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通过在线有氧呼吸测量实现污水厂能效优化

Optimizing the Energy Consumption of the Aeration Processes by using Online Respiration Measurement

Speaker: Dafeng Yang, LAR Process Analysers (Hangzhou) Co., Ltd.

Co-Author: Dr.-Ing. Werner Arts, LAR Process Analysers AG

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内容概况 / Structure

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2. 优化过程 / Optimizing the process
3. 两个优化策略 / Two optimizing strategies
4. 测量的重要性 / Importance of respiration (BOD) measurement
5. 最佳呼吸测量技术 / Respiration measurement technology
6. 污泥活性 / Sludge activity
7. 硝化干扰 / Nitrifying disturbance
8. 总结 / Summary

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1. 简介 / Introduction

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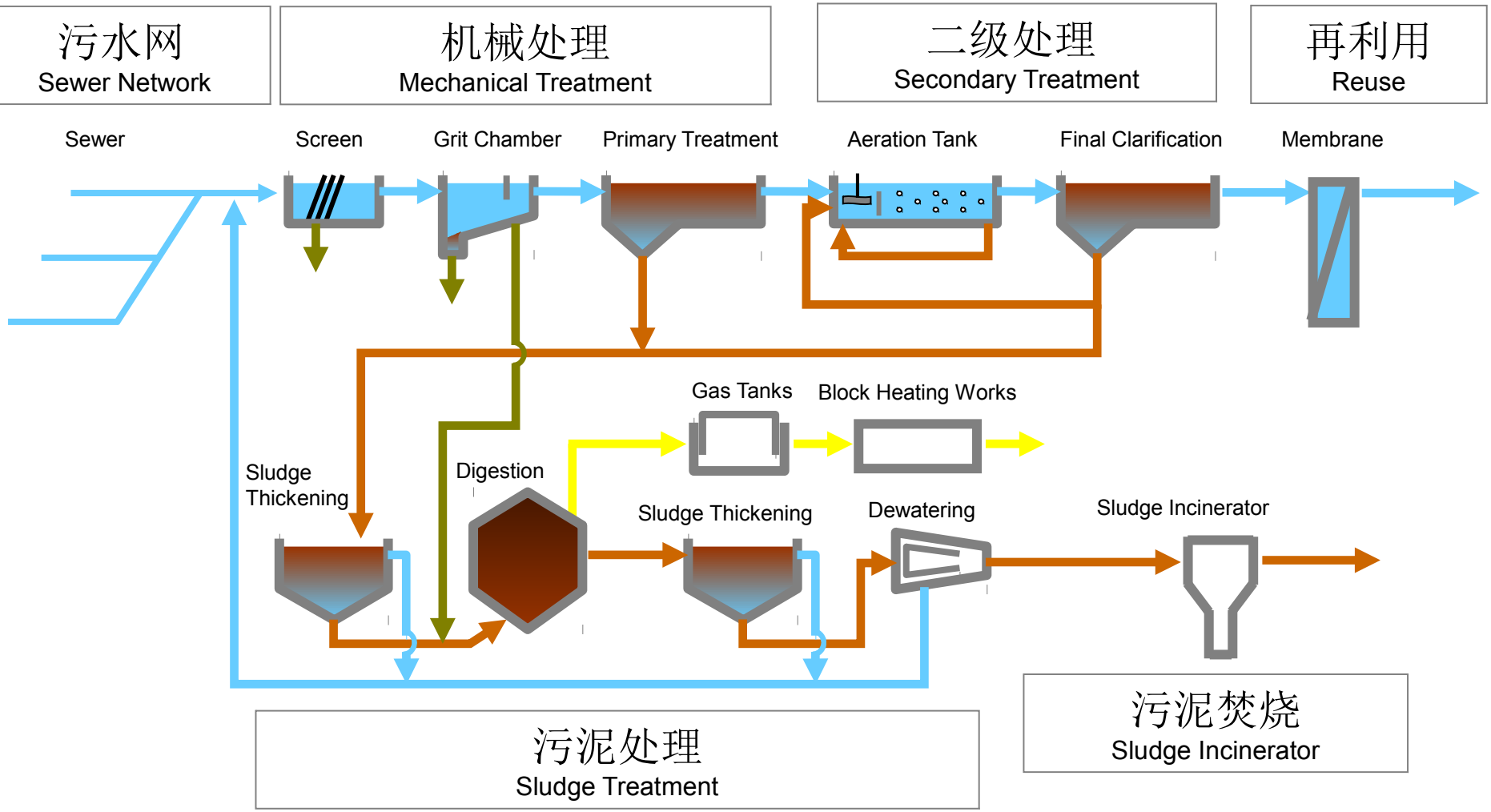

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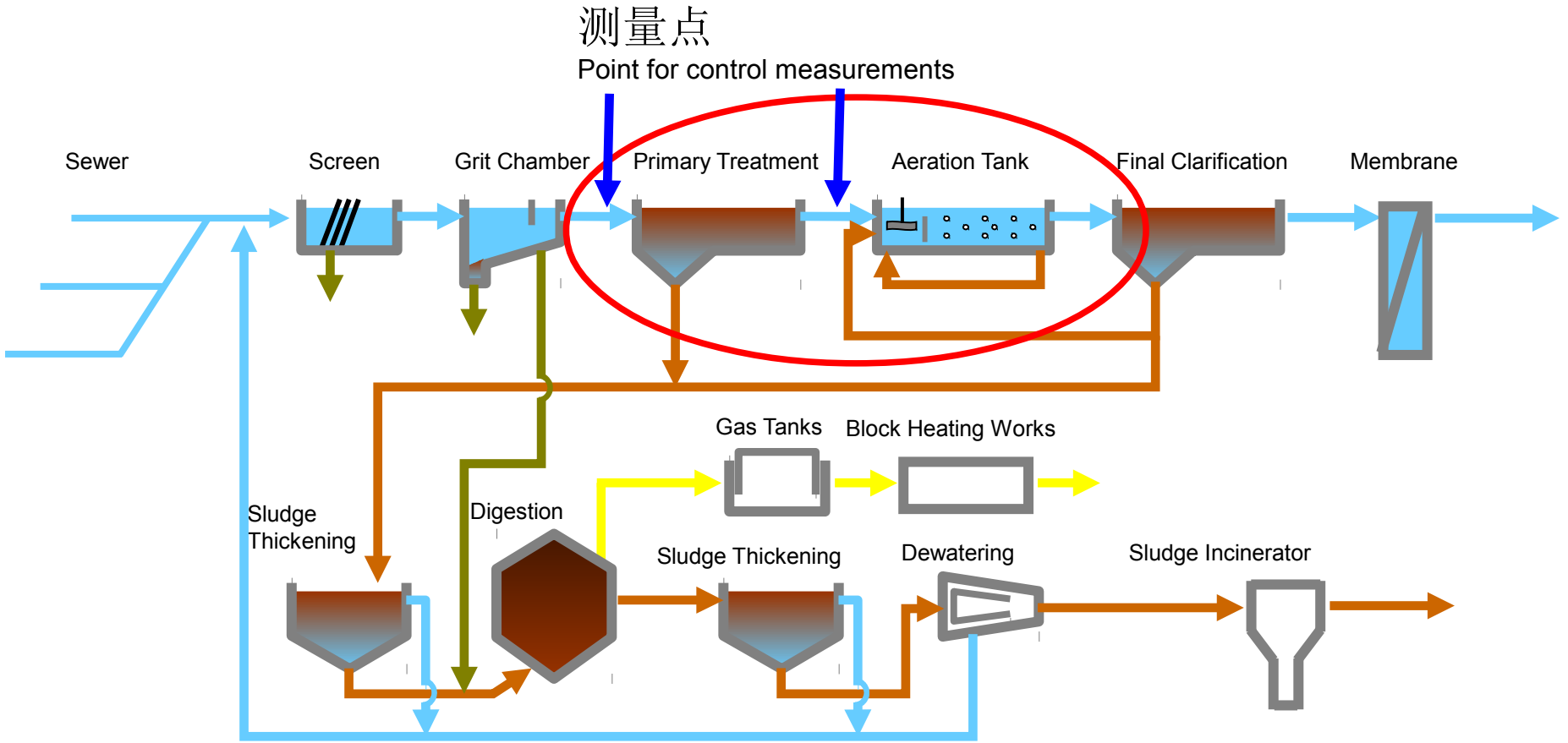
1. 简介 / Introduction



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2. 过程优化 / Optimising the Process

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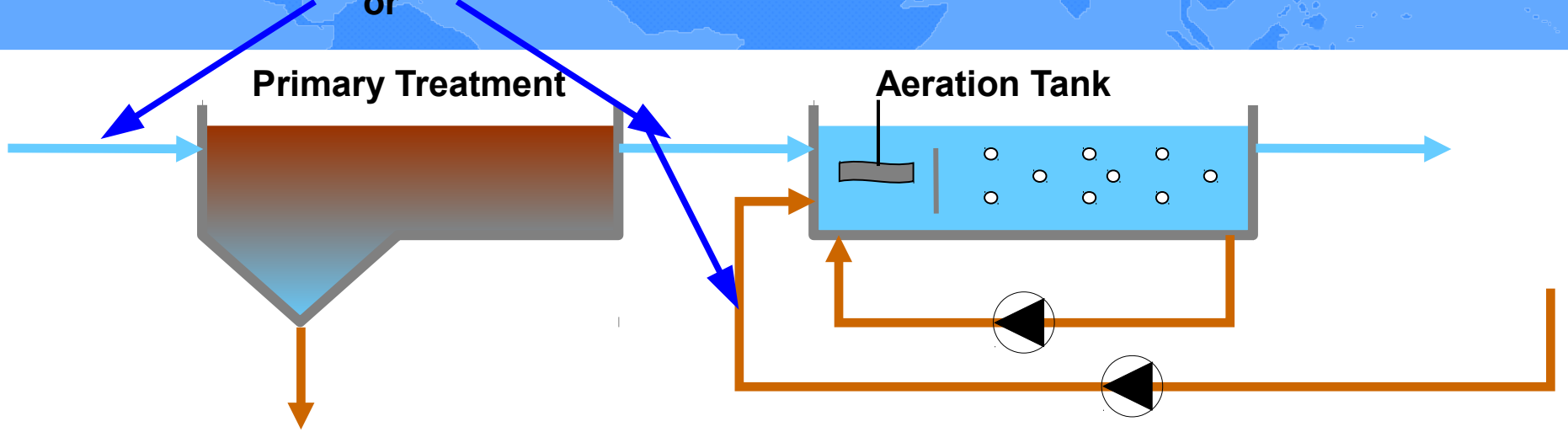
要点 Important to know:

- Incoming load
  - 流量 Flow
  - 呼吸率（ BOD) Respiration (BOD)
  - COD, TN
  - 污泥活性 Sludge activity
- Incoming disturbance
  - 毒性 Toxicity

or



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3. 两大优化策略 / Two Optimising Strategies

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1. 负荷稳定 Constant load rate

保持稳定的负荷 Keep the load rate stable

(BOD or COD * m³/min = kg/m³/min) => constant

→ 曝气及污泥回用在稳定的条件下进行

Aeration and sludge return can run at stable condition (rates)

→ 可以使 泵和曝气机在最好的环境下使用，从而节省用电

Best working point for pumps, blowers => saves electricity=money

2. 用已知的负荷率控制曝气和污泥回用

Controlling the aeration

and sludge return by knowing the **load rate**

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3. 两大优化策略 / Two Optimising Strategies

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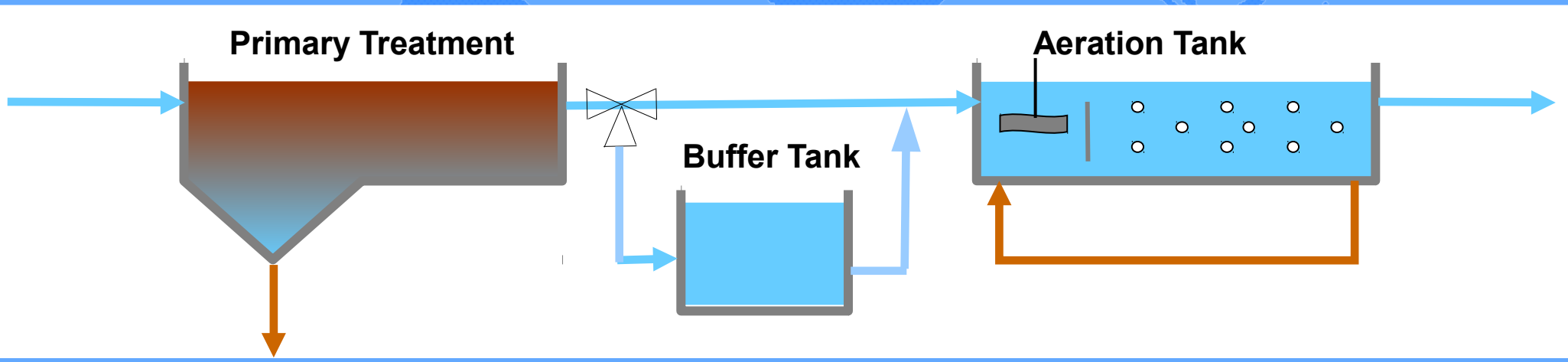
1. 负荷稳定 / Constant Load Rate

- 缓冲池 Buffer tanks or buffer capacity nessessary
  - 专业缓冲池 Special buffer tanks
  - 预处理 Pre-treatment (basin)
  - 雨水池 Rain-storage tanks can be used

- 测量流量，呼吸率，污泥活性以及 COD, TN 或硝化毒性

  Measuring flow, respiration and sludge activity
  Additionally COD, TN or Nitrification-Toxicity



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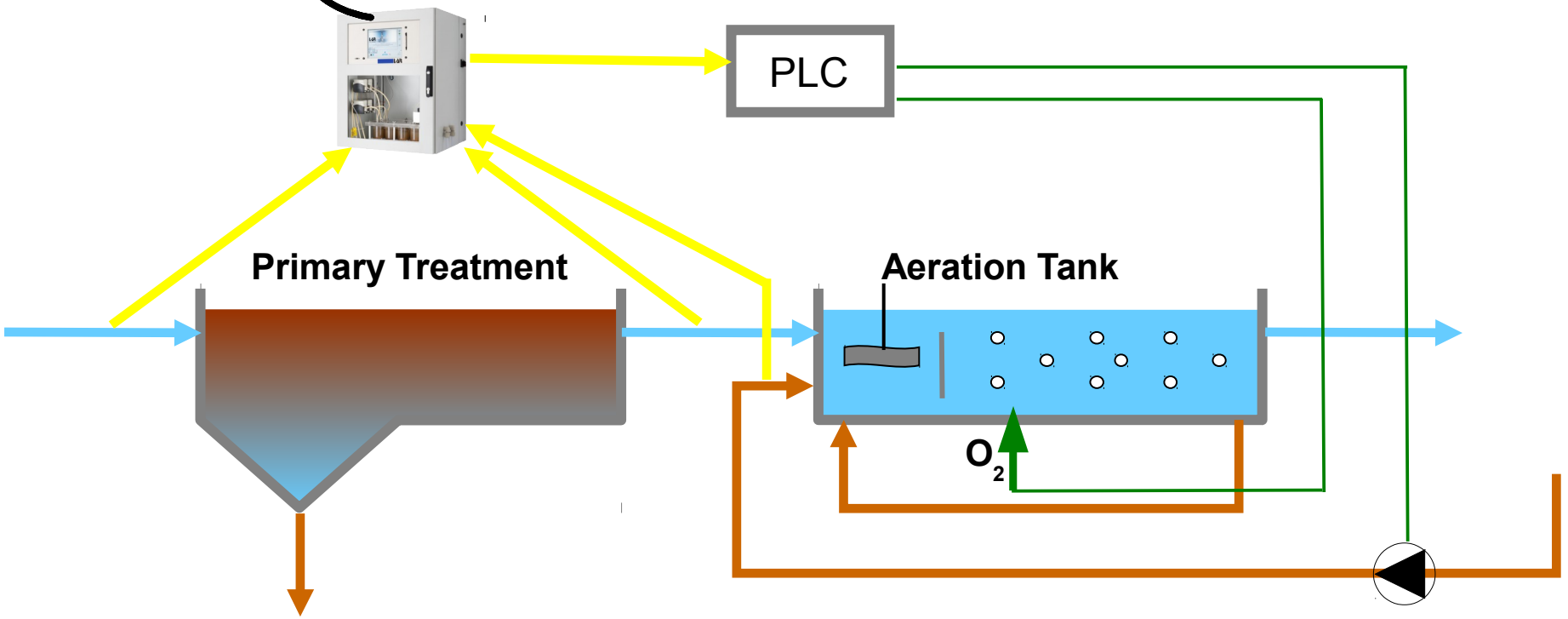
3. 两大优化策略 / Two Optimising Strategies

2. 通过负荷率来控制曝气 / Controlling Aeration by Load Rate

- 流量 Flow
- BOD
- 污泥活性 Sludge activity
- COD
- 毒性 Toxicity



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4. 呼吸测量的重要性 / Importance of respiration (BOD) measurment

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有机物生化降解处理 Biological treatment for organic degration:

BOD 减少 reduction and $NH_4^+ \rightarrow NO_3^-$ (Nitrification)

Nitrification simplified:

$2\ NH_4^+ + 5\ O_2 \rightarrow 2\ NO_3^- + 4\ H_2O$

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4. 呼吸测量的重要性 / Importance of respiration (BOD) measurment

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不测量呼吸率的原因

Respiration measurement is not in common use because:

- 缺乏可靠的呼吸率测量方法（氧气消耗率）

  lacking of reliable respiration Measurement (oxygen uptake rate)

- Missunderstanding in useing BOD for this purpose in the past

- 传统 BOD 测量太慢 Typical BOD measurements is not fast enough

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4. 呼吸测量的重要性 / Importance of respiration (BOD) measurment

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过程控制中的呼吸测量 Respiration (BOD) mesurement for controlling the process

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Respiration (BOD) ≠ **BOD_5** = **cBOD**

- 在线呼吸（耗氧量）
  On-line respiration (oxygen uptake rate)

- 含碳有机物和氨氮氧化过程中的需氧量
  Oxygen demand for carbonaceous organics and NH_4^+ oxidation

mg O_2 / l * min

实验室结果需要 5-7 天
Lab result after 5/7 days

碳
Carbonaceous BOD

无 NH_4^+ 氧化
without biological oxygen demand for NH_4^+ oxidation

mg O_2 / l

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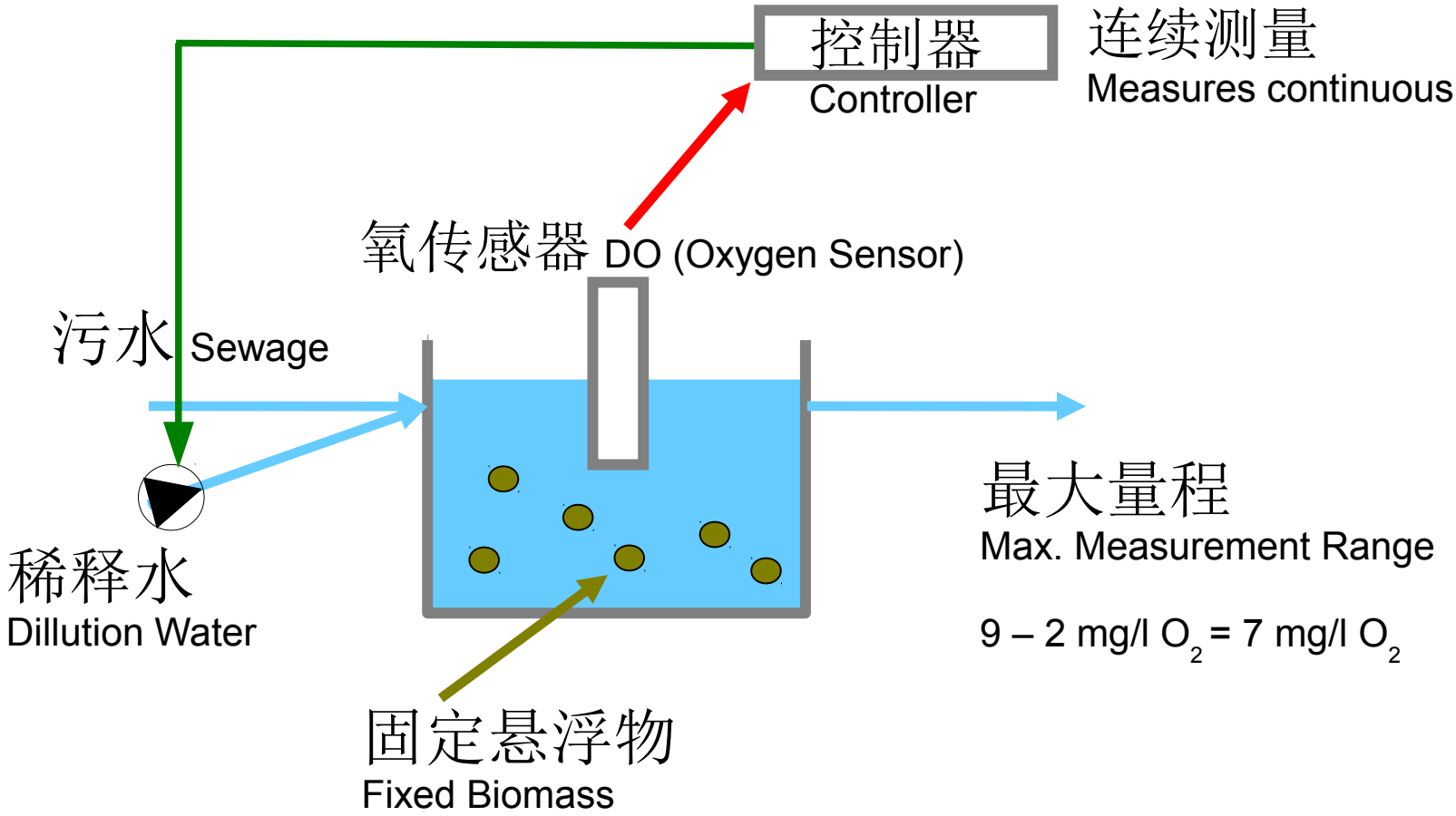
4. 呼吸测量的重要性 / Importance of respiration (BOD) measurment

典型的测量 / Typical measurement for uptake rate



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4. 呼吸测量的重要性 / Importance of respiration (BOD) measurment

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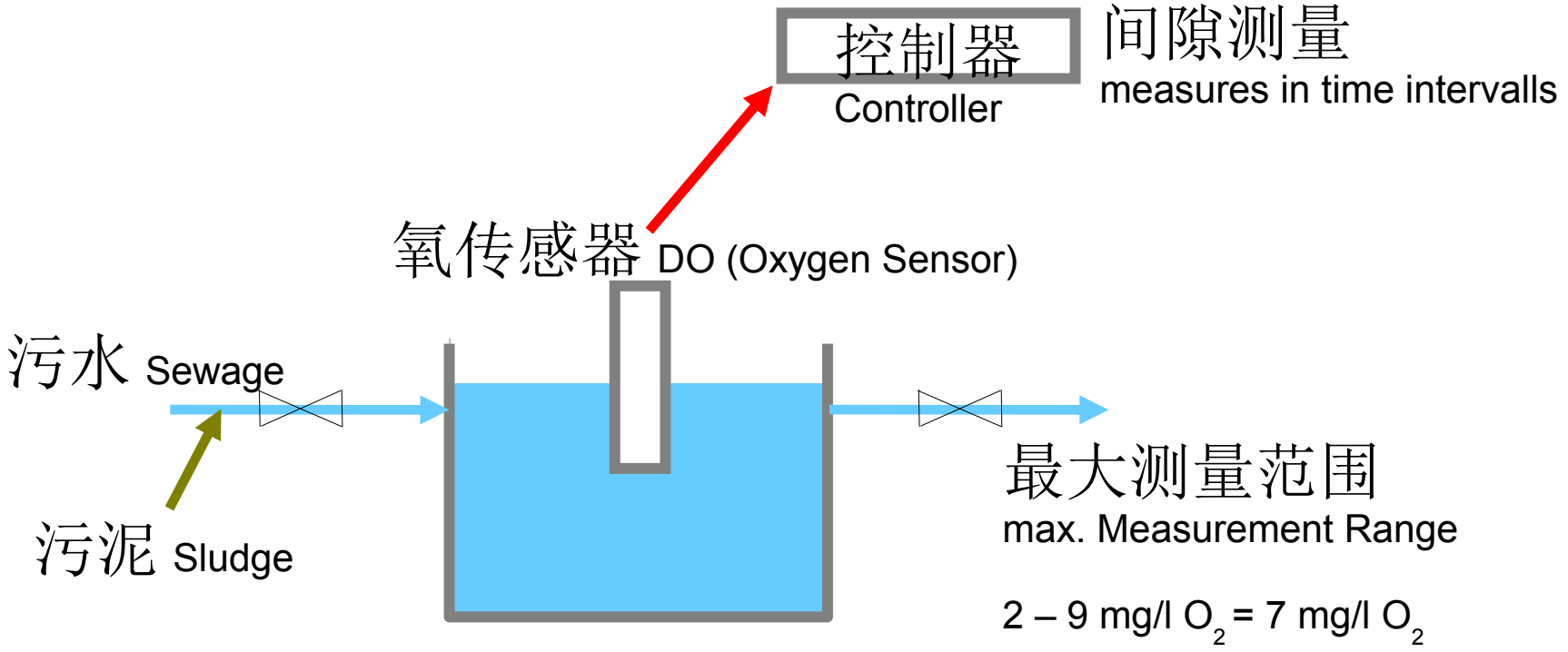
Batch type



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4. 呼吸测量的重要性 / Importance of respiration (BOD) measurment

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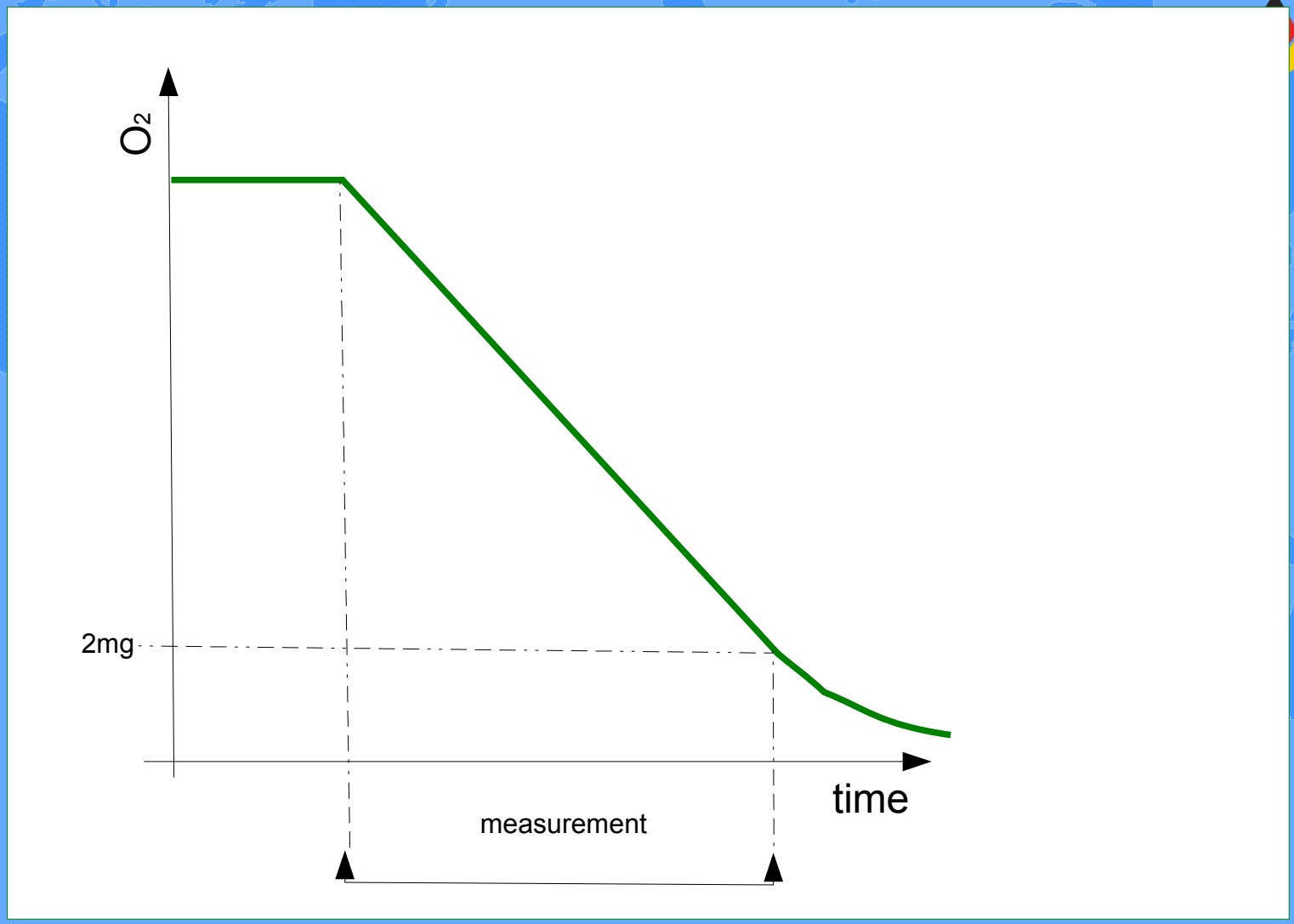

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5. 呼吸技术测量 / Respiration measurment technology

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不合适的测量方法 / Bad example:

使用传感器测量 / Using DO – Sensors

- DO 测量范围有限 measurement range of DO sensors is limited
- 传感器的污染 sensor contamination → 维护 maintenance
- 溶氧电极 electrochemical DO
  - 对于部分化学物质不敏感 sensitive against a range of chemicals:
    只能持续工作数天 sometimes they last just 1 – 2 days

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5. 呼吸技术测量 / Respiration measurment technology

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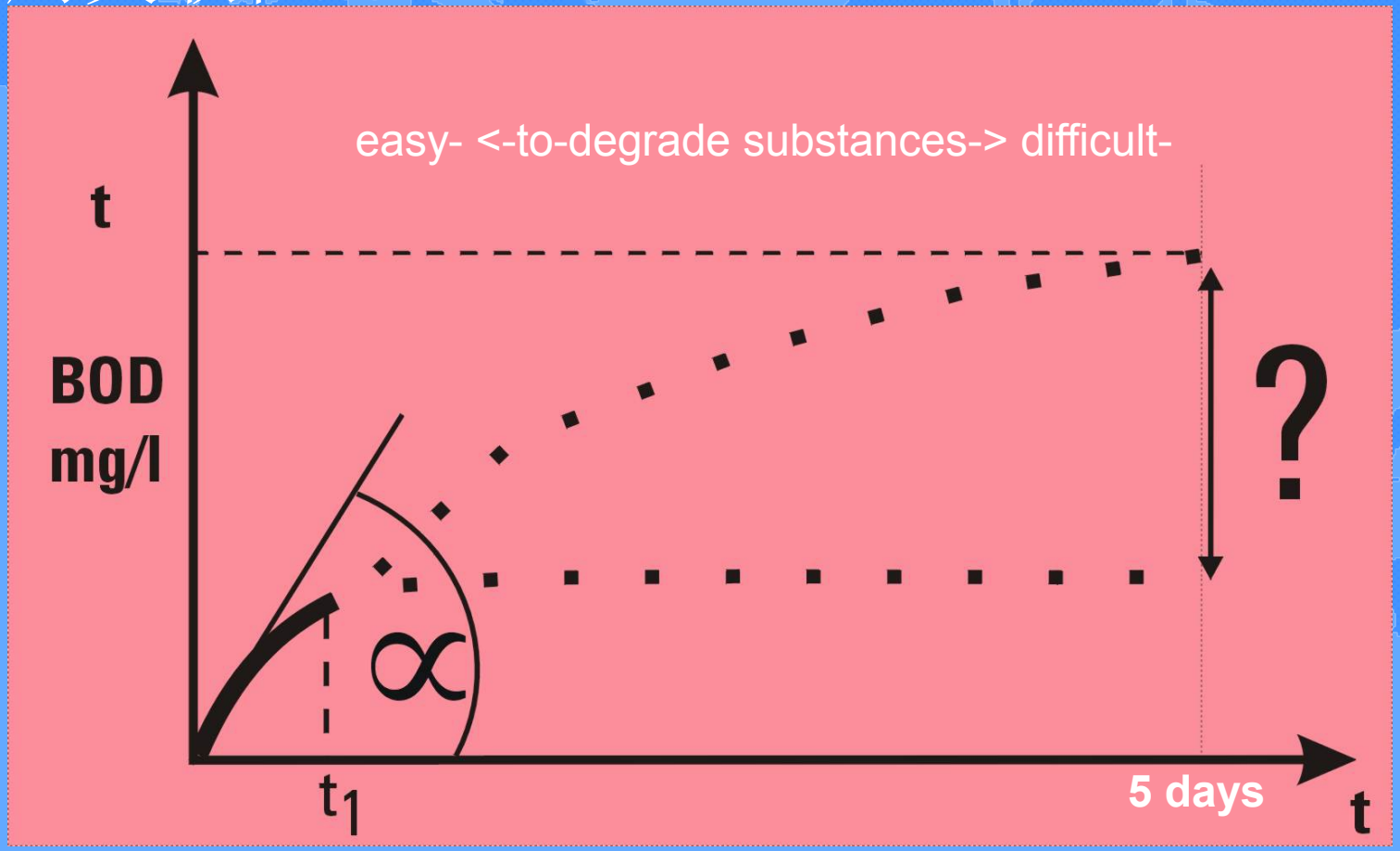
不合适测量方法 / Bad example:

使用传感器测量 / Using DO – Sensors

一周关联性 Correlation is week



典型 Typical:
BOD 300 mg/l
or higher

真实的测量范围 DO – measurement real range only 5-7 mg/l

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5. 呼吸技术测量 / Respiration measurment technology

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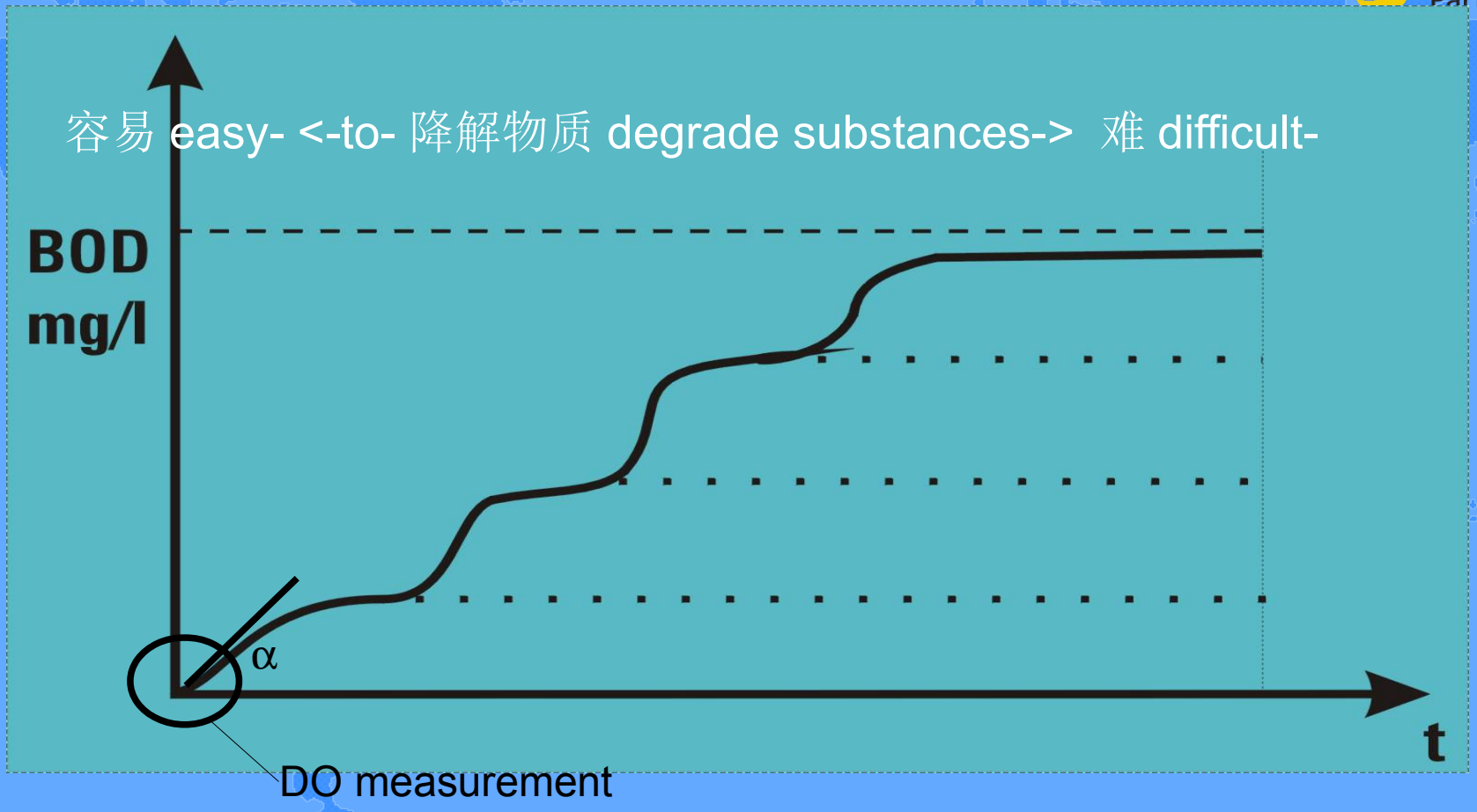
不合适的测量方法 / Bad example:

使用传感器测量 / Using DO – Sensors



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5. 呼吸技术测量 / Respiration measurment technology

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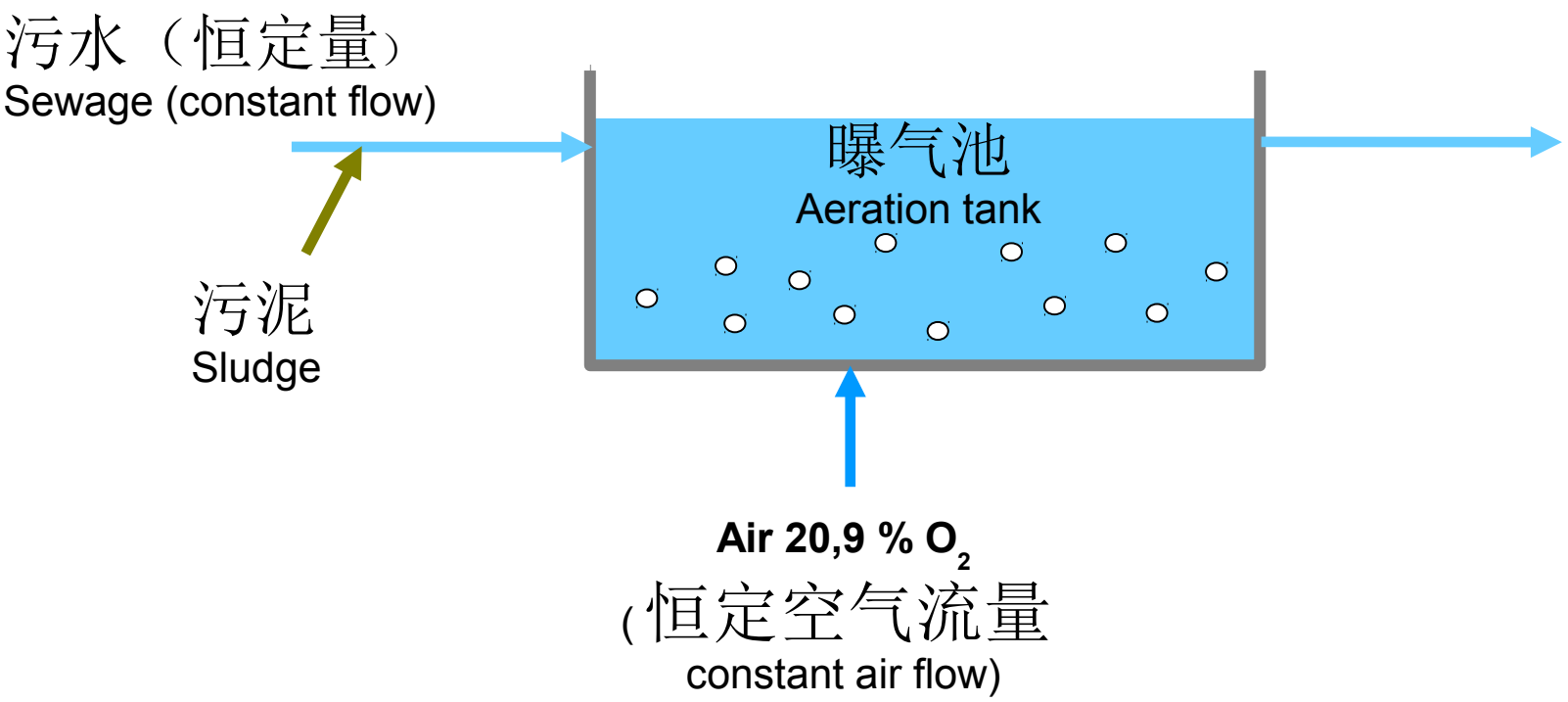
最佳技术 / Best Technology:

模拟处理 Miniature Treatment Plant



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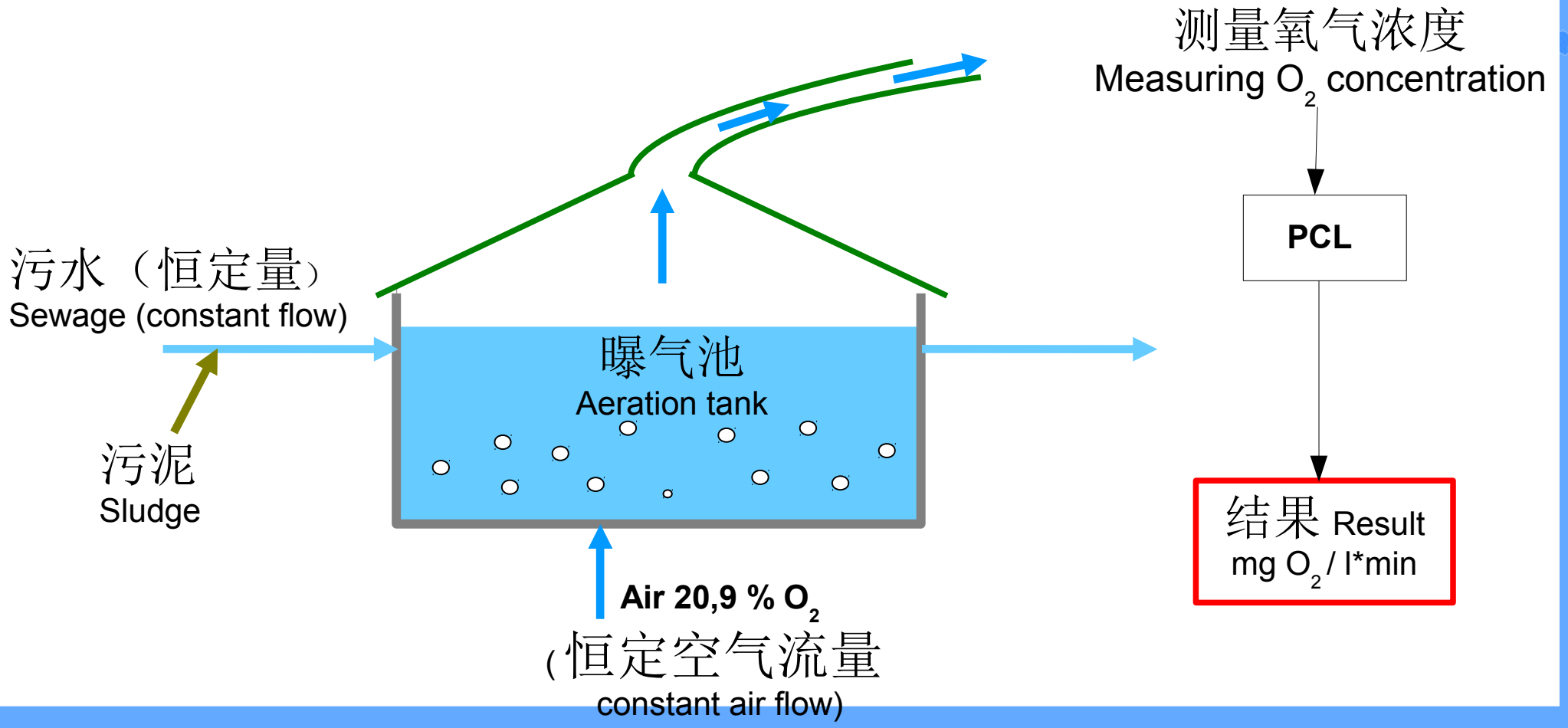

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5. 呼吸技术测量 / Respiration measurment technology

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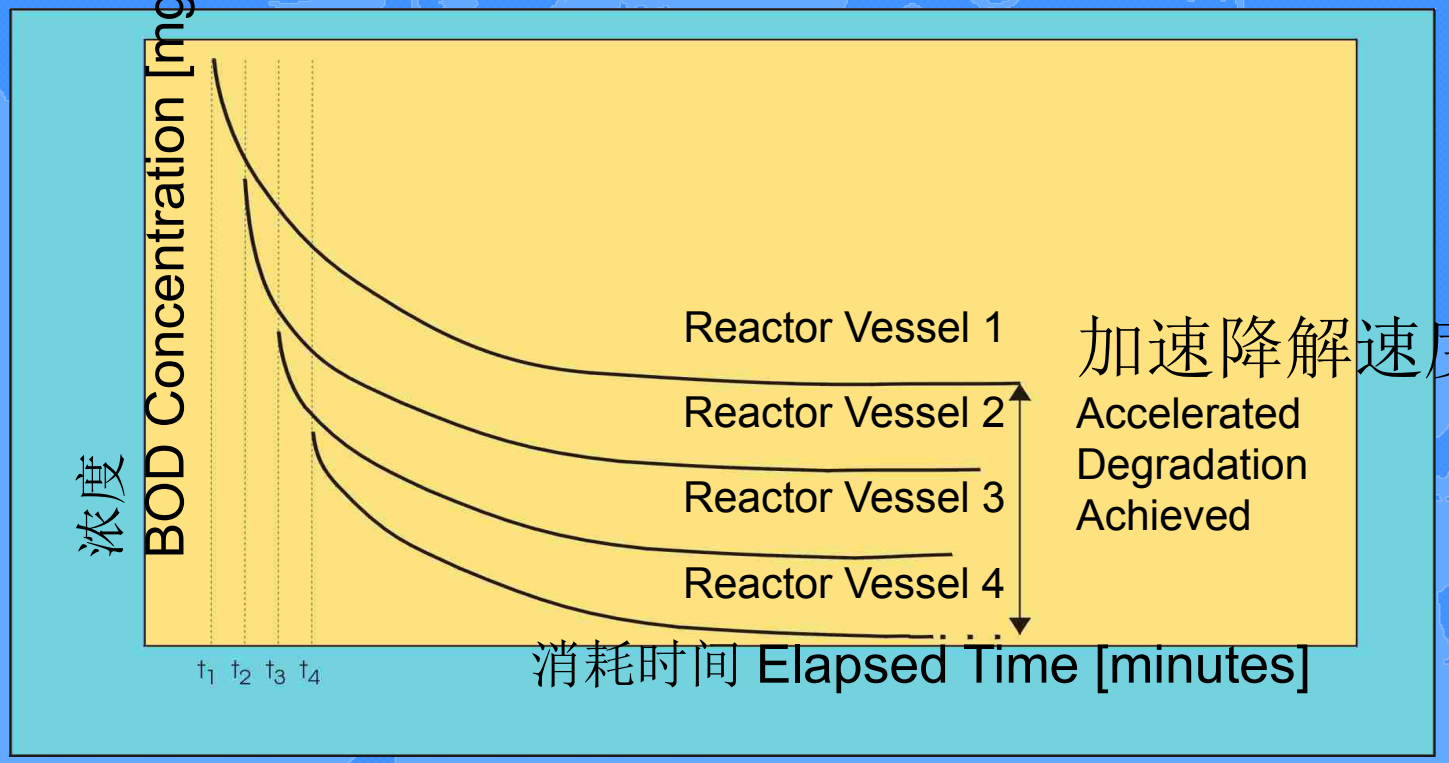
最佳技术 / Best Technology:

1. 使用 4- 级 - 反应器以减少测量时间
Using 4-cascade-reactor



2. 控制反应器中水温至 35℃
Control the water temperature inside the reactor (cascade) to approx. 35 °C

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5. 呼吸技术测量 / Respiration measurment technology

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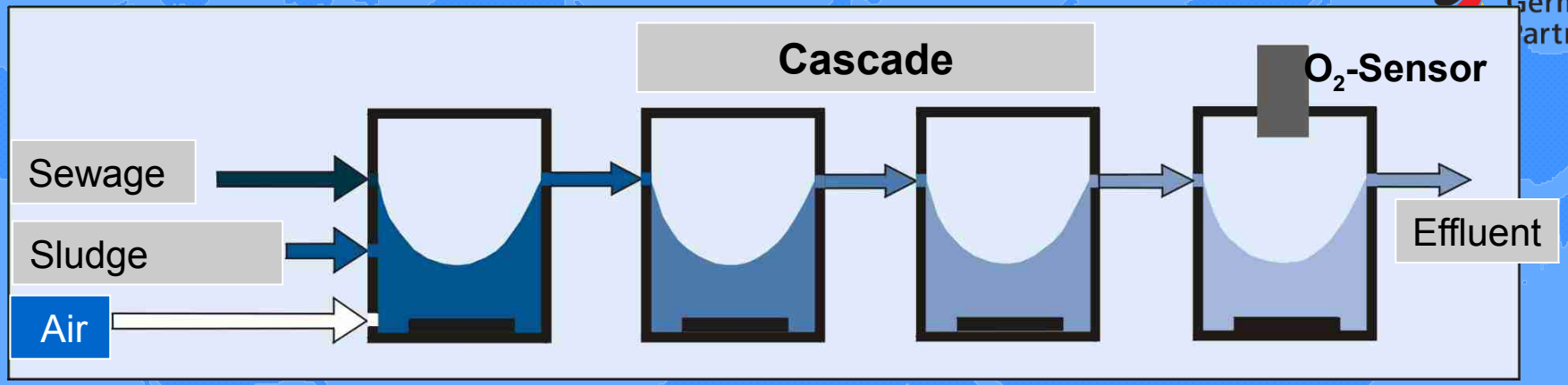
最佳技术 / Best Technology:

模拟处理 Miniature Treatment Plant



3. 测量空气中的氧气消耗量 Measuring O_2 reduction in air

4. 15-30 分钟就可以得到准确的结果
Response-time 15 to 30 minutes with excellent results
依据工厂生化悬浮物 based on the plants biomass

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5. 呼吸技术测量 / Respiration measurment technology

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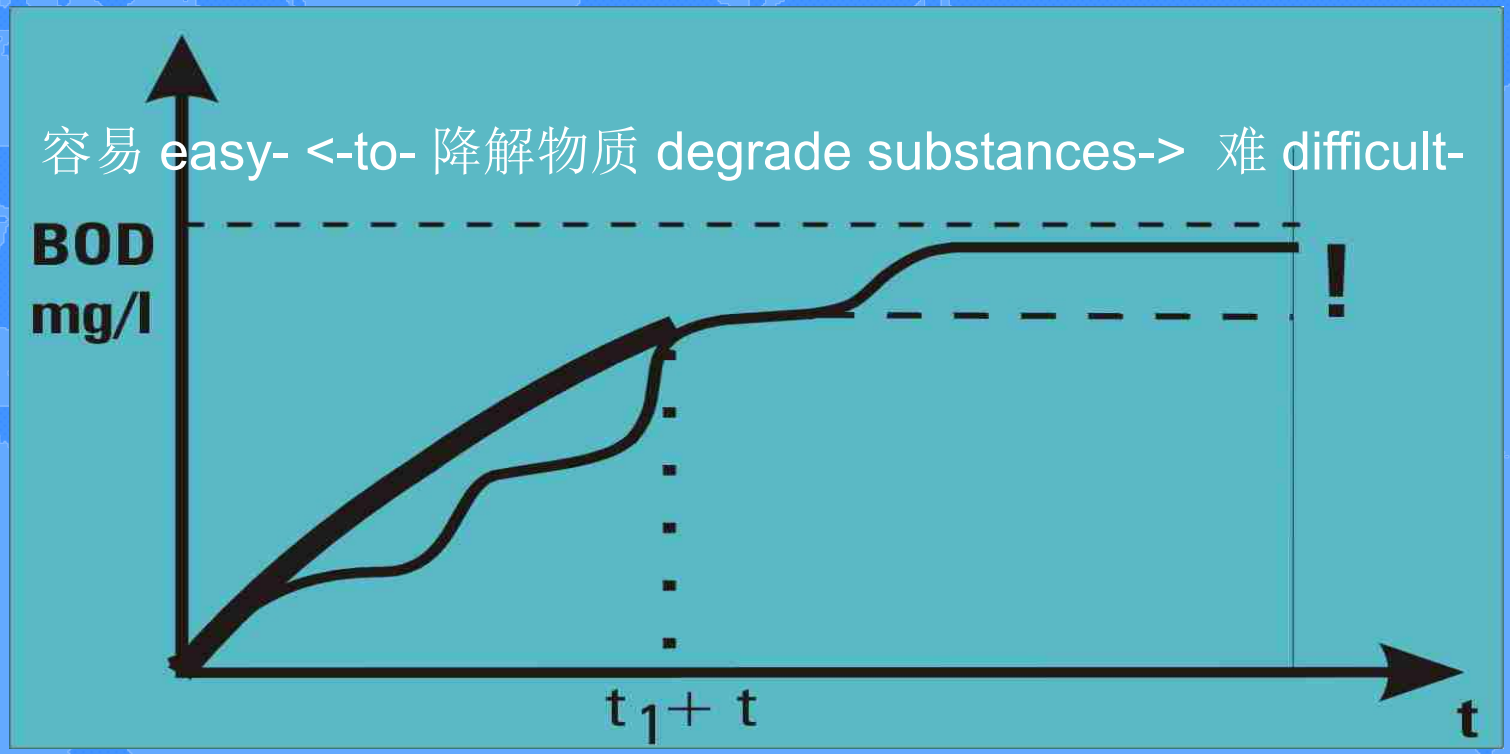
最佳技术 / Best Technology:

模拟处理 **Miniature Treatment Plant**

呼吸率
Respiration



与实际相符

Good correlation to real value

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6. 污泥活性 / Sludge activity

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- 改变污泥活性 Sludge activity changes
- 曝气过程中需要足够的活性污泥
  Aeration process needs sufficient amount of biomass
- 抽取污泥过程需要耗电
  Pumping process of the sludge consumes electricity

测量污泥活性的原因 **Reasons to measure sludge activity**

- 控制和优化污泥回流 Control and optimize the sludge return

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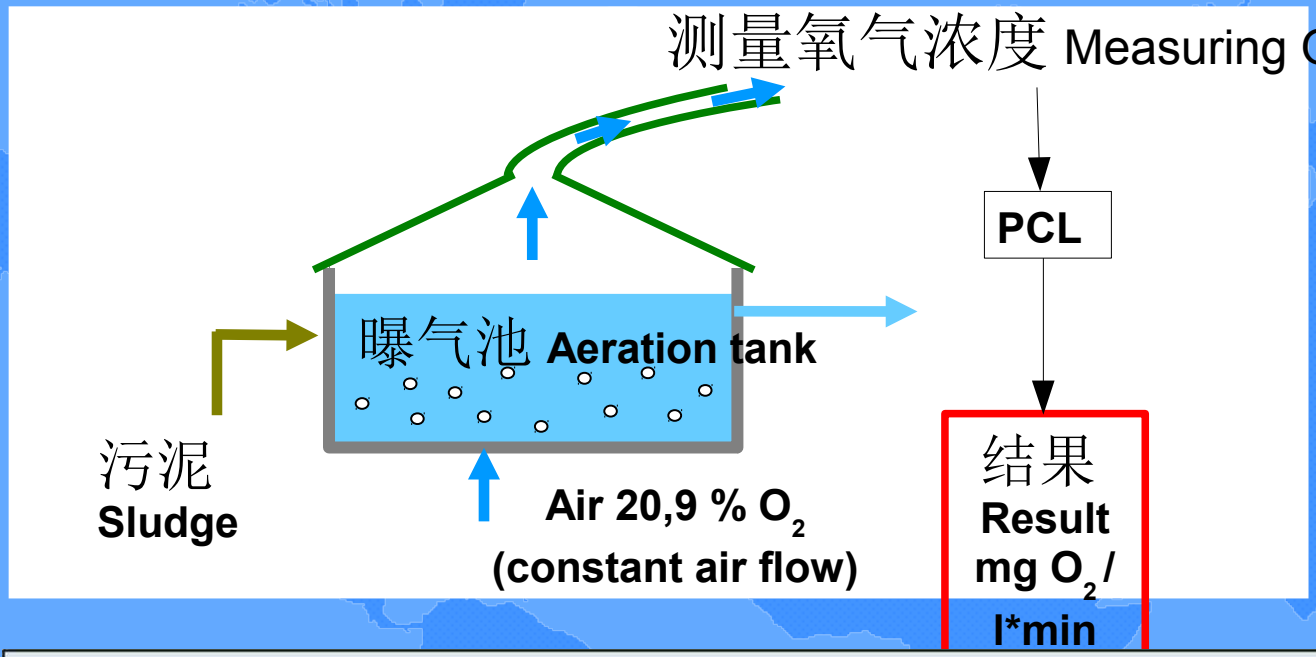
6. 污泥活动 / Sludge activity

测量污泥活性 / Measurements for sludge activity



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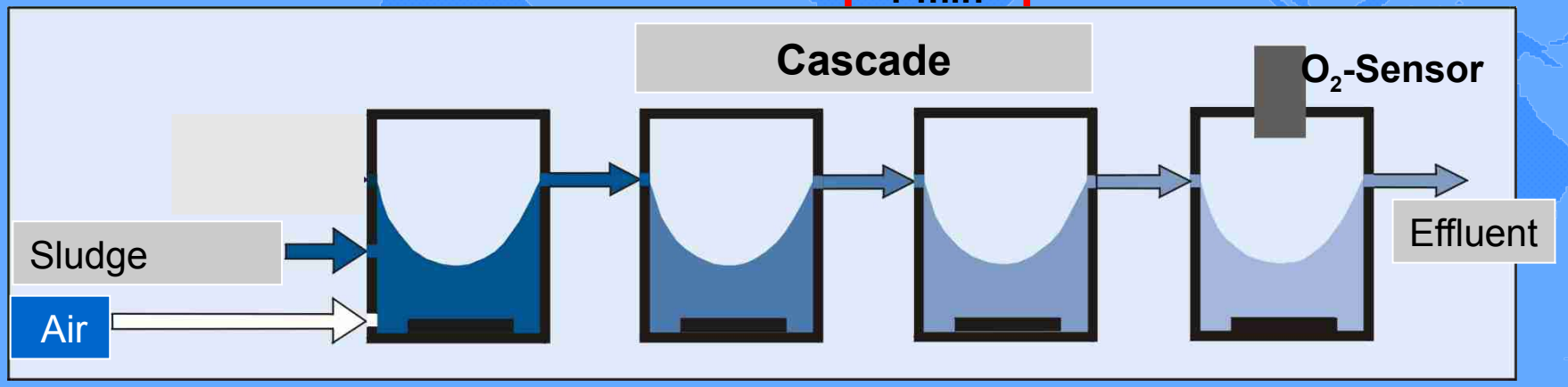

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6. 污泥活动 / Sludge activity

毒性测量
Toxicity measurement

硝化作用 Nitrification

Sewer
Screen
Grit Chamber
Primary Treatment
Aeration Tank
Final Clarification
Membrane
Gas Tanks
Block Heating Works
Sludge Thickening
Digestion
Sludge Thickening
Dewatering
Sludge Incinerator

硝化抑制率的风险
Risk for nitrifying inhibition

毒性测量
Toxicity measurement

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7. 硝化干扰 / Nitrification Disturbance

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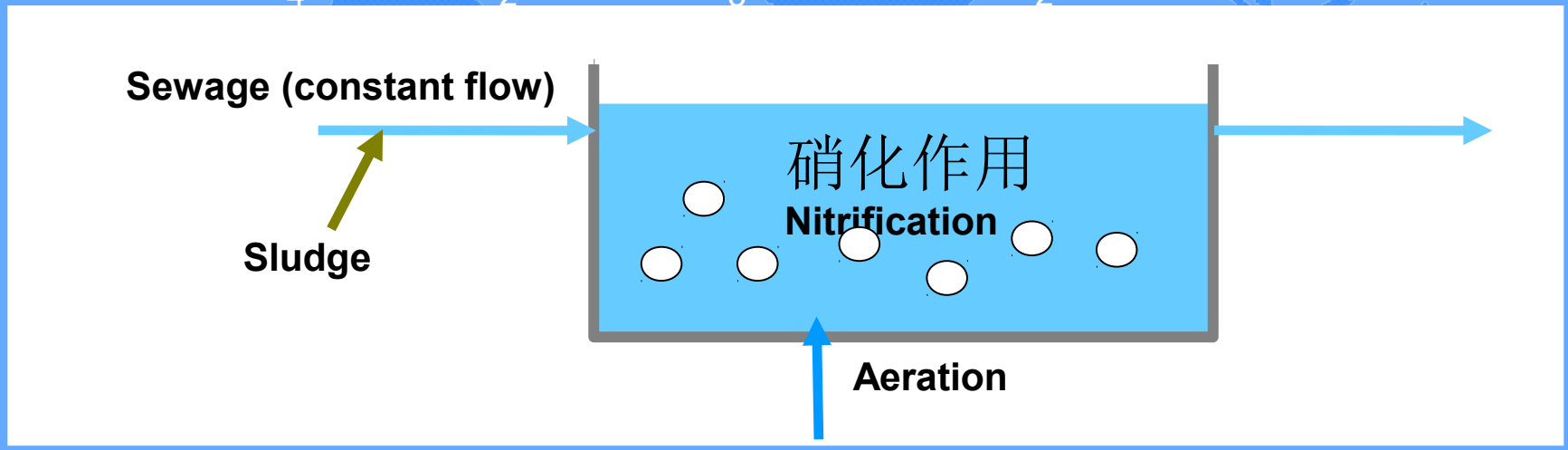
如何使用硝化菌测量毒性

Measurement of Toxicity to the Nitrifying Bacteria

硝化作用 Nitrification:

- 氨氧化成硝酸盐
  Oxidation of ammonia into nitrate

- 反应方式
  Reaction: $NH_4^+ + 2\ O_2 \rightarrow NO_3^- + 2H^+ + H_2O$



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7. 硝化干扰 / Nitrification Disturbance

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毒性物质可能导致的后果

Consequence by exposure Nitrifying-Inhibitors (Toxicity)

- 对化学品敏感的硝化菌
  Nitrifying bacterias are very sensitive against harmful chemicals

- 有害物质抑制硝化反应
  Many harmful substances inhibit nitrifying activity

- 低浓度：范围 0.01-10 毫克 / 升
  Low concentration, range 0,01 – 10 mg/l as example
  Take 1 mg/l → 1 g/ m³, 1 kg/ 1000 m³

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7. 硝化干扰 / Nitrification Disturbance

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毒性物质可能导致的后果

Consequence by exposure Nitrifying-Inhibitors (Toxicity)

- 增加曝气？只会增加能量，没有帮助！
  Increasing the aeration?
  Only waste more energy. Doesn't help.

- 唯一的办法？去除硝化抑制物！
  The only way:
  Keep Nitrifying inhibition substances **out**!

- 如何了解到？ 测量，并且及时测量即可！
  How do you know?
  Measure it constantly and early enough!

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7. 硝化干扰 / Nitrification Disturbance

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如何测试毒性 / How to Measure the Nitrifying Toxicity?

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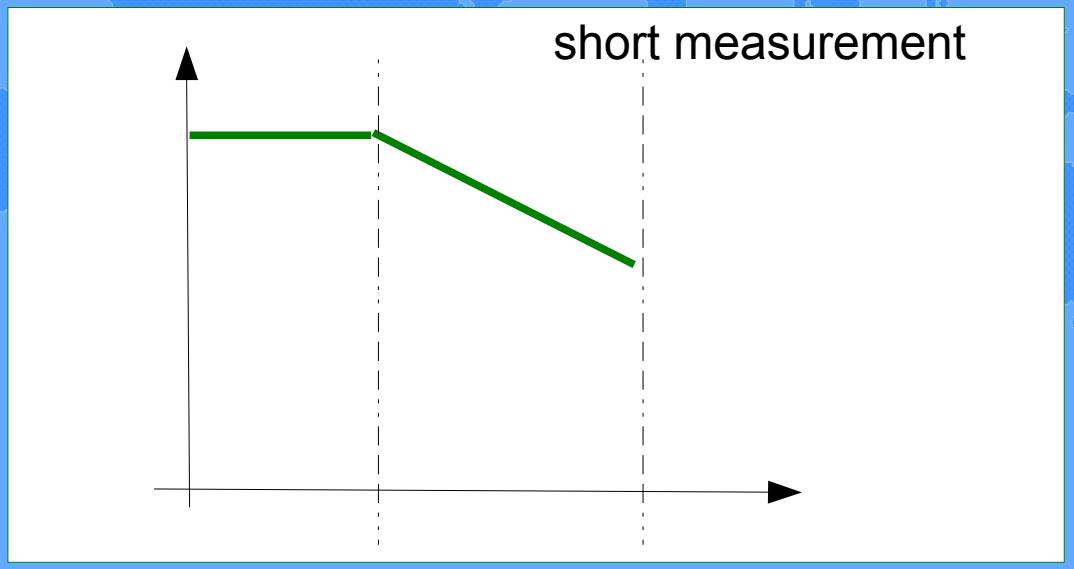
- 快速相应是重要的
  Fast uptake rate measurement is important
- 溶阳电极可以适用
  here DO – sensors can be suitable
- 光学溶氧电极传感器：与其它化学法相比更加精确测量
  but, only the ”optical” DO Sensors:
  - low on ”matrix” effects with other chemicals



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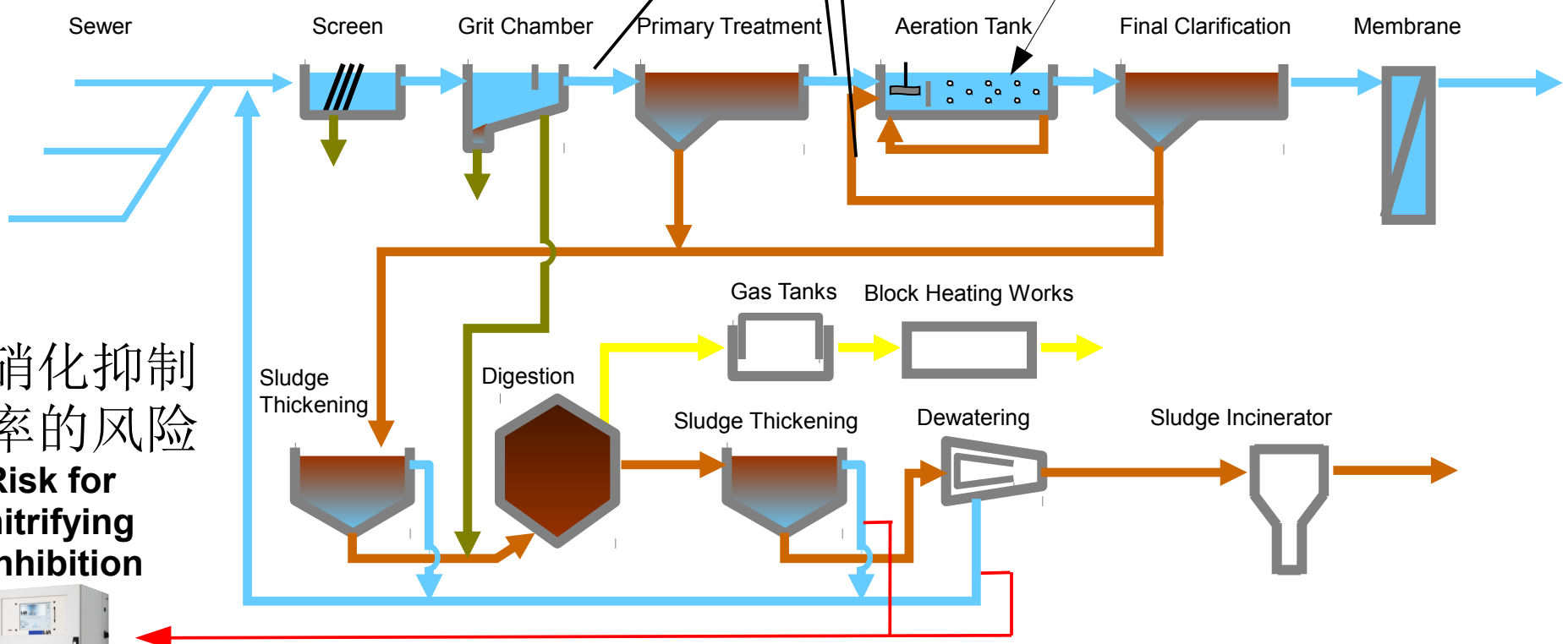
8. 总结 / Summary

呼吸率 毒性

Respiration (BOD)Toxicity



硝化抑制率的风险

Risk for nitrifying inhibition

毒性监测

Toxicity measurement

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8. 总结 / Summary

1. 呼吸测量能够节省能量，意味着节省费用
   Respiration measurement enables **energy=money** saving

2. 污泥活性测量的重要性
   Measurement of sludge activity is important

3. 防止有毒化学品对硝化菌的抑制
   Protection of the nitrifying bacterias against harmful chemicals (inhibitors) is necessary

4. 通过恒定负荷策略优化处理
   Optimization through constant load strategy

5. 调节氧化曝气达到最佳需求
   Adjust the O_2 - blowers and pumps to the optimal O_2 - demand

6. 怎样的分析仪适用
   What analysers are available and serve these purposes?

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BioMonitor®

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BioMonitor®

在线呼吸测量 On-line Respiration (BOD)

- 测量范围 BOD: 1-200,000 mg/l
- 测量单位mg/l Respiration in mg/l
- 高降解率 High degration
- 反应时间3至60分钟
  Response time from 3 to 60 min
- 污泥的活性 Sludge activity
- 采用工厂自身活性污泥 using plants own biomass

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NitriTox®

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NitriTox®

在线毒性 On-line Toxicity

- 测量范围：0-100% Toxicity: 0-100 %
- 反应时间小于5分钟 Response time < 5 min
- 毒性监测 Toxicity monitoring
- 消化菌具有自我再生功能
  Self-regenerating culture of nitrifying bacteria
- 高灵敏度 Highest sensitivity
- 无记忆效应 No memory effects
- 低维护成本 Low operation cost

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谢谢

Thank you

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