



Automated online Microbiological water quality monitoring is possible now

A perfect fit for securing the water is free of microbes

2015 Arizona Water Reuse

Session 4A: Additional Topics

Joep Appels / microLAN BV



- When we look back, is this the future?
- 1983: the last year that Lake Mead was officially full.....



http://time.com/3933614/lake-mead-record-low-water-shortage/





2015 Arizona Water Reuse Symposium

- Introduction microLAN
- Introduction online microbiological
- monitoring
 - Overview applications / customers
- International perspectives of Watereuse
- Conclusions
 - We have to look back to the future....





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On-line Biomonitoring Systems

- MicroLAN: micro Luminescence Analysis Netherlands:
 - MicroLAN BV: Waalwijk, the Netherlands
 - MicroLAN Shanghai Zean

Market leader in non-chemical monitoring

- ¹ 1st on-line Toxicity monitor using luminescent bacteria (in 2004)
 - 250+ installations world-wide
 - Key references with US EPA, Veolia, Suez, SAB Miller etc.
- Unique systems for monitoring of toxicity of chemical contaminations.
 - water intake protection -> Drinking water / food
 - river water monitoring -> Rhine, Danube, Yellow River
 - wastewater monitoring (influent / effluent).

01-02-1995

Vught 3 Eindhoven 30 Maastricht 122

Back to the future ?

Just 16 million people
4 International River Basins
1/3 below sea level
1/3 depending on surface water for drinking water supply
Rising levels in rivers and the sea....

Vught-Centrum

Tilburg

A65







WTP's are required to treat

wastewater to kill bacteria before

discharging the effluent into streams or rivers, by using either chlorination, ultra-violet light, or ozone.

However various pathogens have been shown to persist through the

wastewater treatment process.

It is extremely important to keep WTP's maintained and functioning properly, <u>to</u> <u>decrease the amount of</u> <u>contaminants discharging into</u> <u>rivers</u>.



microLAN "CONTROL"-Line Monitoring Systems, for Early Warning and Trend Monitoring of

Algae, Bacteria & Chemicals

BE IN CONTROL OF YOUR WATER QUALITY!

Water (intake)protection







250+ installations Worldwide

Drinkingwater protection & Event monitoring

- Amsterdam Waternet
- Washington, Fairfax Water
- US EPA Cincinnati
- Beijing Olympics
- Shanghai World Fair

Large Projects

- Henan Prov., CN 14x
- Zhejiang Prov. CN 10x
- Heilongjiang Prov. CN 10x
- River Monitoring:
 - Rhine, Elbe, Danube
 - Yangtze, Pearl, Yellow, Huaihe, Huaghe

Other Projects

- SAB Miller, Colombia
- Gelatin Manufacturers
- Min. of Defense NL
- Various R&D projects.

South to North

Program China



CONTROL Monitoring product Line





High Frequency / Low Quality data

Chemical toxicity monitoring **TOXcontrol**





Our goal:



Develop a monitoring platform

- For screening of drinking water safety
 - It's a indication of (a change in) bacteria activity
- For identification of different bacteria (groups)
 - > presence / absence of these bacteria





- Trend monitor and Early Warning System for microbiological (Faecal) contamination
- Enzymatic reaction with fluorescence detection
- 2-3 h detection, bigger sample volume(up to 5L) better statistics compared tolab (cultivated) methods (but correlationis location depending)
 - Developed for the drinking water industry but now applied for Watereuse applications within several EU projects
 - After the disinfection but before the distribution



BACTcontro

micro

On-line Biomonitoring Systems



Specifications







Without the filter >5 - 10.000 cfu in < than 1 hour

- Based on Fluorescent measurement of specific enzymatic activity:
 - B-Glucuronidase-> indicates E.coli activity
 - B-Galactosidase-> indicates Coliform activity
 - Alkaline Phosphatase -> Total Activity
 - Enterokokken (2015 with KWR)
 - Sample volume: 100 5.000 ml
 - Filtration over a 0,45 my Ceramic filter
 - Detection: 1-5 cfu per 100ml (depending on sample volume)
 - Short measuring intervals (2-3 hours) up to 6 per day (+ additional blanks)
- Filter changing: 75 to 450 measuring cycles (depending on the turbidity).

Fluidics BACTcontrol





Fluidics BACTcontrol



- Sample going into the reaction chamber
- Sample is filtered and E.coli stays in the reaction chamber
- Filtered samples goes to waste
- Buffer is added
- EC solution (B-Glucuronidase) is added and reacts with the enzyme in the bacteria
 - A fluorescent compound is released which is measured by the Fluorimeter





Initation	Filtration	Measurement	Cleaning
5 minutes	1 – 300 min.	< 60 minutes	< 60 minutes
System filling	0,2 – 1 ml/s	Temp. 36-44 C. 96.8 - 111.2 F	Temp. 65 C. = 149 F.
Rinsing & cleaning	Volume depending	Heating of rector	Heating of reactor
All pumping operations through the filter in reverse direction	Filter condition depending	Buffer & reagent dosing & stabilisation. Stepwise	Disinfection of system with chlorine solution
		measurement of the fluorescent signal	

BACTcontrol : Functionality





BACTcontrol: Comparison







TABLE 1 – Accuracy of GLUase activity measurement, Escherichia coli abundance estimated by the miniaturized MPN method and FC plate counts in three different contaminated river water samples

Sample	GLUase activity		Escherichia coli	i	FC	
	(pmoles MUF∙min ⁻¹ ·100 ml ⁻¹)ª	CV ^b	(N·100 ml ⁻¹) ^a	CV ^b	(N·100 ml ⁻¹) ^a	CV ^b
1	6.7 ± 0.5	8	1218 ± 381	31	540 ± 142	28
2	80 ± 12	15	7880 ± 8259	105	14040 ± 3179	23
3	590 ± 87	15	29540 ± 15853	54	52000 ± 12981	25

The three measurements were repeated 5 times on each sample and the mean, standard deviation, coefficient of variation were calculated.

^a Mean ± standard deviation; ^b the coefficient of variation was calculated as the standard deviation divided by the mean and multiplied by 100.

An early warning method to detect faecal contamination of river waters Servais et al 2005

MPN = Most Probable Number / FC = Faecal coliforms



Trends in Analytical Chemistry, Vol. 44, No. , 2013

Table 2. Results for the application	n of the reported techniques for bacteriolog	gical detection of water s	amples	
Type of technology	Parameters analyzed in water samples	LoD	Analysis Time	Ref.
Light scattering	Cryptosporidium E. coli	1 oocysts/mL 1000 CFU/mL	60 min Continuous	[15,55]
ATP luminescence	Total microbial biomass	200 CFU/ml	5 min	[59]
Immunoassays	Bacillus anthracis	100,000 CFU/mL	15 min	[18,60]
	Legionella pneumophila	800 CFU/mL	180 min	
Polymerase chain reaction (PCR)	E. coli, Enterococci,	15 CFU/100 mL	3 h	[24,26]
-	Legionella pneumophila	100 genomes units/L	3 h	
Enzyme fluorescence	E. coli, total coliforms	50 CFU/100 mL	1 h	[32,33]
FISH	E. coli	100-100 CFU /mL	2 h	[61]
		10 CFU /100 mL	10 h	
Molecularly-imprinted polymers	Bacillus	not specified	1 day (plus bead synthesis)	[37]
Electrochemiluminescence (ECL)	E. coli, Salmonella	1000 cells/mL	1 h	[62]
Raman spectroscopy	E. coli	1000 cells/mL		[45]
Dye-loaded microspheres	E. coli	1000 cells/mL	1 h	[63]

On-line bacteriological detection in Water. Trends in Analytical Chemistry, Vol. 44, No. , 2013, Ramon Lopez-Roldan, Pol Tusell, Sophie Courtois, Jose Luis Cortina

We can concentrate up to 5,000 ml !

Trends



Overview of customer & applications

- -Ground water intake: -IWB Basel, Switzerland
- Drinking water intake:
 - Water Utility Denmark
- Reclaimed water
 - -Waste water utility Spain



IWB Basel, CH

BACTcontrol





IWB Basel, CH

BACTcontrol

microLAN

On-line Biomonitoring Systems



IWB Basel, CH







Enzymatic bacteria monitoring (**blue line** = BACTcontrol) compared with Flow Cytometry (red dots) -> Good correlation with surrogate detection -> this is a process monitor !



- A Danish drinking water facility determining a contamination using the BACTcontrol
- The graph shows an increase in enzyme activity date 6/5-2014 and suddenly a high peak in coliform activity. The water works reacted on the first rise in activity, and water from the water work was not used as drinking water, when the high contamination occurred.





According to the Spanish legislation for reclaimed water, it is set an extensive control (and disinfection) of the load of E. coli in treated water:

						USOS DEL	AGUA REG	ENERADA						
	USOS UF	RBANOS	US	OS AGRÍCOL	AS	uso	S INDUSTR	ALES	USOS REC	REATIVOS		USOS AMB	ENTALES	
VALORES MÁXIMOS	Residenciales	Servicios urbanos	CALIDAD 2.1	CALIDAD 2.2	CALIDAD 2.3	CALIDAD 3.1	CALIDAD 3.2	CALIDAD 3.3	CALIDAD 4.1	CALIDAD 4.2	CALIDAD 5.1	CALIDAD 5.2	CALIDAD 5.3	CALIDAD 5.4
E.coli UFC/100ml	0	<20	100	1000	10000	10000	1000	0	200	10000	1000	0	No se fija límite	Se estudia en cada caso





Compared with lab:

- Membrane filtration
- Incubation
- Chromogenic TBX
- culture medium 24 h



E.coli load at different stages of the treatment plant



Watereuse in Spain



- The BACTcontrol was used to study the reliability, functionality and possible correlation between the online results with lab results, on a WWTP in South Spain
- Some conclusions are that there is a good correlation between online and laboratory results(as shown in the graph), and with the use of the online BACTcontrol any method of disinfection can be automated.
- Red line = BACTcontrol / Blue Line = lab results / Green Line = flow of Waste water





- Some international Watereuse applications (where microLAN is involved)
 - River Rhine
 - China



The perspective is depending on the location....





- length: 1,320 km
- catchment area: 185,000 km²
- inhabitants in c. a.: ~ 50 Mio.
- drinking water for: 5.5 Mio inhab.
- shipping:
- ~ 11,000 ships
- ~ 175 Mio. tons
- ~ 1/3 hazardous freight
- 50 % of Europe's chemical industry in catchment area





20 million of the 50 million people who today live in the Rhine watershed drink treated Rhine water which in most cases is produced from riverbank filtrate and (in NL) direct abstraction

Rhine water that has been cleaned when percolating different layers of earth and gravel for months is mostly being delivered from wells.

The raw water then undergoes several treatment procedures in the water works.

Diluted Waste water !





The Rhine has always transported too large amounts of suspended matter to allow perfect drinking water quality.

The Romans already led Rhine through an aqueduct from the Eifel mountains to Cologne.

Today, requirements to drinking water quality are much more strict than those applicable to mineral water.



The Chinese way solving water shortage





Field trials online bacteria monitor



Netherlands:

- Watereuse Municipal WWTR Kaatsheuvel
- Municipal WWTP + sandfilter / biofiltration
- For golf park and amusements park



Aquavalens FP7 EU research projects: 🔭 AQUAVALENS

🔪 Spain

- Aguas de Barcelona, drinking water utility, part of Suez
- Trial starts end of the year, within the FP7 Aquavalens

Germany:

- Validation with TZW Karlsruhe (research institute)
- First starting on lab, within the FP7 www.Aquavalens.org

Watereuse -> WSBD - > Efteling





6. And finally to the amusement park



- Pathogen reduction
- 1st time online monitoring







General information about possible chosen utilities – DWTP

Country	Tuno of courses	Climate	Disinfectio	n methods	WSP	Period of time to
Country	Type of source	Climate	Production	Distribution	Implanted	sample
Germany	Surface water (river)	Temperate	Ozone, ClO ₂	-	WSP Period of same Implanted Same (Yes) (Yes) (Yes) 12 m Yes 12 m ISO 22000 (Food Industry) = WSP	
UK	"Upland", surface, humic	Temperate, maritime	Cl	Cl	(Yes)	12 months
Denmark	Groundwater	Cold	UV	-	Yes	+ Events
Spain	Surface water (river) Ground water	Mediterranean, warm, semi-arid	Ozone, ClO2	Cl	ISO 22000 (Food Industry) ≡ WSP	

General information about the treatment DWTP

Country	Treatment steps (where to analyse)	Pathogens (what to analyse)	Online analysers to be tested	Kits to be tested
		V: norovirus		
Germany	sedimentation (effectivity	B: Campylobacter, pathogenic E. coli	BACTcontrol: coliforms, after coagulation	
	assessmenty	P: C + G		
	T	V: Pending to define		
UK	(officiency assessment)	B: E. coli		MST: catchment
	(efficiency assessment) P: Pending to define V: Pending to define microl AN: total activity			
	(efficiency assessment) Distribution P: Pending to define DTU: ATP Raw water / Before & after V: Pending to define			
Denmark	Raw water / Before & after	B: Pending to define	(final)	
	01	P: Pending to define	DTU: ATP	
		V: at least one (norovirus)		
Spain	sand filter / GAC / Treated water	B: Salmonella e., P. aeurginosa	DTU: ATP	catchment
		$P \cdot C + G Toxoplasma?$		

These are all very important conditions with the consideration of the use of an online microbiological monitor



AQUAVALENS

L'Obregrat River, Barcelona







Length170 km (110 mi) Elevation1,259 m (4,131 ft) Elevation 0 Avg. Discharge 20.77 m³/s (733 cu ft/s) Basin area 4,948.3 km² (1,910.5 sq mi)







Example of San Joan Despí DWTP belongs to Aigües de Barcelona (really complex plant)





- Test will start later this year with Agbar and supported by CETaqua
- Customer needs to decide if
 the sand filter can be
 removed from the treatment
 line
- Monitoring locations at:
 - Raw water,
 - After sand filter
 - After GAC filtration

Parameter	Units	Rav	v water (2	2014)
rarameter	Units	Min.	Average	Max.
рН	pH Units	7,3	8,2	8,9
Conductivity (20 °C)	µS/cm	353	1.269	3.903
Temperature	°C			
Total Organic Carbon (TOC)	mg C/I	0,5	4,6	13,1
Turbidity	UNF	6,85	210,74	14.400,00
Nitrates	mg NO3/I	4,38	9,03	18,50
Nitrites	mg NO2/I	<0,1	0,26	0,72
sulphates	mg SO4/I	78,80	146,00	207,00
Ammonium	mg NH4/I	<0,05	0,80	7,72
Total coliforms	NMP/100 ml	-	6.000,00	300.000,00
Colony count at 22 °C	UFC/ml	-	6.000,00	200.000,00
fecal coliforms	NMP/100 ml	2.000,00	40.000,00	100.000,00
E. coli	NMP/100 ml	270,00	60.000,00	
Pseudomonas	UFC/100ml	8.000,00	400.000,0 0	
Clostridis sulfit- reductors	UFC/100ml	2.000,00	8.000,00	20.000,00
Clostridium perfringens	UFC/100ml	0,00	20.000,00	400.000,00
Enterococs	UFC/100m I	75,00	7.000,00	90.000,00

US Projects UNIV



Water Treatment Facilities Henderson

- River Mountains Water Treatment Facility
- Nearly 90 % of our drinking water comes from the Colorado River via Lake Mead.
- Daniel Gerrity, Ph.D., Assistant Professor Department of Civil and Environmental Engineering and Construction, Howard R. Hughes College of Engineering, UNLV



a River Mountains Water Treatment Facility (RMWTF) began delivering treated water in October 2002



he River Mountains Water Treatment Facility houses the SIMMA Water Guality Laboratory and Applied Rasearch A evelopment Center, one of the most sophisticated municipal water quality laboratory complexes in the world.





Microbiological monitoring with BACTcontrol

- The BACTcontrol to be tested with direct potable reuse applications
- Proposal for testing this in a
 Ozone-BAC application



Toxicity testing with iTOXcontrol

- The iTOXcontrol will be tested to measure Toxicity of tertiary treated wastewater as well as water intended for potable reuse.
- The potable reuse water will be tertiary filtered water that will also be ozonated and run through biofilters.

Conclusion 1



- So many cleaning & disinfection technologies....
- We need to monitorwhat is Safe & Reliable
- The BACTcontrol will be a safeguard for this process !

Summary of overall assessment	1	Cl. Control	Cintrient (Sec.)	Lee Charles - Ley	AKA CATACON	Querto mon	Contraction and all all all all all all all all all al	Sec. Con the Hard	Sector 4	IL UN UNTER	Rev Mort Green	Labler Warding Control of Control	
E Chlorine	-	-	-	+	+	+	+	+	+	+	-		
-B UF only	-	+	+	-	+	•	•	-	-	•	-	-	
B UV only	+	+	+	•	+	+	•	+	+	•	•		
O Alternative + Residual	+	•	•	+	+	•	-	+	+	+	+	1	
Chlorine only	-	-	-	+	-	+	+	+	+	+	-		
Conventional pre-treat + Chlorine	+	-	-	+	-	•	•	+	+	•	-		
by UF only	-	-	•	-	-	•	•	-	-	•	-		
Conventional pre-treat + UF	•	+	+	-	+	-	-	-	-	-	-		
Image: Second													
ម្មី MF + UV	•	+	-	•	-	+	•	-	-	•	+		
Conventional pre-treat + UV	•	+	+	•	-	+	•	+	+	•	•		
Conventional pre-treat + Ozone + UV	+	•	+	+	+	-	-	+	+	•	+		
Alternative + Residual ⁽²⁾	+	•	•	+	+	-	-	+	+	+	+	1	
UF = ultrafiltration, MF = microfiltration, Conv + = better than average, - = worse than average, ⁽¹⁾ UF + chlorine residual or Conv + UV + chlorine	ventio: • = av resid	nal pr verage ual	e-trea	it = e.;	g, coaş	gulatio	on/sed	iment	ation				





- Online bacteria monitoring can now be used for water quality and safety purposes
- Demonstration projects for online Bacteria monitoring
 - Several starting in Europe now
 - US with UNLV (and others ? Looking for funding.....)





From Toilet ([®]) to Tap ?????





Use a professional marketing campaign for this.....



Newsweek

JUSTADD

CALIFORNIA'S

MICROLAN "CONTROL"-LINE MONITORING SYSTEMS

- To be "IN CONTROL" of
- your water quality / security !

Thank you, for questions pls mail to joep.appel@microlan.nl Or visit our website www.microlan.nl



What happens Oct. 21st 2015?



It's already here..... we don't have to look back

http://www.morefm.co.nz/Man-breaks-record-with-275m-flight-on-hoverboard/tabid/96/articleID/24172/Default.aspx