Emerging Issues in Source Water Management
and Strategies for Addressing New Drinking Water Regulations
Indianapolis, April 12-13 2006

Control of Cryptosporidium and Giardia in Drinking Water– European Perspective

Dorothée LENES
Technical Direction
Sanitary Risk, Water Quality and Resources department
Veolia Water France

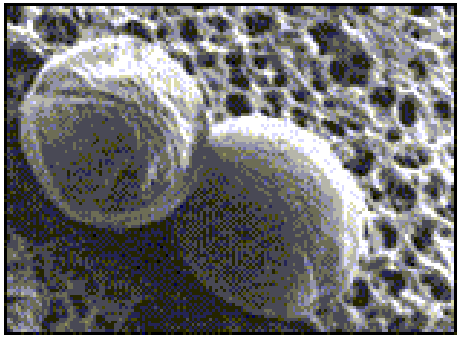
Dr. Chandra MYSORE
Director, Drinking Water Treatment Operations Technical Support
Veolia Water North America

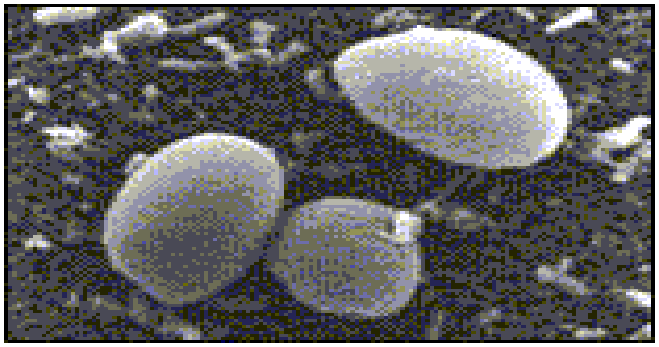
CONTENTS

- **1.RECOMMENDATIONS for Crypto/Giardia control in WTP (French approach)**
- **2.ADVANCED TREATMENT:**
  - **2.1.UV (French perspectives)**
  - **2.2.Membranes (UK perspectives)**

VEOLIA WATER

1. RECOMMENDATIONS in WTP (VW French approach)





1.1.French context

- **Regulation:**
  - No regulatory limit on Cryptosporidium or Giardia in the Drinking Water
  - No regulatory performance target for the drinking-WTP
  - Regulation : « water must not contain a quantity of microorganisms, parasites, or other substance that can cause a human health threat. »

  - Monitoring:
    - Index of faecal contamination (quality standards): E.coli, enterococci
    - Indicators of treatment efficiency (guidelines): turbidity, anaerobic spores

- **Resource contamination:**
  - Resources are frequently contaminated by both parasites, as water resources in other countries

- **Several outbreaks due to parasites**

VEOLIA WATER

1.2.Recommendations for Veolia Water operators in France

- **Identification of vulnerable resources :** surface water and groundwater under the influence of a surface water
- **Monitoring:**
  - Increased monitoring of Index/Indicators in treated water (vs regulatory frequencies)
  - Parasites raw water monitoring recommendations
- **Continuous monitoring of turbidity** in the filtered water
  (Goal: < 0,3 NFU – Regulatory guideline: < 0,5 NFU)
- Assessment of the sanitary risk for the consumer with a simple **risk assessment tool**

VEOLIA WATER

1.2.Recommendations for Veolia Water operators in France: risk assessment

- **Objectives of the tool:**
  - **Interpretation of raw water analysis results**
  - **Determination of a risk-based performance target (log reduction) for each site**

- **How ?**

  Risk assessment on the basis of:
  - **Concentration of Crypto/Giardia in raw water**
  - **Performance of the treatment plant**

VEOLIA WATER

Use of the risk assessment tool: performance of the WTP

TRAITEMENTS PHYSIQUES

TRAITEMENTS	Abattement CRYPTOSPORIDIUM et	
	Min	Max
Coagulation / floculation / décantation	0,5	1
Coagulation / floculation / décantation floc lesté ou lit de boue pulsé	1,5	2,5
Flottation	1,3	3
Filtration simple	0,5	1
Coagulation sur filtre	1	2
Clarification + Filtration	1,5	4
Filtration lente biologique	4	4
Microfiltration	5	>5
Ultrafiltration	5	>5

TRAITEMENTS CHIMIQUES

Les Ct donnés ici sont issus de la littérature : ce sont des Ct moyens.
Il est recommandé aux utilisateurs d'appliquer ces valeurs aux Ct10.

	CRYPTOSPORIDIUM					
	Valeurs correspondant au traitement habituel		Valeurs de Ct (ou dose pour les UV) pour un abattement de :			
Procédé de traitement	Ct ou dose	Log	0,5 log	1 log	2 log	3 log
Ozone	1,6 mg/l.mn	0,5		2,9 mg/l.mn	5,3 mg/l.mn	
Chlore	15 mg/l.mn	0		7000 mg/l.mn	4000-8000 mg/l.mn	
Dioxyde de chlore	12 mg/l.mn	0		52 à 200 mg/l.mn	140 à 520 mg/l.mn	
UV	10 mJ/cm2	2,5 à 3	1,6 mJ/cm2	2,5 mJ/cm2	5,8 mJ/cm2	10 - 12 mJ/cm2
	40 mJ/cm2	>3				

	GIARDIA					
	Valeurs correspondant au traitement habituel		Valeurs de Ct (ou dose pour les UV) pour un abattement de :			
Procédé de traitement	Ct ou dose	Log	0,5 log	1 log	2 log	3 log
Ozone	1,6 mg/l.mn	> 2,5	0,23 mg/l.mn *	0,48 mg/l.mn *	0,95 mg/l.mn *	1,43 mg/l.mn *
Chlore	15 mg/l.mn	0,5	17 mg/l.mn *	35 mg/l.mn *	69 mg/l.mn *	104 mg/l.mn *
Dioxyde de chlore	12 mg/l.mn	1,5	4 mg/l.mn *	7,7 mg/l.mn *	15 mg/l.mn *	23 mg/l.mn *
UV	10 mJ/cm2	2,5 à 3	1,5 mJ/cm2	2,1 mJ/cm2	5,2 mJ/cm2	11 mJ/cm2
	40 mJ/cm2	>3				

* A 10°C

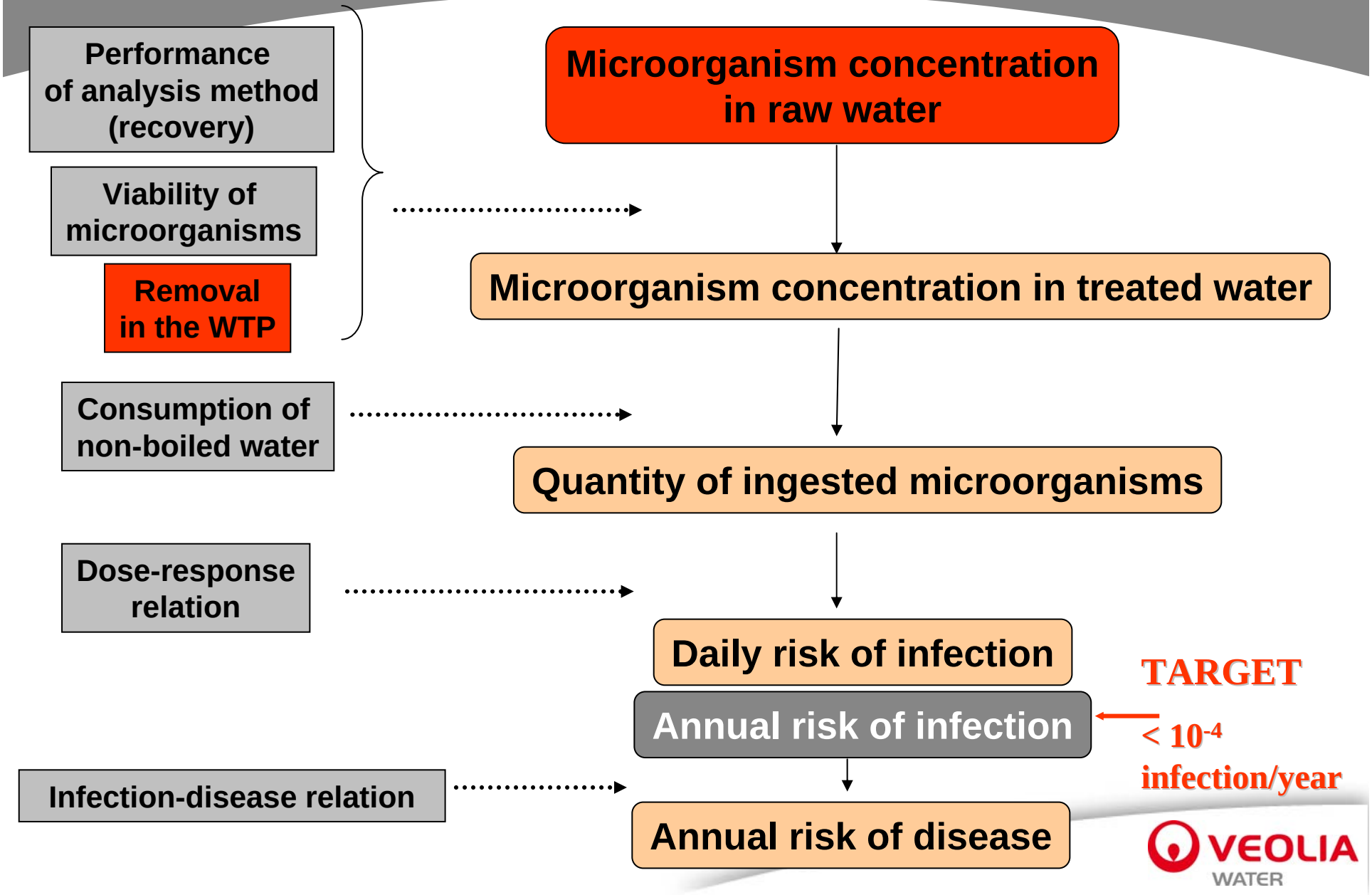
Literature data:

US-EPA, WHO, AFSSA

(Food Sanitary Safety French Agency)…

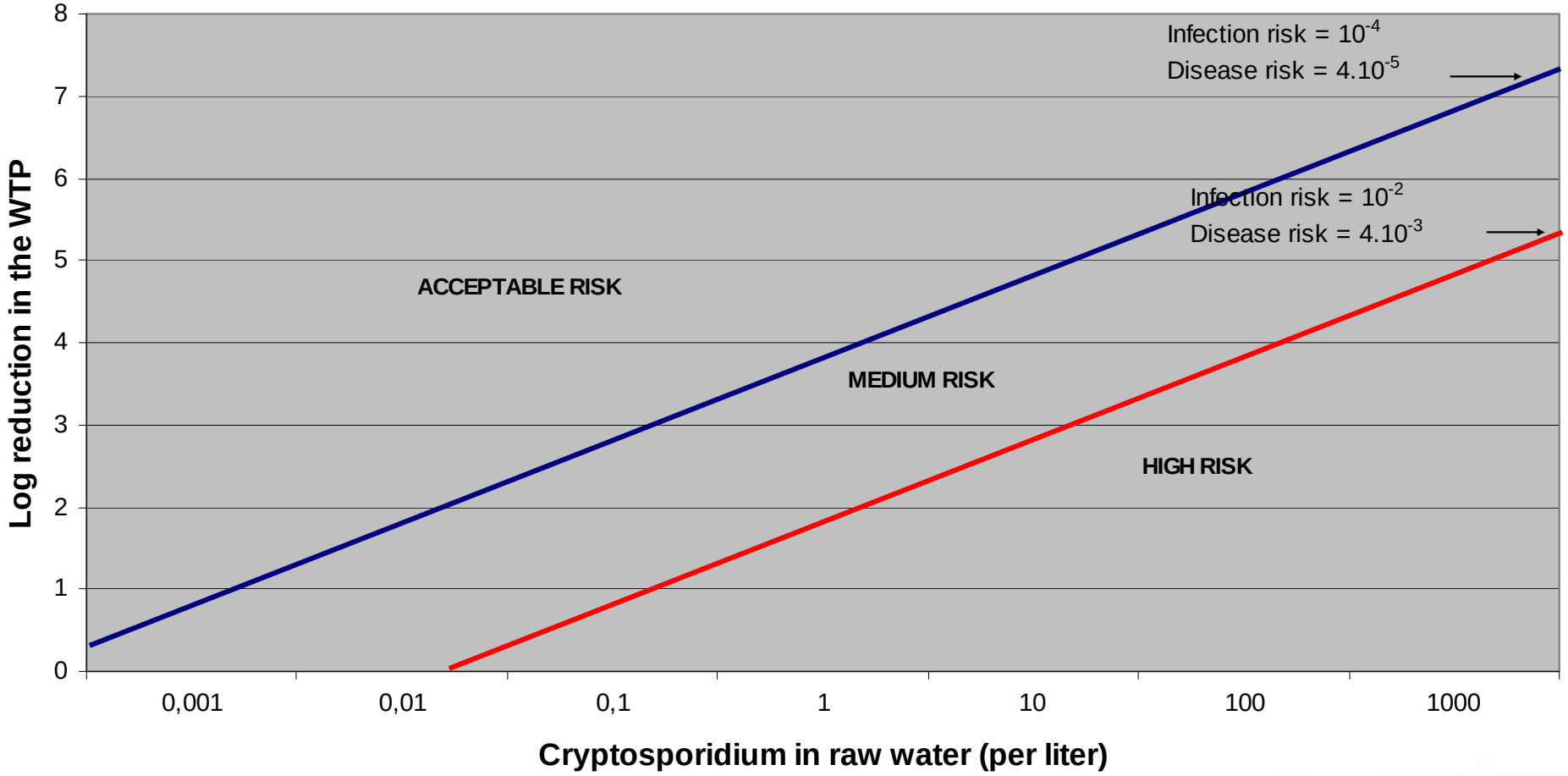
VEOLIA WATER

Principle of the risk assessment tool



Principle of the risk assessment tool

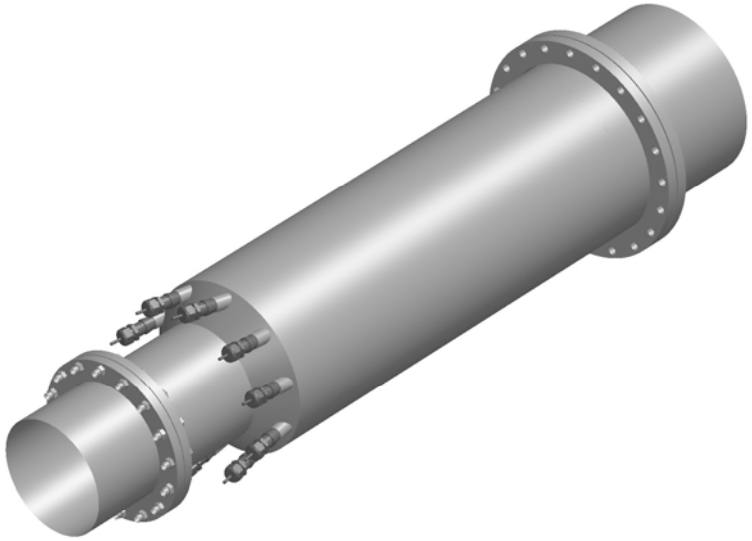
EX: CRYPTOSPORIDIUM



VEOLIA WATER

2. TREATMENT:

2.1. UV



Desinfection treatment and Cryptosporidium removal

- **Chlorine and Chlorine dioxyde:**
  - Very low reduction of parasites (for usual CT in WTP)
  - Desinfection by-products: chlorites, THM, others (HAA…)

- **Ozone:**
  - Better reduction of parasites (but still low for Cryptosporidium for usual CT and low T)
  - Desinfection by-products: bromate

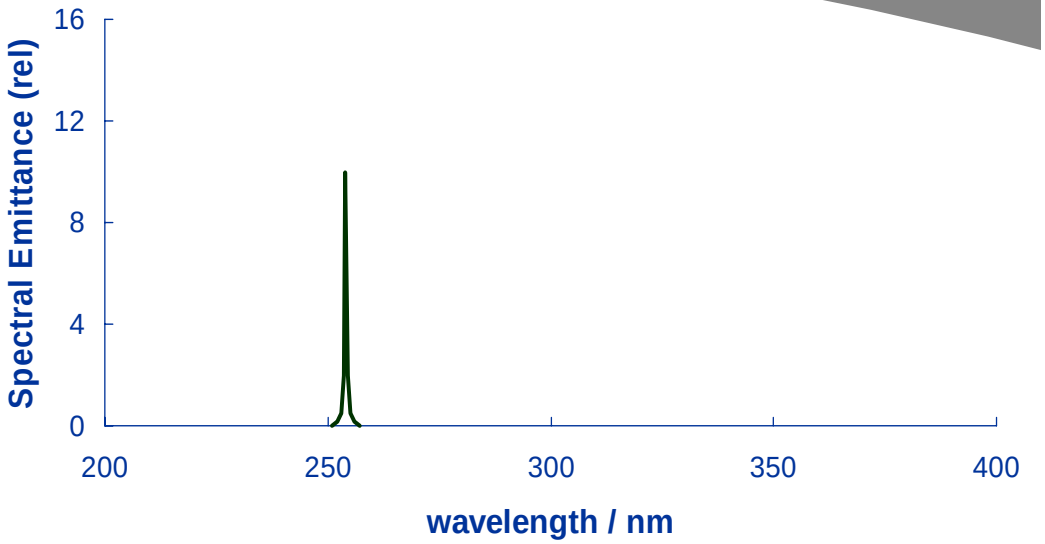
- **UV:**
  - Good inactivation of Cryptosporidium
  - No desinfection by-product

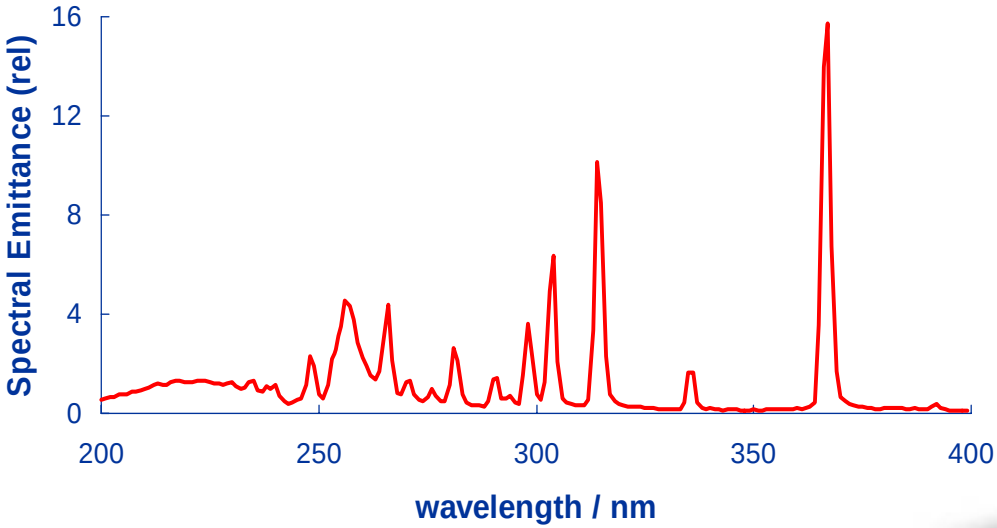
VEOLIA WATER

Low-pressure lamps / Medium-pressure lamps

Low-pressure lamps

Monochromatic





Medium-pressure lamps

Polychromatic

VEOLIA WATER

LP / MP : advantages / disadvantages

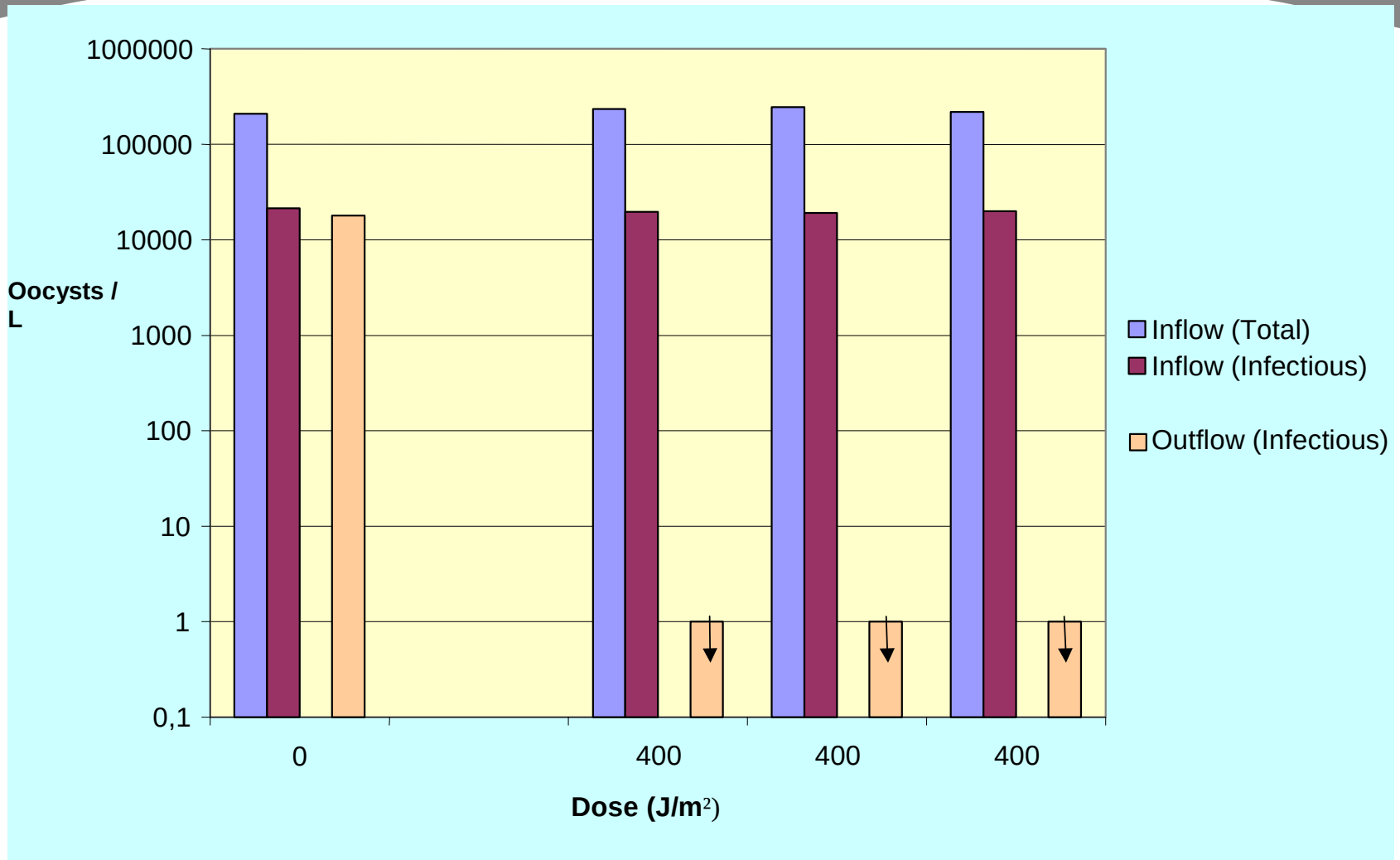
	LP lamps	MP lamps
Life time	16 000 h	8 000 h
Number of lamps	high	low
UV efficiency	25 – 35%	10 – 15%
By-products formation	No	No (if quartz sleeve with free O3)
Electrical consumption	low	high

Cryptosporidium:

Same inactivation for the same germicidal dose (Veolia Water experimental studies, 2004-2005).

VEOLIA WATER

UV efficicency vs CRYPTOS & GIARDIA

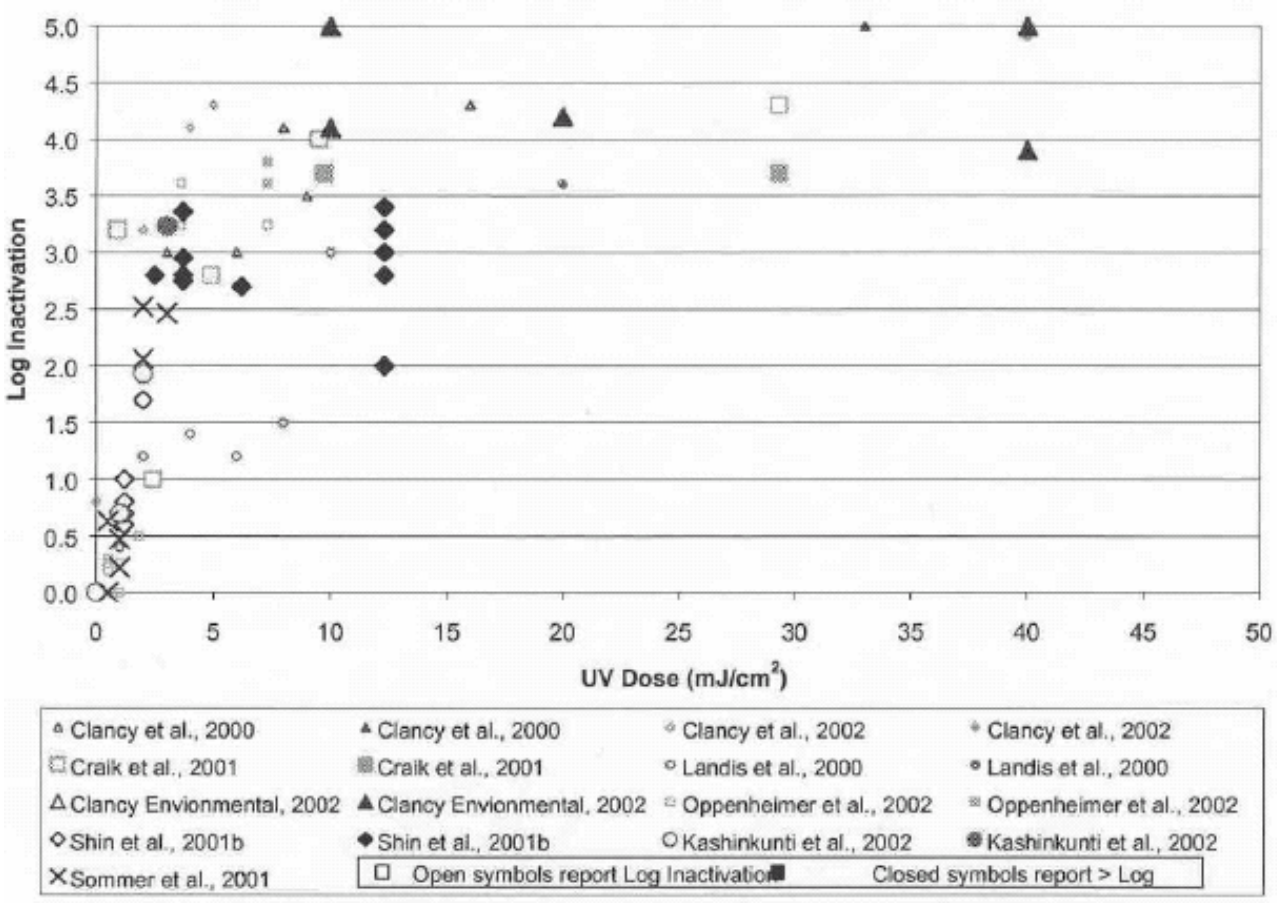


Inactivation results for *Cryptosporidium parvum*
Medium-pressure tests VW 2003

VEOLIA WATER

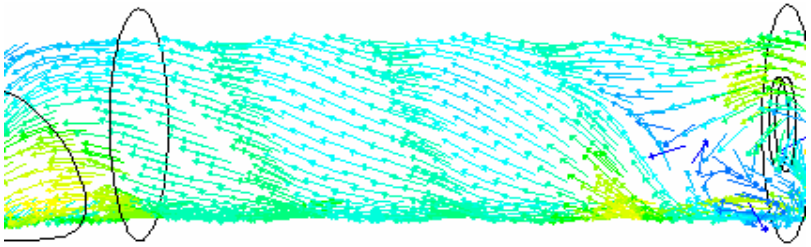
UV efficiency vs CRYPTO & GIARDIA

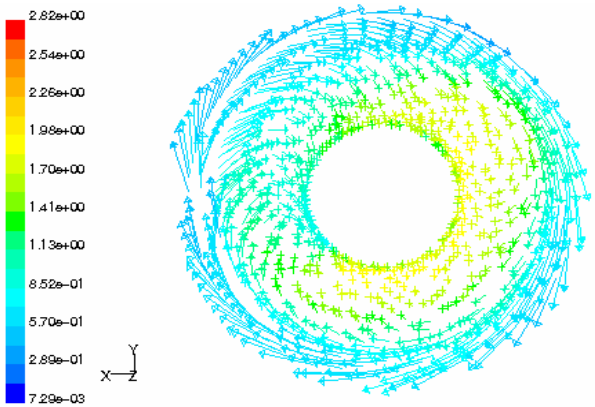
UV inactivation data for Cryptosporidium



Parameters influencing the process efficiency

- **Transmission of UV in water**
- **Lamps aging**
- **Hydraulical design of the UV-reactor**
  - **Distance between lamps**
  - **Homogenous exposure time in the UV-reactor**





Hydraulical modelisation
with CFD calculation

VEOLIA WATER

Validation of a UV installation

- **MP lamps in France:** « VW Solutions and Technology » is the only company who has an agreement
- **LP lamps are authorized in France**:
  - Reference text: Circulaire DGS/PGE/1 D of the 19th january 1987

  « *The UV dose, which is the product between the intensity of UV radiation and the exposure time, is higher than 25000 µW.s/cm²* »
- **Interpretation:** the minimum dose in the dose distribution should be higher than 250 $J.m^{-2}$: no recommendation for the verification !
- **In Europe:** 2 leader countries concerning the UV regulation:
  - Austria: ÖNORM M 5873-1 (Low Pressure) et Draft ÖNORM M 5873-2 (Medium Pressure)
  - Germany: DVGW W 294
- **2 main obligations:**
  - Reduction Equivalent Dose (RED) of 400 $J.m^{-2}$ determined on biodosimetry tests on *Bacillus subtilis* spores
  - Standardized removable UV-sensor

VEOLIA WATER

UV technology for Crypto/Giardia control: conclusion

- **Efficient technology**
- **Not yet widespread in France**
- **Good solution when:**
  - **Contamination of the water resource**
  - **Unsufficient treatment (ex: groundwater with simple chlorination)**
- **Probably more and more implemented in the years to come**

MP-UV installation in Divonne-les-Bains (France)

200 m3/h

VEOLIA WATER

2. TREATMENT:

2.2. Membranes

Introduction

- Drinking Water Inspectorate (DWI) introduced regulations for monitoring Cryptosporidium in 1999.
- Due to the nature of the analytical method, the infectivity of an oocyst cannot be conclusively determined.
- Hence, inactivation treatments for *Cryptosporidium* (e.g. Ozone or UV) cannot be used in the UK as a means to meet the *Cryptosporidium* regulations.
- Only by changing the nature of the source water or by installing an approved membrane system can the site be moved to no longer being at risk.
- There is regulatory need to ensure that the membrane is capable of removing all particles greater than one micron.
- Treatment Standard is < 100 oocysts per 1000 litres.

VEOLIA WATER

Clay Lane WTP

- Clay Lane, which had previously seen *Cryptosporidium* oocysts in its raw waters was deemed to be “at significant risk” of breaching the treatment standard.
- As there was no physical barrier to *Cryptosporidium* at Clay Lane, it was decided that a membrane plant should be built.
- The plant, commissioned in April 2001, is one of the largest potable water ultrafiltration plant in the UK.
- Capable of treating 160 ML/d (42 MGD)
- The approved membrane system has to be capable of continuously removing or retaining particles greater than one micron in size, backed by an integrity testing system.

VEOLIA WATER

Plant Design

- Clay Lane takes water from eight borehole sources in the Bushey and Watford area to the North West of London. Water is drawn from a chalk aquifer and is normally of good quality although occasionally susceptible to surface ingress.
- Average daily output is 118 ML/d (30 MGD), although this can be increased to 160 ML/d during peak demand. The combined abstraction capacity of the boreholes is 210 ML/d.

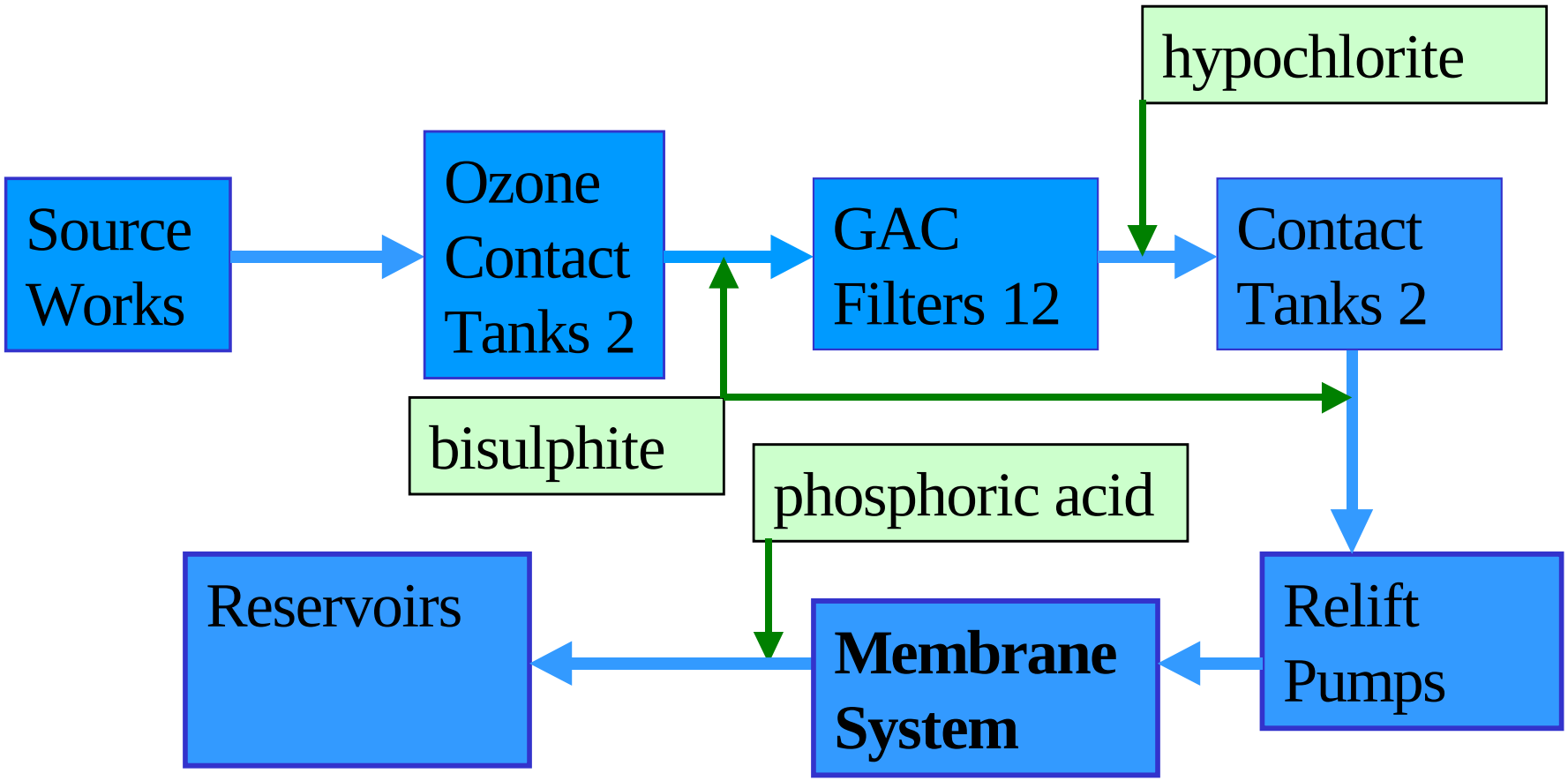
VEOLIA WATER

Raw Water Quality

Parameter	Range
Water Temperature (°C)	9-11
pH	6.8-7.3
Alkalinity (mg $CaCO_3$/L)	327-337
Color (pcu)	23-300
Bromide (μg/L)	90-209
TOC (mg C/L)	1.3-4.1
Turbidity (NTU)	0.1-2.4

VEOLIA WATER

PLANT SCHEMATIC



VEOLIA WATER

Plant Design

- Prior to the membrane installation, turbidity control was largely on borehole management. Ozone and GAC were in place for pesticide removal.
- Filtration units are of Norit Membrane systems using the X-flow XIGA concept elements.

- At a pore size of 0.02 to 0.03 microns it will remove 99.999% of;
  - bacteria
  - most viruses
  - Cryptosporidium

- Maximum gross flux rate is 132 LMH (75 GFD)

VEOLIA WATER

Plant Design

- **The primary membrane plant consists of 32 primary filtration units, each of which operates as an individual filter in dead end mode with its own flow control. Each filtration unit has12 housings, which contain 4 membranes elements. Each element contains approximately 9300 fibres.**
- **The secondary plant, for back wash water recovery has 12 housings with 2 membrane elements in each. 0.1% of the plant flow goes to sewer.**

VEOLIA WATER

VEOLIA
WATER

CONCLUSIONS

- **The installation of the membrane plant at Clay Lane has resulted in greater security of supply whilst ensuring that the water quality is of the highest standard.**
- **Membranes are a highly effective way of dealing with Cryptosporidium and changing turbidity, forming an absolute barrier against particles greater than one micron in diameter.**

VEOLIA WATER