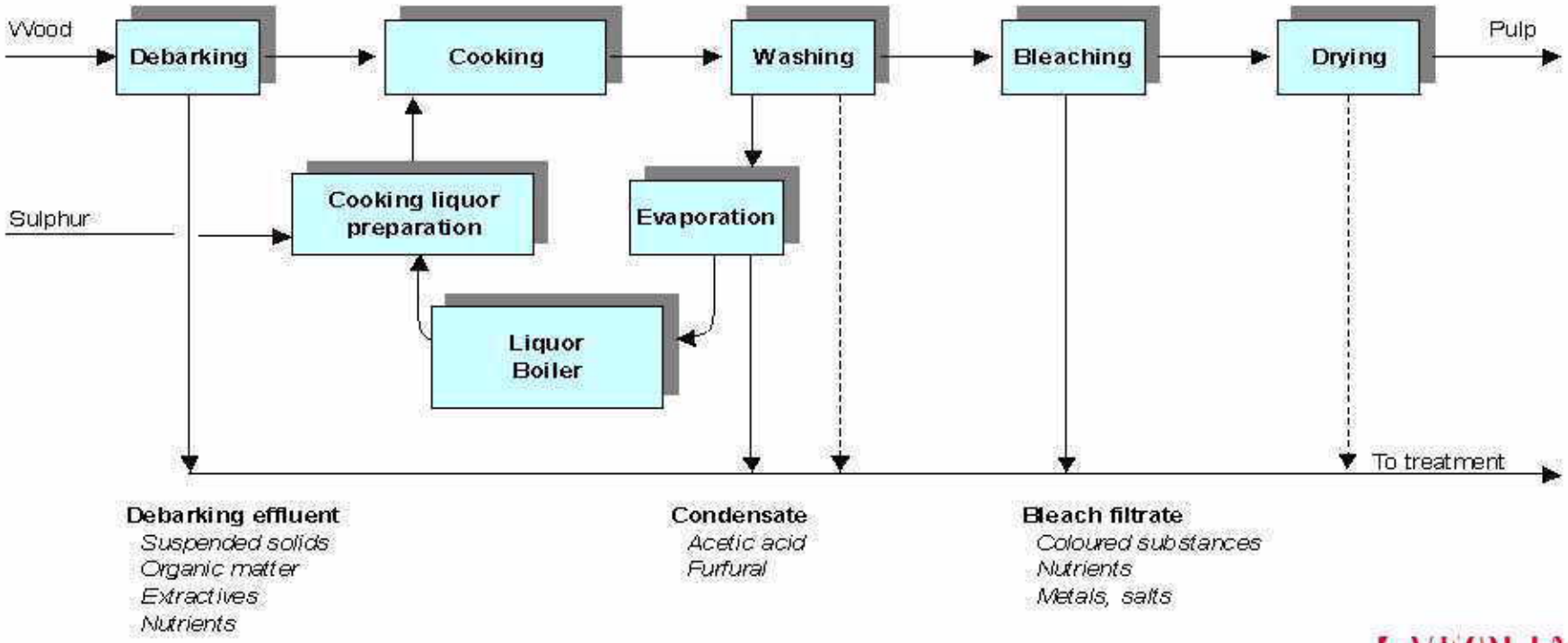
Wastewater from Pulp and Paper Processes

Sulphite Pulping



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Wastewater from Pulp and Paper Processes

Sulphite Pulping Discharges

- Dissolving pulp mills may have high discharges (Hemicelulose)
- Cooking process generally driven further than in kraft pulping why bleach plant discharges are normally lower
- TCF bleaching common → no chlorinated compounds
- Condenstes contain high amount of acetic acid and furfural

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Wastewater from Pulp and Paper Processes

Summary: Sulphite Pulping

- Common in Central-Europe and China but being outphased in other areas
- Main organic load originating from condensates and bleach plant
- Condensates high in COD concentration
- Acetic acid and furfural in condensates
- Toxic compounds (resin and fatty acids) in debarking and effluents

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Wastewater from Pulp and Paper Processes

Mechanical Pulping Processes

- Processes include
  - Chemi-thermomechanical pulping (CTMP)
  - Thermo-mechanical pulping (TMP)
  - Stone Groundwood (SGW or GW)
  - Pressurised Groundwood (PGW)
- Mechanical defibration in refiners or with stone
- Chemical pretreatment in CTMP process (Na_2SO_3 and/or NaOH and Na_2CO_3)
- Typical for mechanical processes is high yield on wood

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Wastewater from Pulp and Paper Processes

Mechanical Pulping Processes

- Mechanical pulping is normally INTEGRATED with paper production
  - Newsprint paper (TMP+ paper machine)
  - Journal paper (GW, TMP + paper machine)
- Some CTMP mills are stand-alone others integrated

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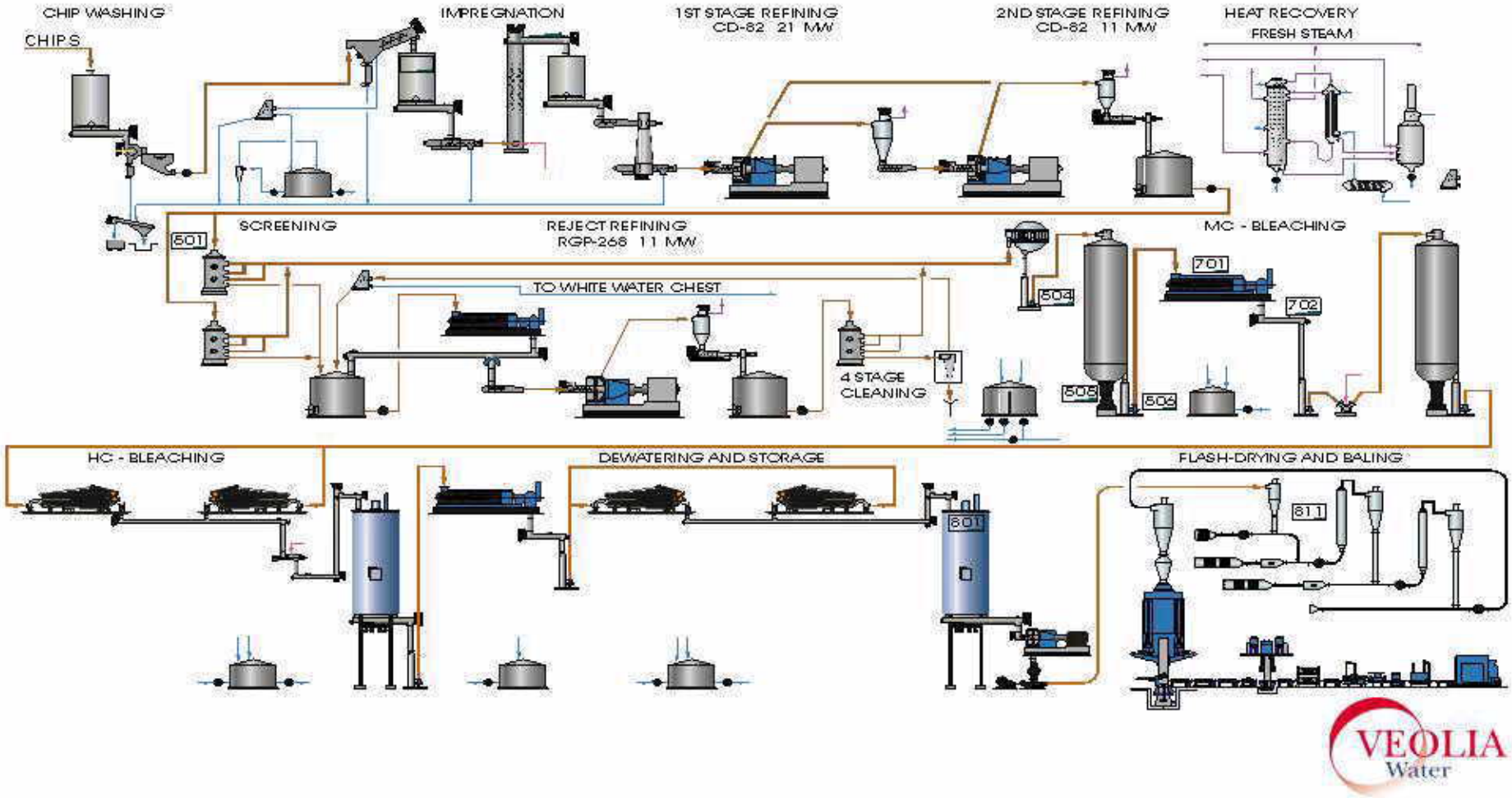
Wastewater from Pulp and Paper Processes

BCTMP Process



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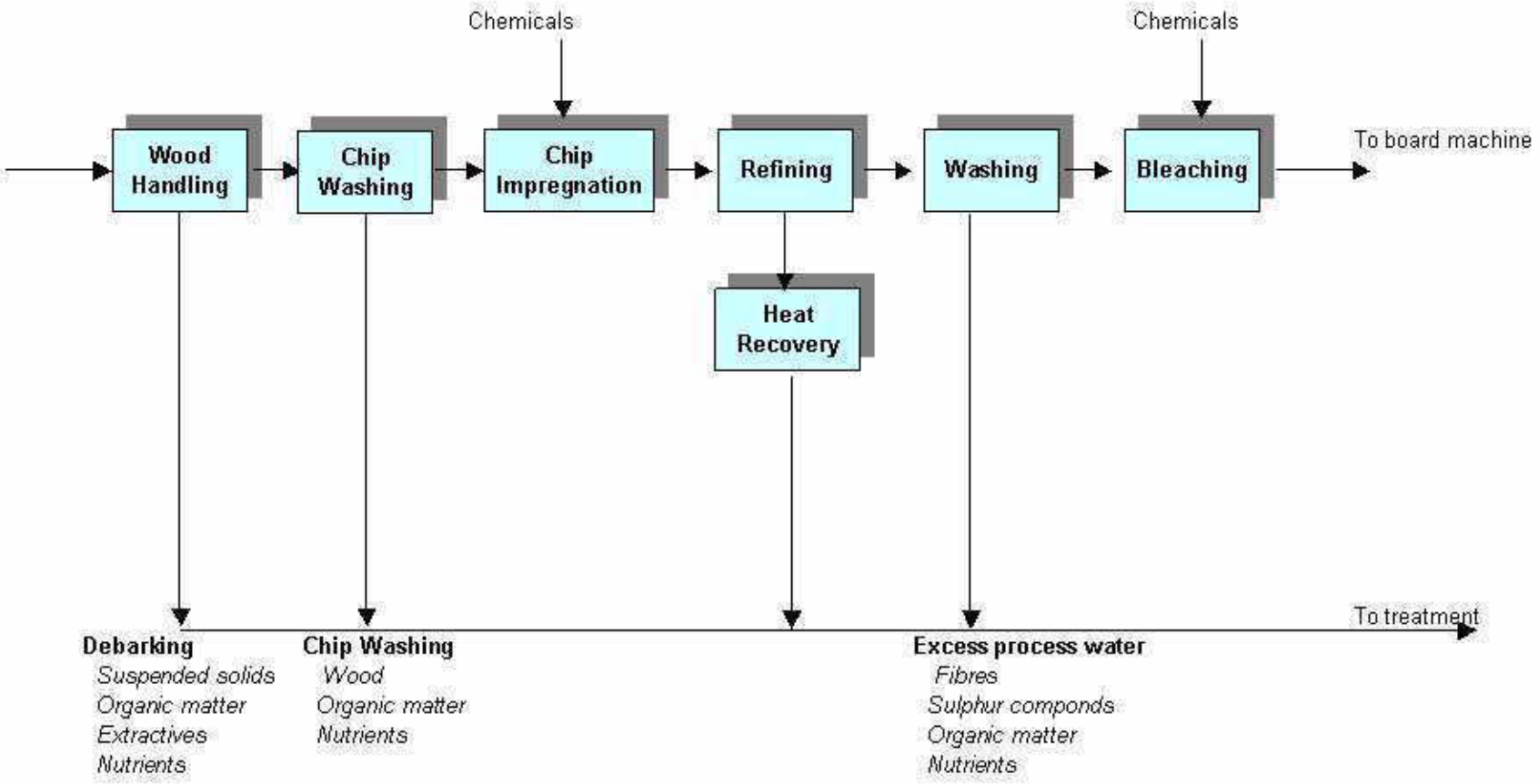
Wastewater from Pulp and Paper Processes

BCTMP Process



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Wastewater from Pulp and Paper Processes

Mechanical Pulping Discharges

Discharges from mechanical pulping processes are primarily dependent on:

- **Pulp yield**
- **Pulp bleaching method**

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Wastewater from Pulp and Paper Processes

Recycled Fibre

- Two main cartegories
  - Mechanical cleaning (pulping) of wastepaper/board only
    - Testliner
    - Corrugated medium
    - Uncoated board
  - Mechanical cleaning and *de-inking*
    - Tissue
    - Printing and copy paper
    - Magazine
    - Coated board and cartonboard
    - Market DIP
- Wastewater quality much dependent on wastepaper quality
- May have almost closed water loops

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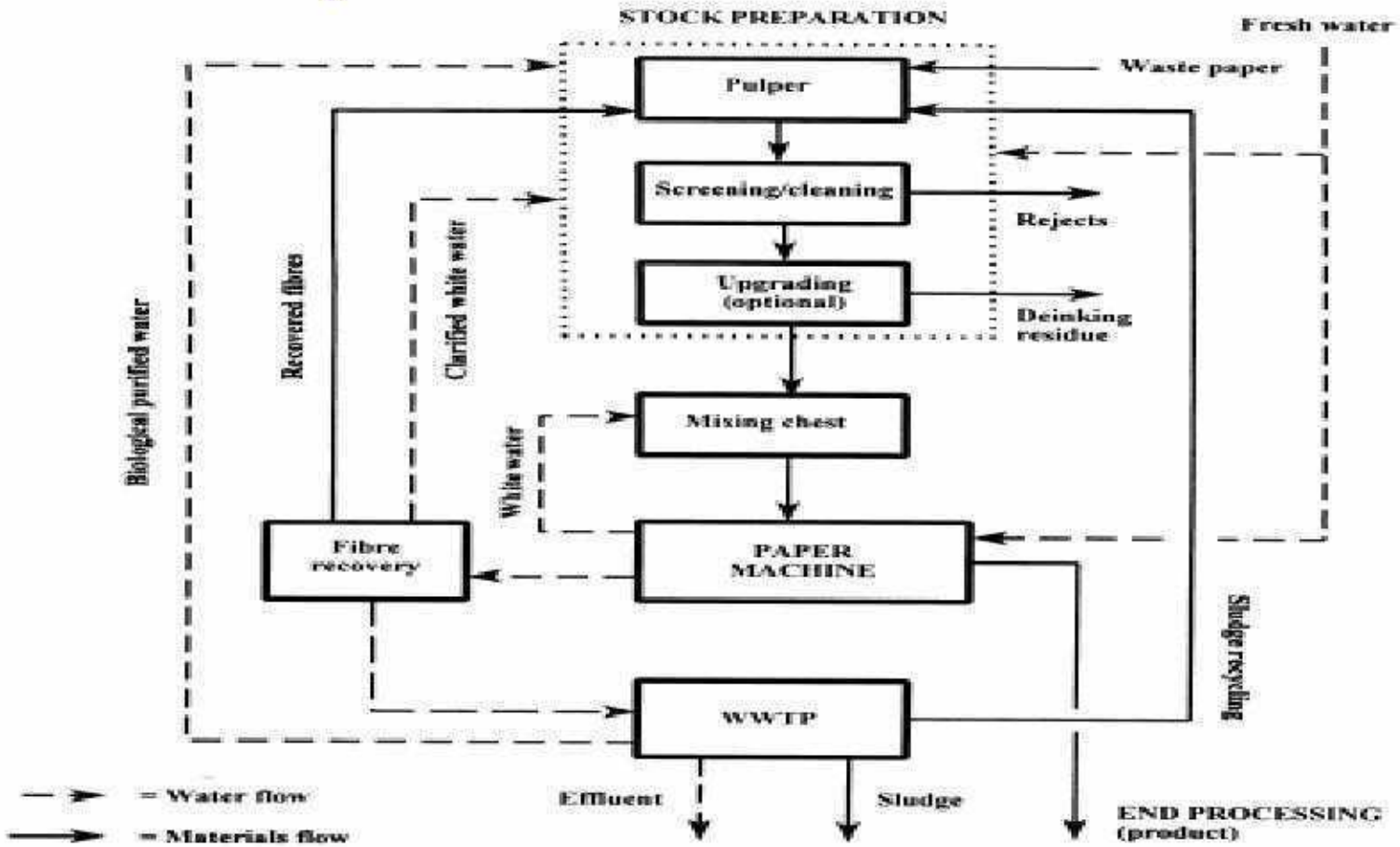
Wastewater from Pulp and Paper Processes

Recycled Fibre Processes



Wastewater from Pulp and Paper Processes

Papermaking

- In paper making processes water are recirculated at a high degree – only excess water ”whitewater” and rejects are normally discharged

- Wastewater contaminants originate from:

  - Pulp
  - Refining of pulp
  - Sizing agents (starch)
  - Fillers and Coating material (caoline, $CaCO_3$,etc)

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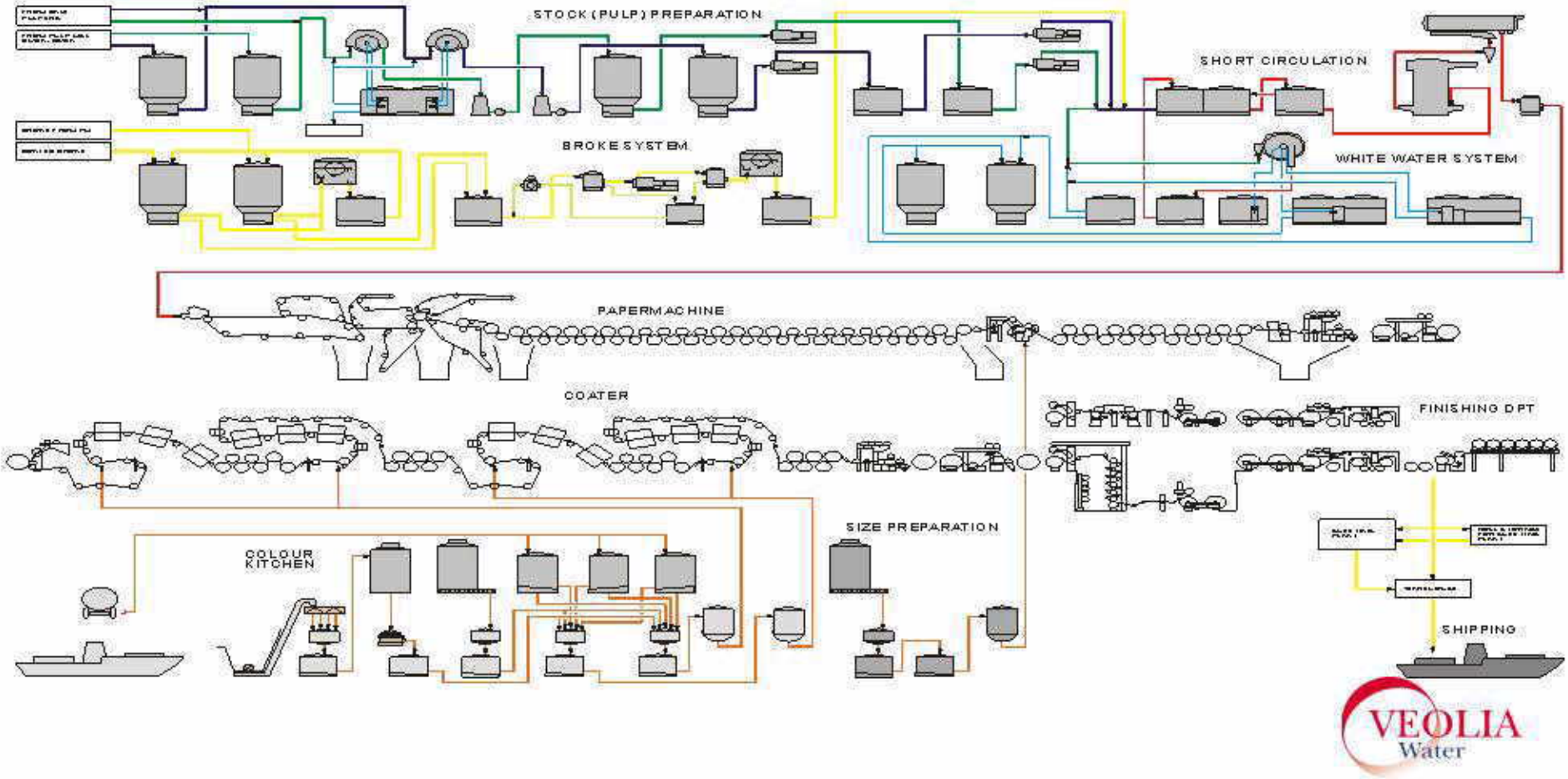
Wastewater from Pulp and Paper Processes

Papermaking



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Wastewater from Pulp and Paper Processes

Special Features and Critical Topics

General

- All mill departments must be reviewed
- Which processes are applied? (debarking, pulping, bleaching,etc)
- Mill status (old mills have generally considerable higher discharges than new)
- Level of spill control
- Level of water conservation
- Review actual variations of loads

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Wastewater from Pulp and Paper Processes

Special Features and Critical Topics

Process specific issues

Bleached kraft pulping

- Most common chemical pulping process
- Main portion of organic load from bleaching
- Bleach plant COD hard to degrade biologically
- Organic load mainly dependent on wood specie, kappa to BP and bleaching process

Unbleached kraft pulping

- Level of spills and washing loss of inmportance
- Water use sometimes very high

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Wastewater from Pulp and Paper Processes

Special Features and Critical Topics

Sulphite pulping

- Main organic load originating from condensates and bleach plant
- Condensates high in COD concentration
- Acetic acid and furfural in condensates
- Toxic compounds (resin and fatty acids) in debarking and effluents

Mechanical pulping integrated with papermaking

- Wastewater loads originates primarily from mechical pulping
- High amount of collodial matter
- Inorganic matter (clay) if fillers or coating applied in papermaking

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Wastewater from Pulp and Paper Processes

Special Features and Critical Topics

Process specific issues

Recycled fibre

- Discharges vary within wide range depending on technical status
- Some mills are almost "effluent-free"

Non-integrated papermaking

- Low amounts of organic matter
- Wastewaters may be colored if colored paper are produced

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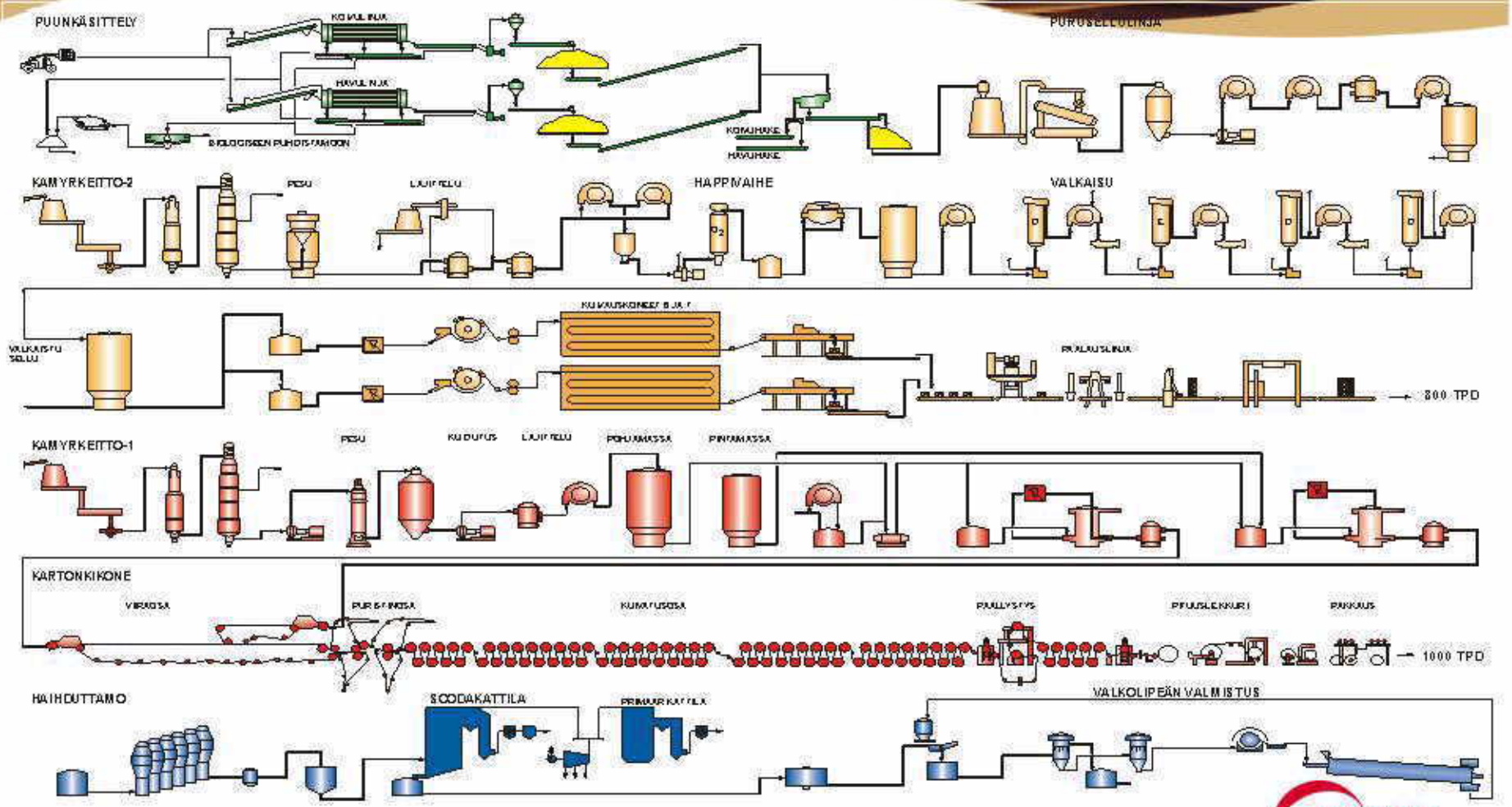
Wastewater from Pulp and Paper Processes



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Aquaflow Competence Center in the P&P Industry

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Effluent Treatment Processes

Content of Presentation:

PRIMARY TREATMENT

- P&P charasteristics
- Equipment
- Process selection

SECONDARY TREATMENT

- P&P charasteristics
- MBP process
- Process selection

TERTIARY TREATMENT

- Need of tertiary treatment
- Chemicals and processes

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Effluent Treatment Processes

What is Typical for Primary Treatment in P&P Industry?

- High and variable amount of suspended solids in the inlet effluent
  - good functioning of primary treatment is emphasized in special situations (start-ups, stops and problems in the mill)
  - occasionally high amount of heavy inorganic material in the effluent (fillers, coating, DIP-sludge, lime mud)
  - poor sedimentation in certain effluents (GW, TMP, CTMP, coating agents)

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Effluent Treatment Processes

What is Typical for Primary Treatment in P&P Industry?

- Neutralization is normally required
  - all the time
  - or only for washing waters in mill stops
- Cooling is normally required
  - effluent temperature is normally 40-80°C
  - wood chips, extractives and biological fouling

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Primary Treatment

Aquaflow Equipment

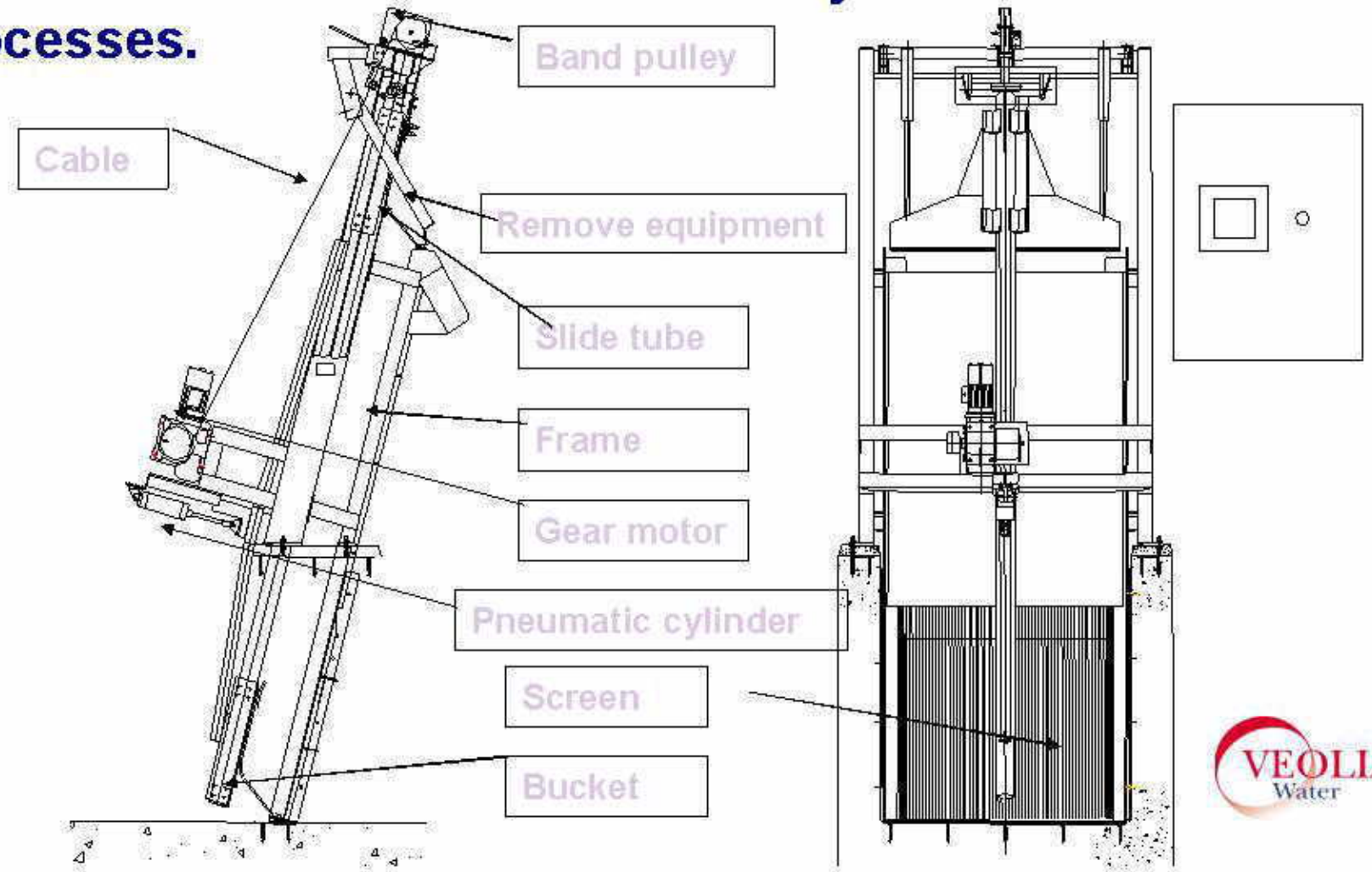
- Bucket screen
- Primary clarifiers
- Primary flotations

VEOLIA Water

Primary Treatment

Bar Screen

Removes oversize solids which may interfere later processes.



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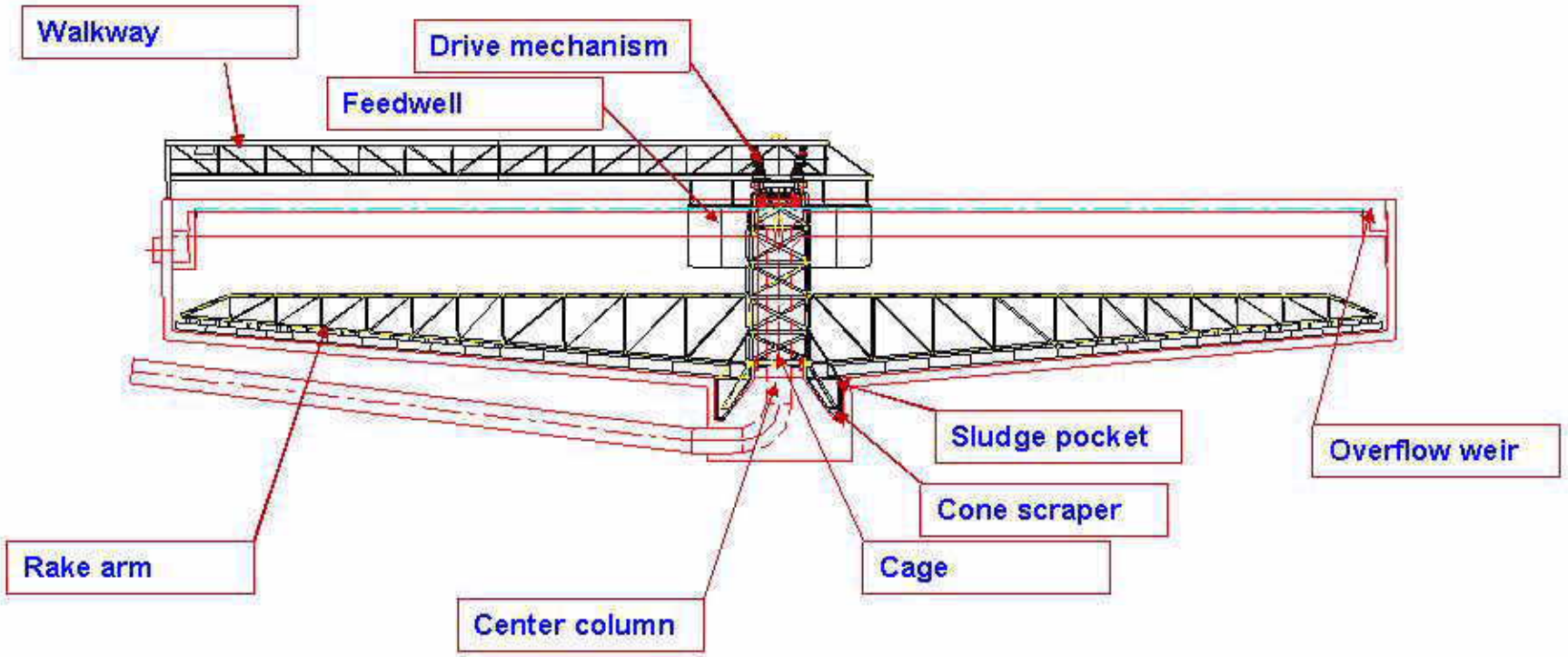
Primary Treatment

Primary Clarifier



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Primary Treatment

AF-Float Flotation Unit (DAF)

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Primary Treatment

- Circular
  - Ø 3,8 m up to 24 m
  - Depth 1,3 m -> 1,8 m

VEOLIA Water

Primary Treatment

- Rectangular
  - 4,2 m x 4,3 m (18,3 m^2) up to 7,2 m x 14,7 m (105 m^2)
  - Depth 1,3 m -> 1,8 m

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Primary Treatment

Equipment are Designed Just for P&P Industry Needs:

- Robust equipment for 24 h/d, 365 d/a
- Maintenance designed for 1-line systems
- Capabilities to handle:
  - High SS capacity
  - Heavy sludge
  - Hot effluents
  - Corrosive effluents

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Primary Treatment

Primary Sedimentation – Selection Criteria

+ Low operating costs
+ Good buffer capacity for solids
+ Simple process
+ Suitable for very high solid contents

- Big footprint
- Long retention time, anaerobic acidification, smells, floating
- Long suction line for sludge, plugging of primary sludge pumps

VEOLIA Water

Primary Treatment

Primary Flotation – Selection Criteria

+ Small footprint
+ Not sensitive for gases, no anaerobic acidification, less smells
+ Good function with chemicals, good results with small, light or charged particles
+ Lower civil costs

- Higher operating costs
- No buffer capacity for solids

VEOLIA Water

Primary Treatment

Expected Purification Results in Primary Sedimentation (without Chemicals)

Effluent type	SS content after sedimentation (mg/l)
Kraft pulp	70...120
Paper&board uncoated	40...150
Paper&board coated	100...300
TMP, GW	150...400
CTMP	300...1000
DIP	50...200
Semichemical, NSSC	300...1000

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Secondary Treatment

What is Typical for Secondary Treatment in P&P Industry?

- Relatively high COD concentration 500-13000 mg/l
- High temperature 35...38°C
- Normally lack of nutrients → N, P must be added
- Some effluents are very sensitive for filament problems
  - VFA, sugars, resin and fatty acids (TMP,CTMP, RCF, OCC, NSSC)
  - variation of produced paper (or pulp) grades
- Variation of harmful chemicals for biology
  - biosides
  - washing agents and dispersing agents
  - colours
  - (hydraulic) oil
  - black liqueur and soap spills (chemical pulp mills)

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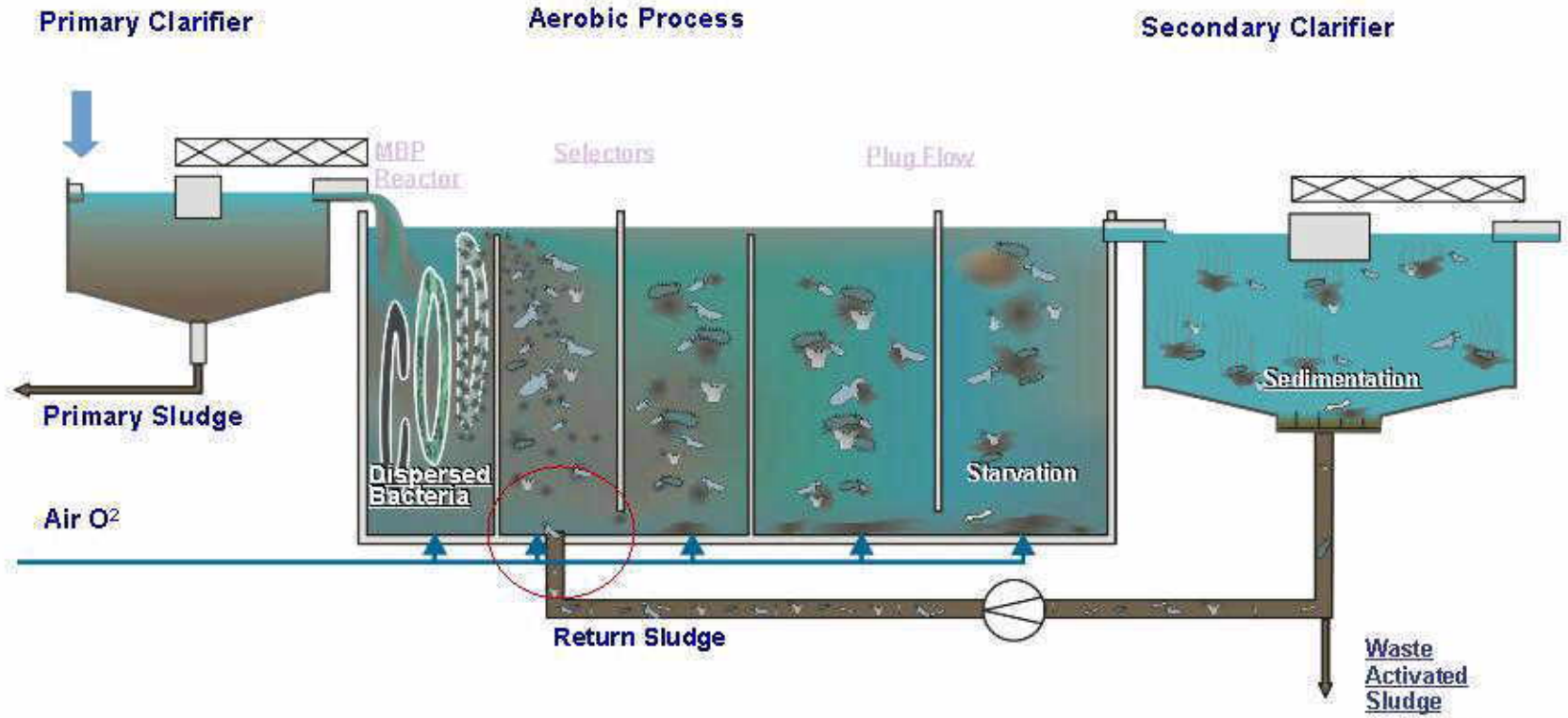
Secondary Treatment

Minimum Biosludge Production = MBP



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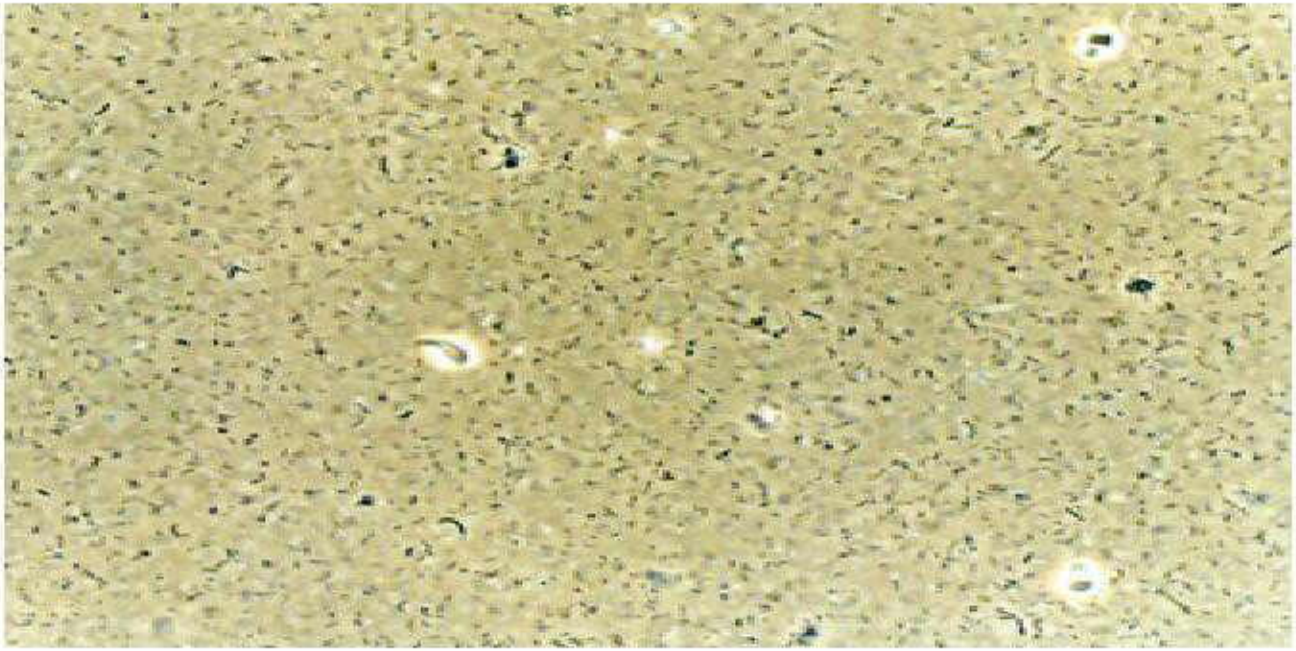
Secondary Treatment

Minimum Biosludge Production = MBP

Dispersed Bacteria in MBP Reactor



1st stage in the food chain

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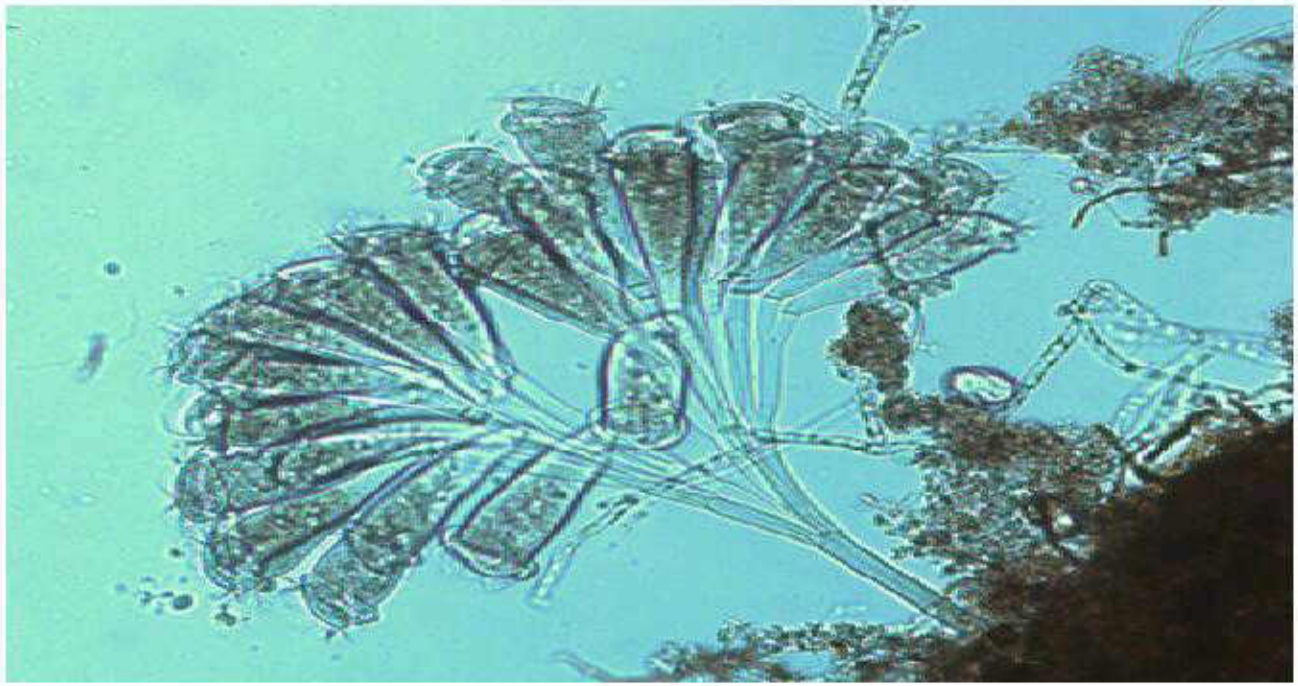
Secondary Treatment

Minimum Biosludge Production = MBP

Colony of Stalked Ciliates Eating



2nd stage in the food chain

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Secondary Treatment

Minimum Biosludge Production = MBP

Ciliates and Suctoria

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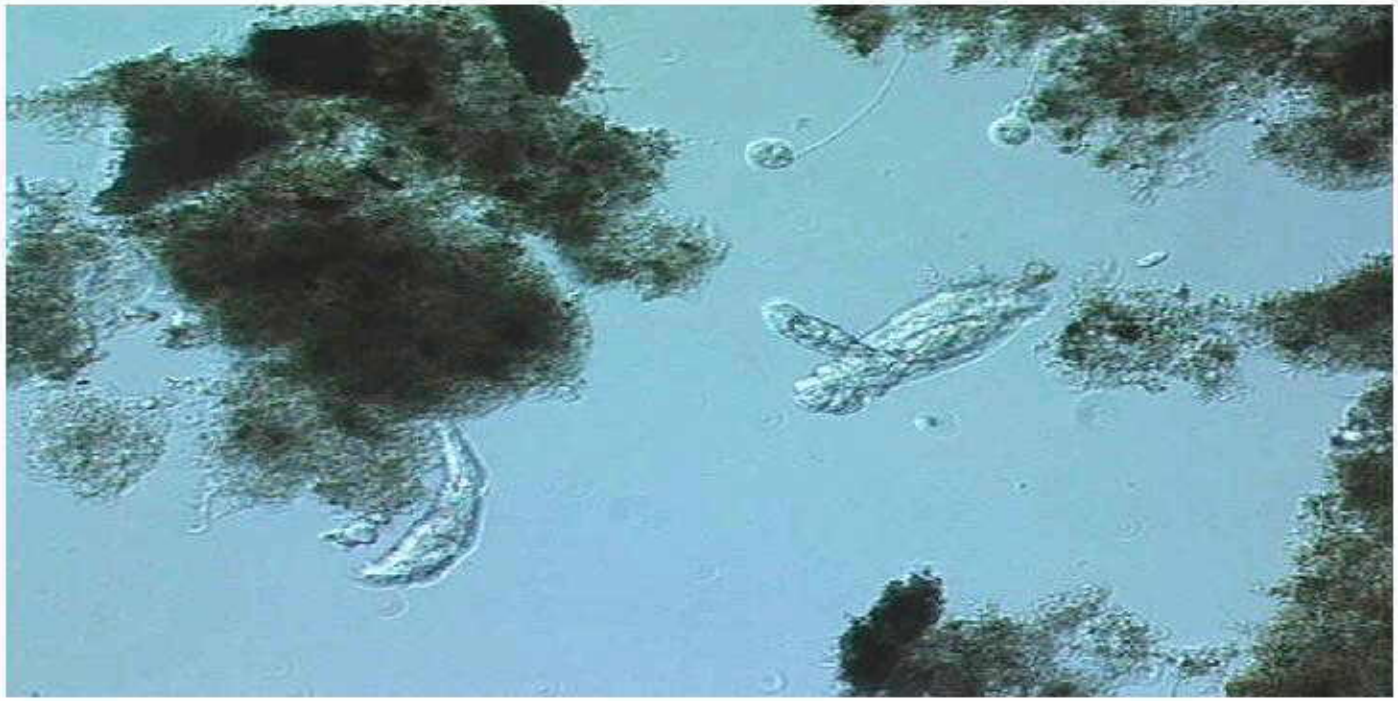
Secondary Treatment

Minimum Biosludge Production = MBP

Rotifers



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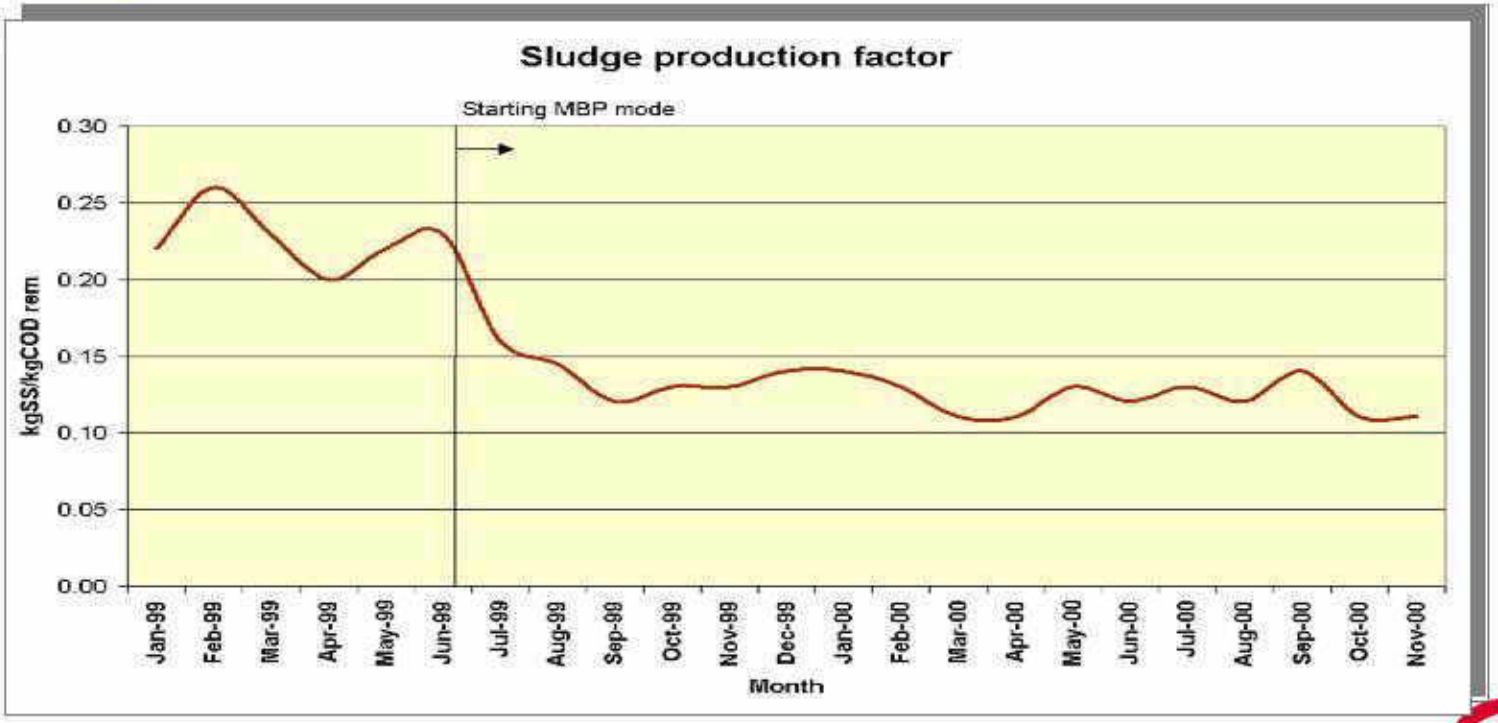
Secondary Treatment

Minimum Biosludge Production = MBP

Sludge Production Factor



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Secondary Treatment

Minimum Biosludge Production = MBP

Benefits of MBP

- 30-50 % lower sludge yield
- good settleability /excellent effluent quality
- stable operation in fluctuating loading conditions
- less chemicals in sludge dewatering
- higher dry solids in slude dewatering

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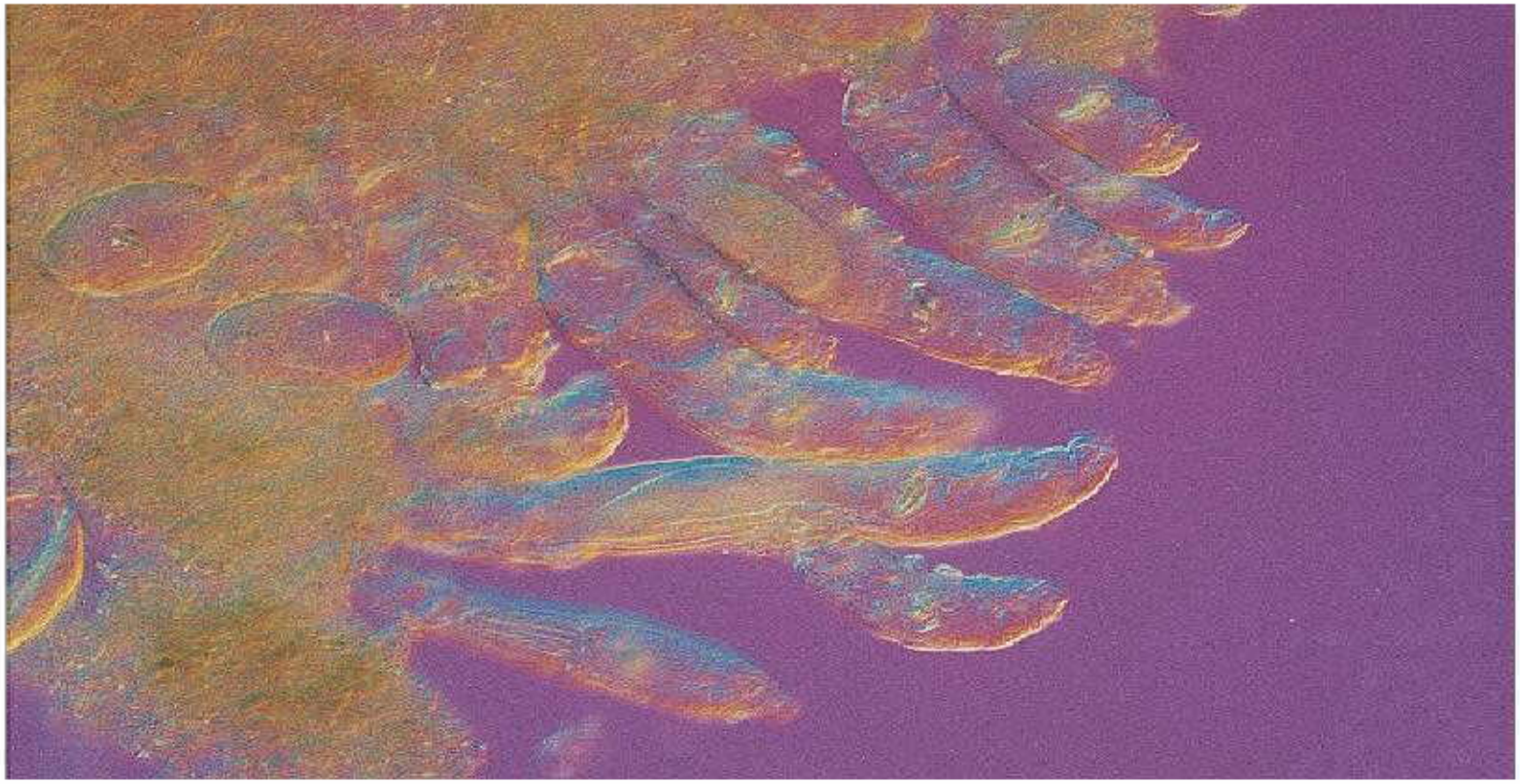
Secondary Treatment

MBBR (= Moving Bed Biofilm Reactor) Process



VEOLIA Water

Secondary Treatment

MBBR (= Moving Bed Biofilm Reactor) Process

- The process is based on the **biofilm principle** and the core of the process is the **biofilm carrier** elements made from polyethylene or polypropylene with a density close to that of water.
- The carriers are designed to provide a **large protected surface** for the bacteria culture.
- The reactors are filled up to 67% of their volume with these carrier elements.
- The biofilm carrier elements are **kept suspended** in the water by air from the diffusers in the aerobic reactors and by means of a mixer in the anoxic reactors.

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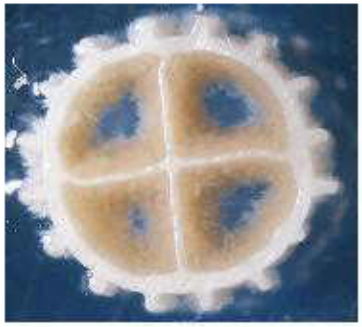
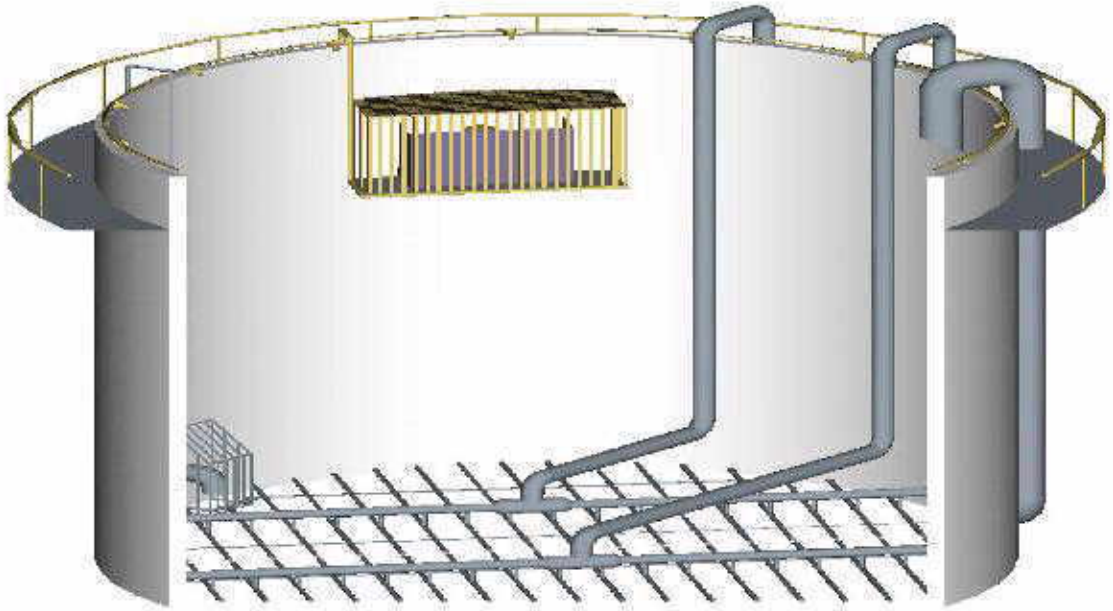
Secondary Treatment

MBBR Process;
Moving Bed™ Biofilm Reactor

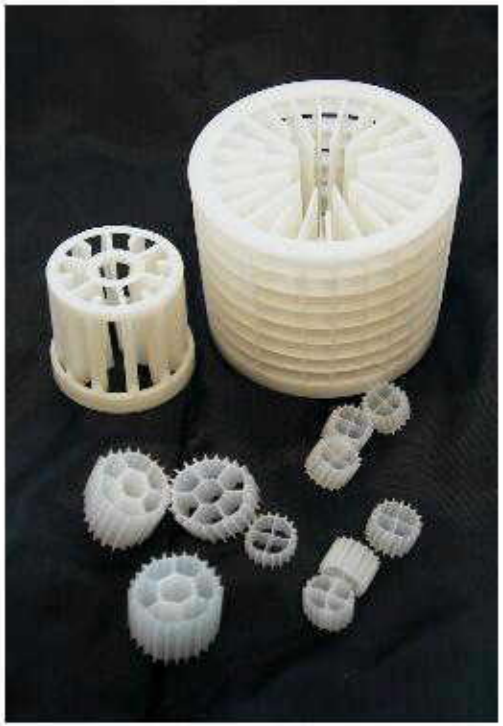


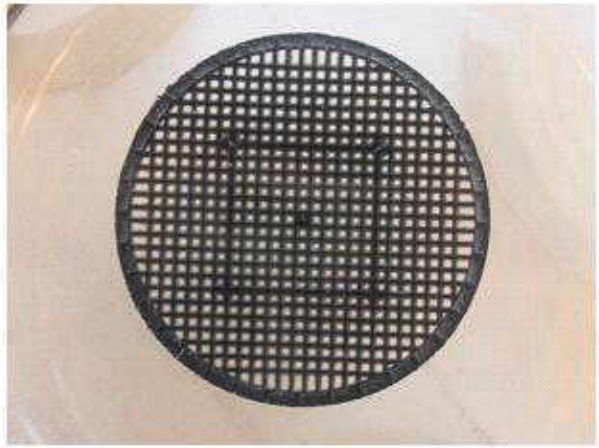


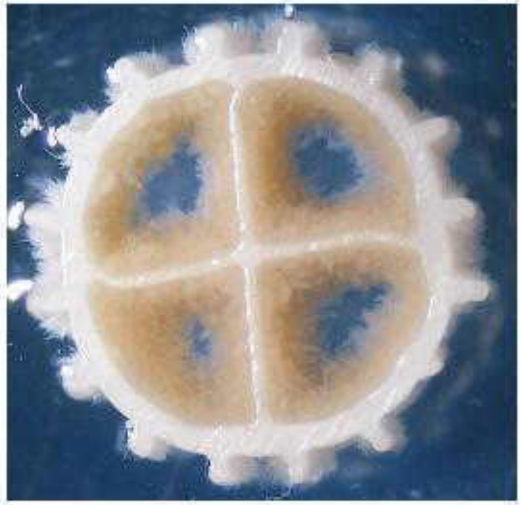
VEOLIA Water

Secondary Treatment

MBBR (= Moving Bed Biofilm Reactor) Process, Different Carriers



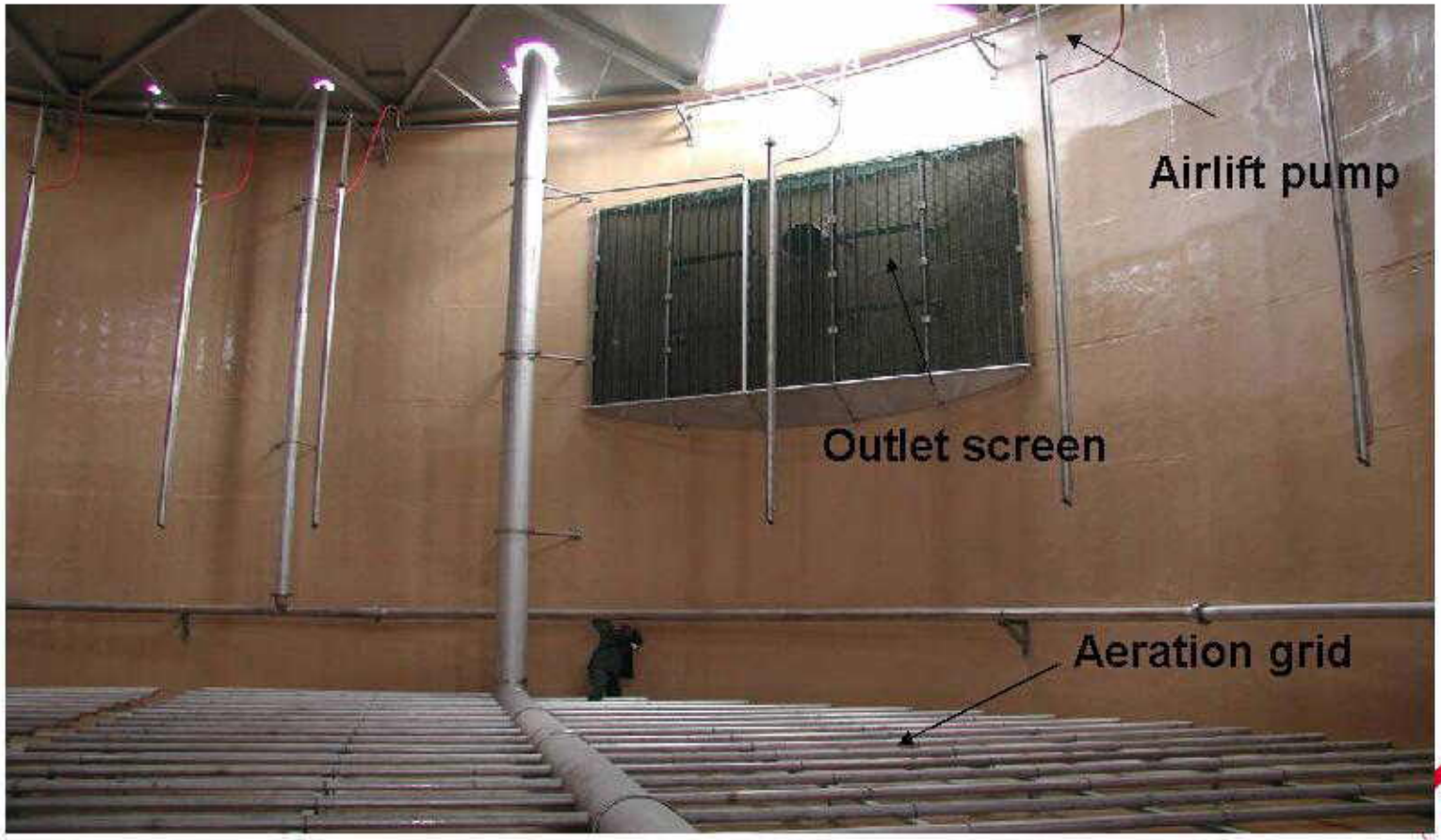




VEOLIA Water

Secondary Treatment

MBBR (= Moving Bed Biofilm Reactor) Process

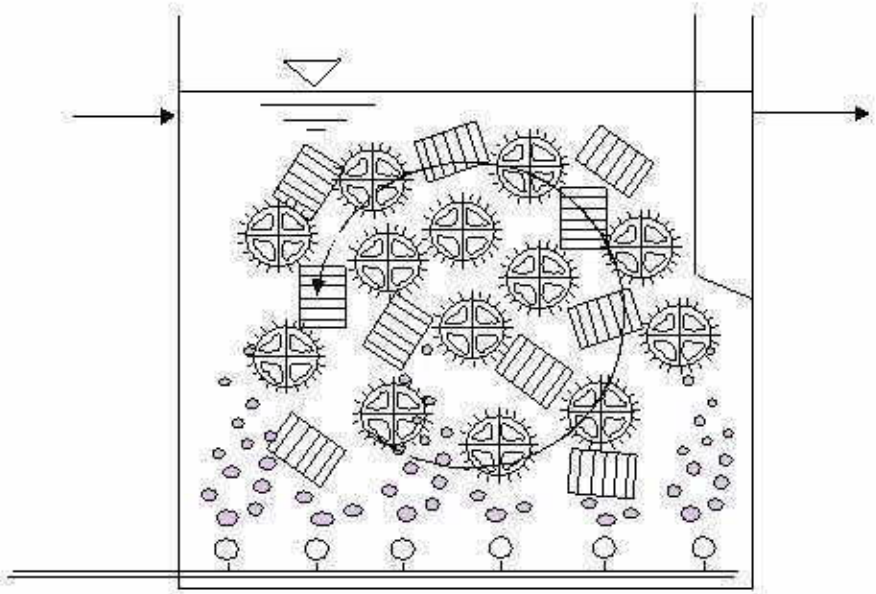


VEOLIA Water

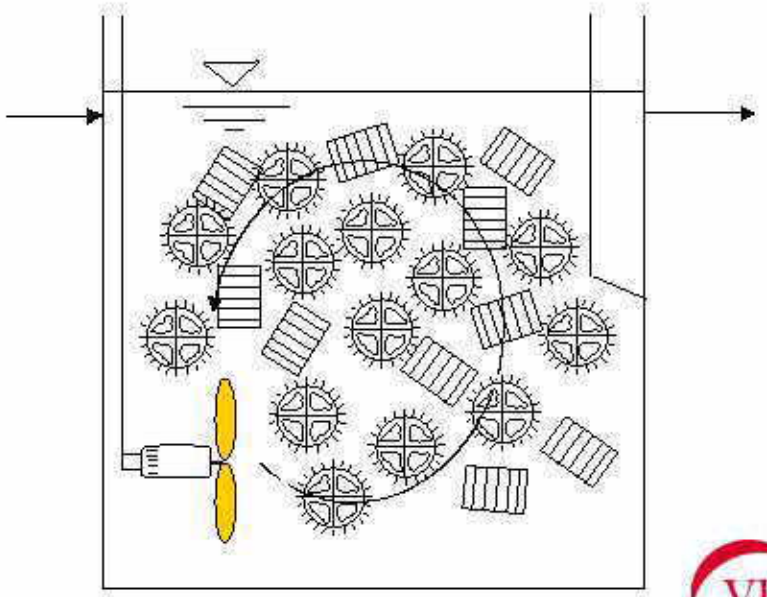
Secondary Treatment

MBBR (= Moving Bed Biofilm Reactor) Process, Mixing in Reactors

Aerobic reactor



Anoxic reactor



VEOLIA Water

Secondary Treatment

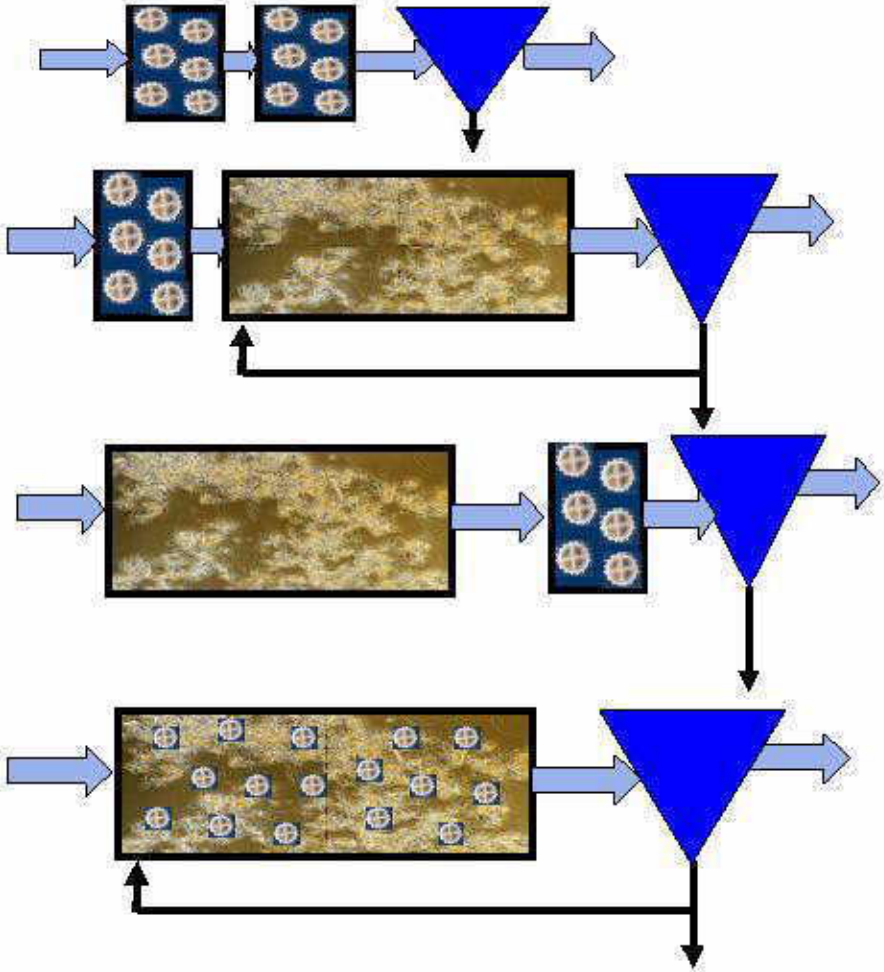
MBBR (= Moving Bed Biofilm Reactor) Process

MBBR as sole biotreatment

MBBR as pre-treatment (roughing, BAS)

MBBR as post-treatment (polishing)

MBBR in activated sludge (HYBAS/IFAS)

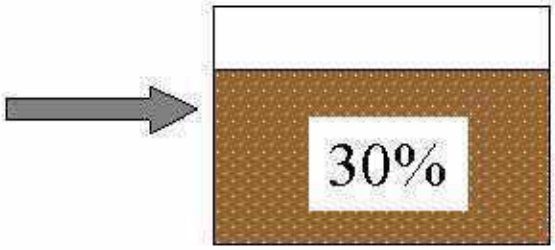


VEOLIA Water

Secondary Treatment

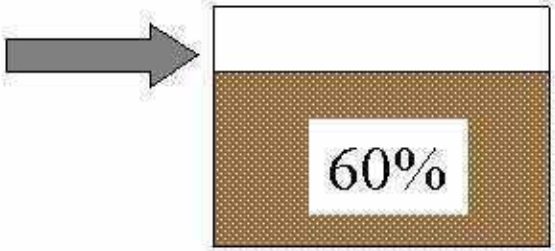
MBBR (= Moving Bed Biofilm Reactor) Process, Future Expansion

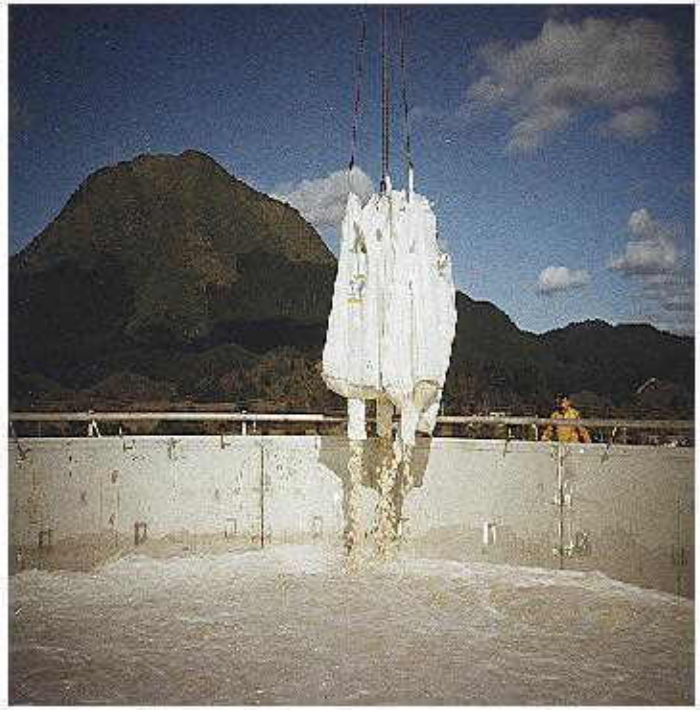
100
kg/d



Increase filling degree by adding more biomedia

200
kg/d





Tertiary Treatment

Needs of Tertiary Treatment

- environmental requirements for:
- Phosphorous
- COD
- AOX
- Colour
- High(SS)
- (BOD)
- (Nitrogen)

VEOLIA Water

Tertiary Treatment

Needs of Tertiary Treatment

- Renovation of old (lagoon based) biological processes
- Much lower investment costs, than completely new biological process
- Polishing process for difficult or filamentous sensitive effluents
- After high loaded processes

WELL DESIGNED TERTIARY TREATMENT GIVES SAFETY FOR TOTAL TREATMENT PROCESS

VEOLIA Water

Tertiary Treatment

Processes

- Chemical coagulation and/or flocculation
- Filtration
  - Sand filtration
  - Microfiltration
  - Membrane processes

VEOLIA Water

Tertiary Treatment

Chemical Coagulation and Flocculation

Coagulation chemicals used:

- Aluminium sulphate/AVR, optimum pH 5-5,5
- Polyaluminiumchloride, PAC, optimum pH 5-5,5
- Ferric sulphate, optimum pH 4-5
- Ferrous sulphate + H2O2 = Fenton or Fennotriox
- Optimum pH 3-3,5
- Organic coagulants
- Lime

VEOLIA Water

Tertiary Treatment

Chemical Coagulation and Flocculation

Flocculation chemicals used:

- Polyacrylamides = Polymers
- (Bentonite)

VEOLIA Water

Tertiary Treatment

Chemical Coagulation and Flocculation

Alternative separation processes:

- **Flotation**
  - Very reliable process for P&P effluents
- **Sedimentation**
- **Filtration**
  - Can be alternative only for low COD effluents
  - Not suitable for filamentous bulking problems

VEOLIA Water

Tertiary Treatment

Filtration Process

- Possibility to very low SS content (P,N)
- Only for low SS content effluents
- Sand filtration, microfilters
  - No reduction of dissolved substances without
  - chemicals
- Membrane processes
  - + selective treatment based on molecular size
  - high investment and operating costs
  - reject disposal
  - fouling

VEOLIA Water

Project Cases

VEOLIA Water

Project Cases

P.T. Riau Andalan Pulp & Paper Sumatra, Indonesia

Kraft pulp mill: 330 000 m^3/d flow

VEOLIA Water

Project Cases

Stora Enso Port Hawkesbury Mill, Nova Scotia, Canada

VEOLIA Water

Project Cases

Stora Enso Norrsundet Mill, Sweden; Modification of Aerated Lagoon to Advanced AST Plant

MBP selector process:

- chlorate removal
- selector pluf flow
- SVI 60...70 mg/l
- Sludge yield < 0.14 kg/kg COD

All targets of the mill were met.

- excellent treatment results
- excellent availability

VEOLIA Water

Project Cases

Celulosa Arauco y Constitución S.A. Valdivia Mills, Chile

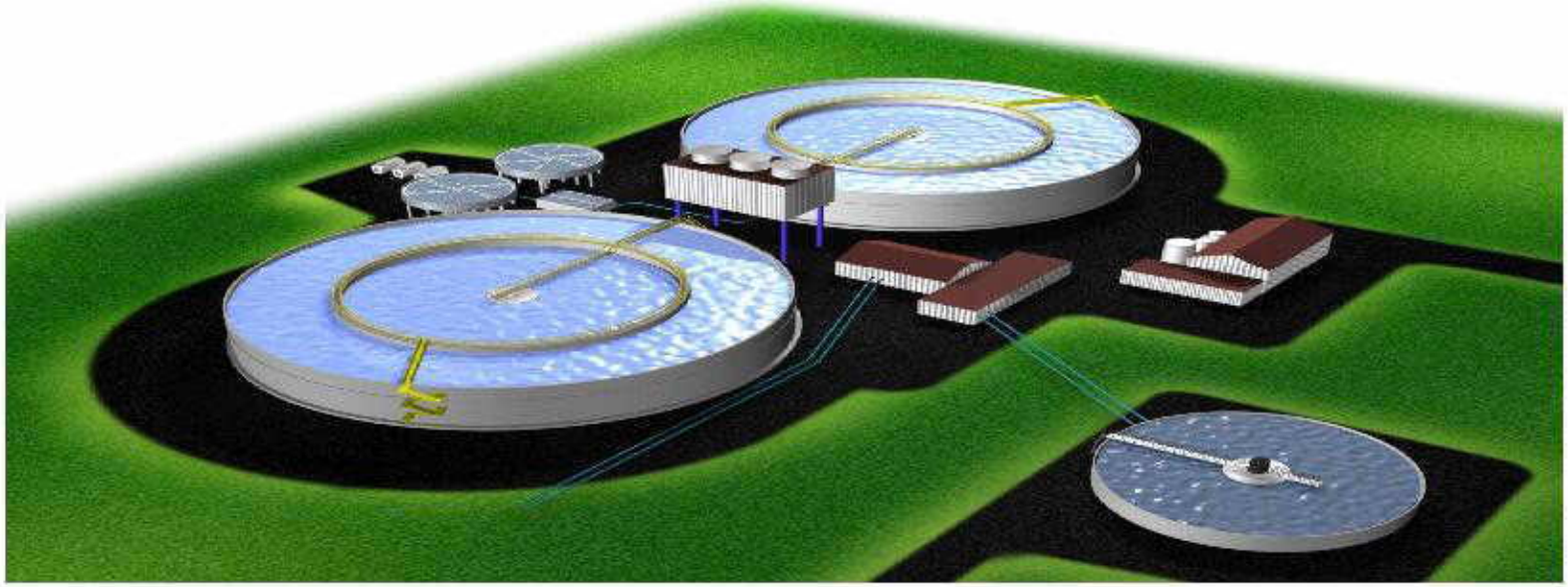
- MBP Selector Process
- Enchanced chlorate removal
- Selector plug flow
- Tertiary treatment

VEOLIA Water

Project Cases

Celulosa Arauco y Constitución S.A.

Nueva Aldea Mills, Chile



Production: 555,000 t/a of pine and eucalyptus pulp

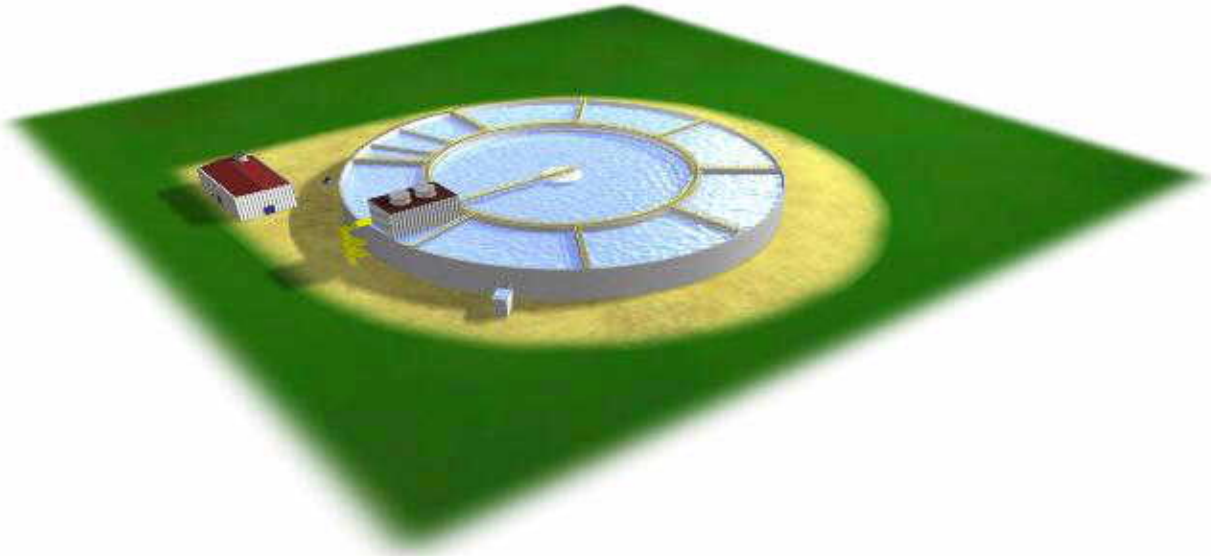
VEOLIA Water

Project Cases

Mondi Ltd., Richards Bay Pulp Mill, South Africa

Minimization of Polution of the Rebuild Mill Based on BAT Treatment

- **Aquaflow MBP selector process**



VEOLIA Water

Project Cases

Kappa Kraftliner, Piteå, Sweden

Production: 700,000 t/a of paper and paperboard
500,000 t/a of pulp (kraft linerboard)

VEOLIA Water

Project Cases

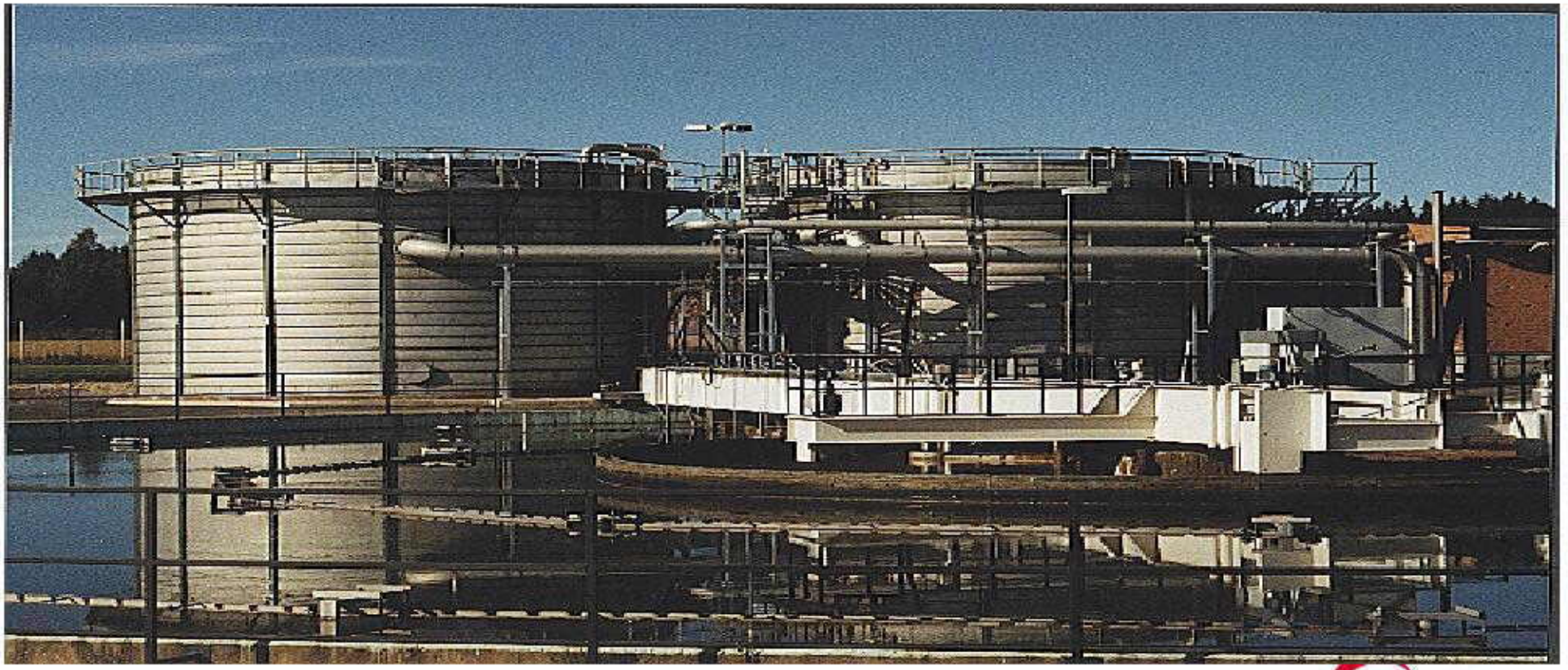
Stora Enso Celbi Pulp Mill, Portugal

Production: 295,000 Adt/a ECF bleached eucalyptus market kraft pulp

VEOLIA Water

Project Cases

Two-Stage MBBR at Bäckhammar Kraft Mill, Sweden



VEOLIA Water

Project Cases

Biofilm - Activated Sludge treatment (BAS)

VEOLIA Water

Project Cases

Stora Enso Varkaus Mills, Finland

Aquaflow's AF-Float tertiary flotation plant treating 60 000 m^3/d biologically treated effluent

VEOLIA Water

Project Cases

M-real Lielahti Mills, Finland

AF-Float 9.5 x 1.3 tertiary treatment DAF, final protection against sludge bulking problems

- **Chemical COD and P removal**

VEOLIA Water