



# Why HPC is in the Current SWTR?

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# First, *How* HPC is in the Current SWTR

- Heterotrophic Plate Count (HPC) and residual disinfectant measurements demonstrate distribution system integrity and performance; they are not measures of water quality, *per se*
- From the Surface Water Treatment Rule Plain English Guide

*“You must monitor for disinfectant residuals in the distribution system. Distribution system monitoring must take place at the same location and frequency as Total Coliform Rule (TCR) sampling. Residual disinfectant concentrations must be detected in at least 95 percent of the samples each month for 2 consecutive months. You may measure HPC in lieu of disinfectant residuals. **If HPC is less than 500 colonies/ml, the site has the equivalent of a ‘detectable residual.’**”*
- That is, HPC < 500 CFU/mL is a surrogate measure for detectable disinfectant residual
- States vary in their rules
  - Many states incorporate federal rules by reference
  - Others exclude HPCs as an alternative measure of distribution system control and operation

# Now, *Why* HPC is in the Current SWTR

- Original SWTR proposed 0.2 mg/L residual disinfectant in 95% of samples
- Purposes were to
  - Ensure the DS is maintained properly and contaminant intrusion is identified
  - Limit the growth of heterotrophic bacteria and *Legionella* in the DS
  - Provide a quantifiable target whose exceedance required action
- Commenters noted that
  - even systems with good biological water quality might not meet the proposed rule and
  - health benefits associated with the rule were uncertain
- In the final rule
  - The numeric limit 0.2 mg/L was replaced with “detectable” and
  - HPC < 500 colonies/mL was added as an alternative indication of “detectable residual”

# Outline

- Goal
  - present background information and generate discussion on the use of HPCs for assessing distribution system water quality
- Outline
  - HPCs and a short history of their use in assessing water quality and system performance
  - Studies describing use of HPCs
  - Alternative to HPCs?
  - Conclusions and Discussion
    - Reiterate the high points
    - Is there sufficient evidence to overturn the ruling?

**Primary reference:** Bartram, J., Cotruvo, J., Exner, M., Fricker, C., and Glasmacher, A., 2004. Heterotrophic Plate Counts and Drinking-water Safety: *The Significance of HPCs for Water Quality and Human Health*. World Health Organization (WHO), Geneva, Switzerland, ISBN: 92 4 156226 9

What is the HPC?

How has it been used?

# HPCS AND THEIR USE IN DRINKING WATER QUALITY ASSESSMENT

# HPCs 101

- Heterotroph – An organism requiring organic compounds as a carbon source
- According to Chowdhury, S\*, heterotrophs
  - include a wide range of bacteria types, including primary and secondary bacterial pathogens (*Escherichia*, *Klebsiella*, *Enterobacter*, *Citrobacter*, *Serratia*, *Helicobacter*, etc.),
  - are associated with the deterioration of aesthetic quality of drinking water (e.g. taste and odour problems, turbidity, etc.), clogged filters, bio-fouling and bio-corrosion) but
  - to date, no epidemiological evidence has been linked directly to HPC bacteria
- But HPCs are not the same as the universe of heterotrophic organisms
  - No single set of medium composition, incubation time and temp and oxygen stress satisfies the needs of all bacteria present in a sample\*\*

\* Chowdhury, S., 2012. *Environmental Monitoring and Assessment* 184:6087–6137

\*\* Reasoner, D.J., 2004. *Int'l J. of Food Microbiology* 92:307-315

# Short History of HPC use in the UK

- UK Ministry of Health – Report 71 (1934) recommended
  - dispensing 1-ml aliquots of water, mixing with nutrient agar and
  - incubation of one set of plates at 20–22 °C for three days (indicates food present) and
  - another set at 37 °C for two days (indicates the number of “dangerous” organisms)
- In an update of Report 71, interpretation was provided, stating:
  - High HPC values do not indicate an immediate threat to human health – “the counts themselves have little direct health significance.””
  - “... changes in the pattern of colony counts ... are usually more significant than the actual numerical count of any particular sample”



Safe Drinking Water Foundation, 2015.  
Water Quality Tests.

[http://www.safewater.org/PDFS/communitywater\\_testkit/Water\\_Quality\\_Tests.pdf](http://www.safewater.org/PDFS/communitywater_testkit/Water_Quality_Tests.pdf).

Accessed 11/15/15

# Methods – US

- 1<sup>st</sup> Ed., Standard Methods (1905)
  - Standard plate count
  - Gelatin nutrient + incubation at 20°C for 48 hours
- 16<sup>th</sup> Ed. Standard Methods (1985)
  - Name changed to HPC
  - Added membrane filtration (MF) method and medium (mHPC agar)
  - Re-introduced the spread plate method
  - Added two low nutrient media (R2A and NWRI)
  - Longer incubation times for low nutrient media
    - 20 or 28°C for 5-7 days for R2A spread, pour or MF plates
    - 5 days at 35°C for NWRI agar



# **STUDIES DESCRIBING THE PERFORMANCE OF HPCS**

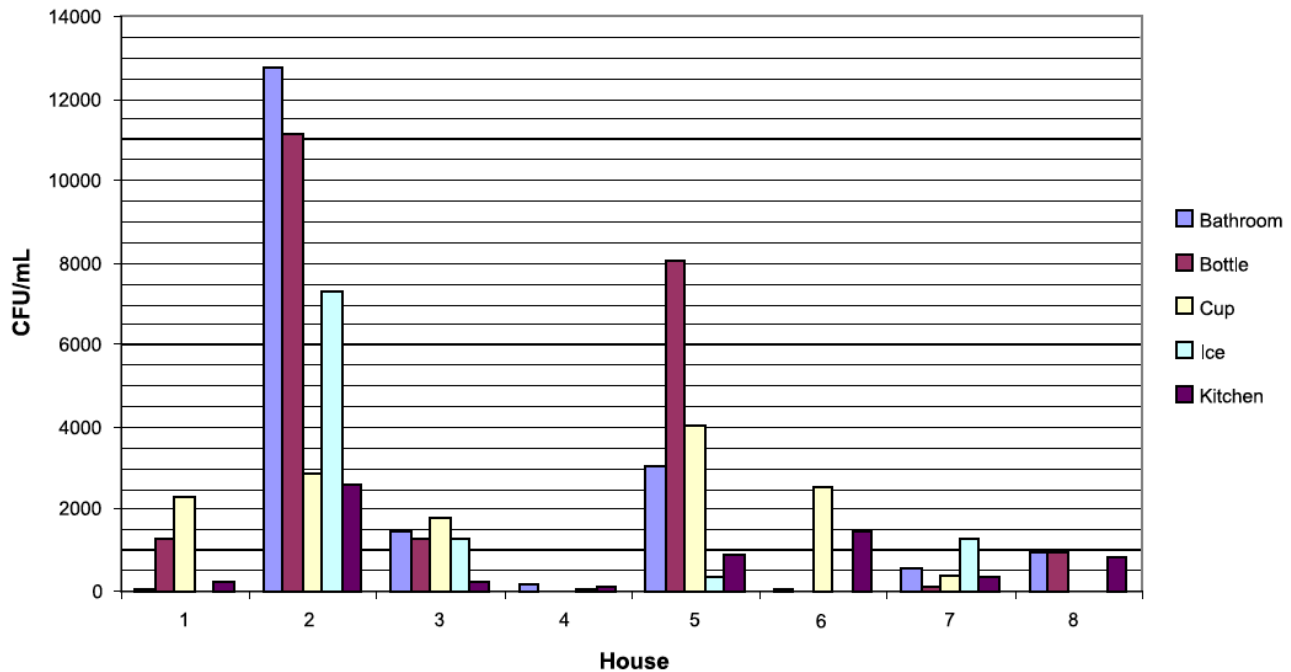
# Performance – Correlations w/ WQ

- Possible to observe
  - High HPC despite the presence of a detectable residual
  - Low HPC in the absence of a residual
- HPC time series show periodic spikes
  - Real water quality significance?
  - Biofilm sloughing?
  - Biofilm disturbance?
- Carter et al.\* attempted to correlate DS water quality with HPC
  - HPC *associated* with lower free chlorine (dead end segment) but
  - No significant *correlation* between free chlorine and HPC
  - HPC correlated with temperature at a distal DS site
  - HPC via different methods were not correlated
- Authors conclude that HPC is indicative of water quality

\* Carter, J.T., et al., 2000. *Water Research* 34(5):1495-1502

# HPCs – Source to Tap

- Pepper\* et al. (2004) studied HPC from source to tap
  - Low HPC throughout treatment and distribution
  - Orders-of-magnitude increase in HPCs in plumbing systems
- HPC clearly signaled degradation of water quality in building plumbing



Pepper, I.L., Rusin, P., Quintanar, D.R., Haney, C., Josephson, K.L., and Gerba, C.P., 2004. .  
*Int'l J. of Food Microbiology* 92:289-295

# HPCs and Indication of Chlorine

- HPCs respond to disinfectants\* but
  - Tolerant species are the predominant influence of die-off rates
  - Tolerant species differ for free chlorine and monochloramine
- Difficult to generalize results because
  - As little as 1% of bacteria are identified using HPC (VBNC, non-culturable organisms)
  - Possibility for resuscitation

\* Wolfe, R.L., Ward, N.R., and Olson, B.H., 1985. *Water Research* 19(11):1393-1403

# Performance – Correlation with *Legionella*

- Duda et al. (2015)\* investigated the correlation between HPC, ATP and *Legionella* presence for plumbing system and cooling tower waters
  - HPC and ATP correlated strongly in plumbing system, weakly in cooling tower
  - Attempted to establish thresholds for ATP and HPC that signal increased occurrence of *Legionella*. High misclassification rate
- Better agreement between ATP and HPC at high counts

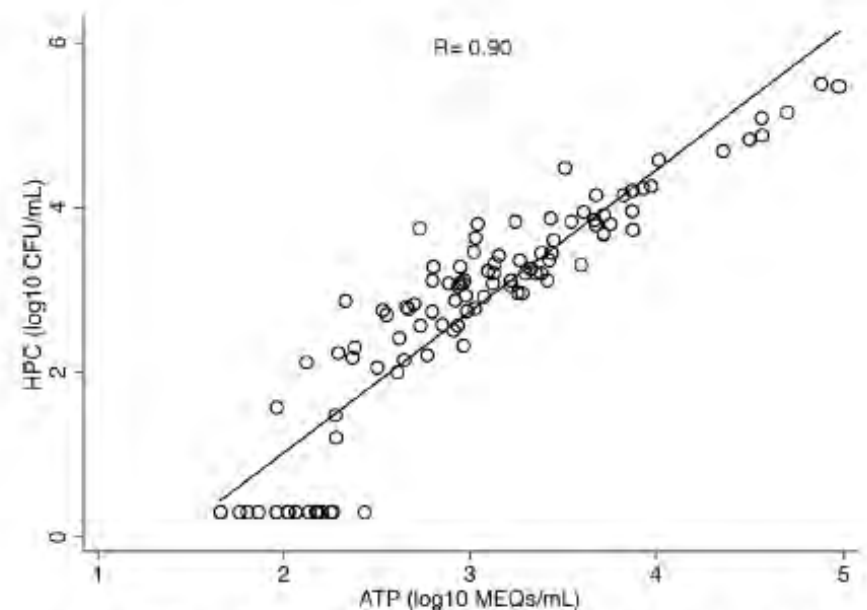


Fig. 1 ATP and HPC measurements in potable water samples demonstrated a strong correlation ( $R=0.90$ )

\* Duda, S., Baron, J.L., Wagener, M.M., Vidic, R.D., and Stout, J.E., 2015. *Environmental Monitoring and Assessment* 187: 393

# Performance – Association with Health Risks

- Health risks associated with the pathogenic fraction of organisms in HPCs are small\*
  - HPCs “doses” associated with food consumption are typically much greater than those from drinking water exposures
  - The pathogenic proportion of organisms in HPCs is usually small
- EPA considered regulation of HPCs as a health-based parameter but chose not to move forward (Allen et al., 2004\*\*)
  - *Insufficient clinical evidence that the addition of a maximum limit on HPC populations would provide a higher level of public health protection than that afforded by existing regulations*
- Epi studies were either equivocal or showed no association between HPCs and acute gastrointestinal illness

\* Sartory, D.P., 2004. *Int'l J. of Food Microbiology* 92:297-306

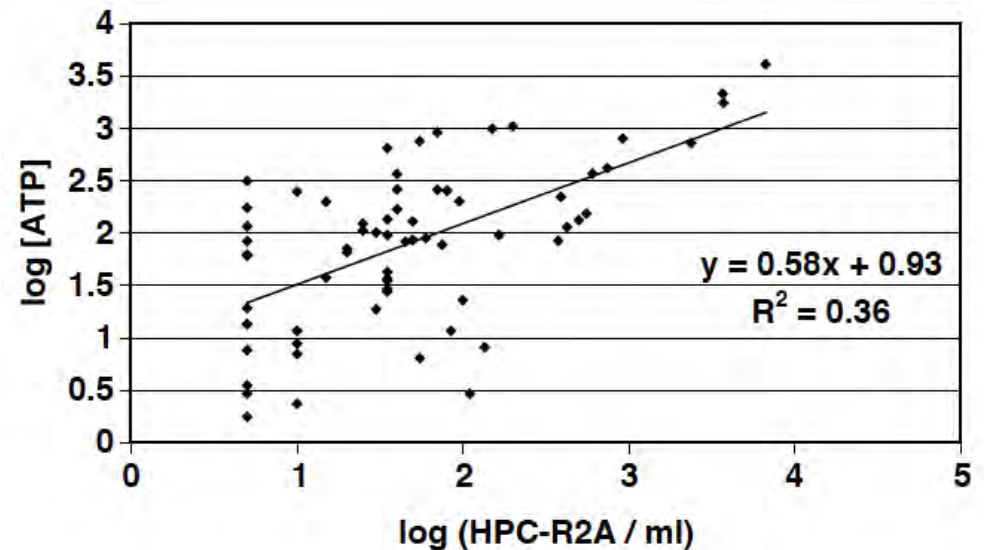
\*\* Allen, M.J. Edberg, S.C., and Reasoner, D.J., 2004. *Int'l J. of Food Microbiology* 92:297-306

ATP

# ALTERNATIVE TO HPCS?

# ATP – An Alternative Measure?

- Studies have evaluated ATP as an alternative to or companion to HPC for assessing bio and chem WQ
  - Generally, better correlation between ATP and HPC at HPC > 100 CFU/mL
  - Sampling error at low counts?
  - Different correlations for different HPC methods



*Delahaye, E., Welté, B., Levi, Y., Leblon, G., Montiel, A., 2003. Water Research 37:3689–3696*



# ATP as a Rapid Measure of Ingress

- Vang et al. (2014)\* spiked treated drinking water with wastewater and untreated surface water
- Evaluated ATP as a rapid alternative to HPC for assessing water quality and identifying ingress
- Determined that ATP is a viable alternative, although currently not as sensitive as HPCs

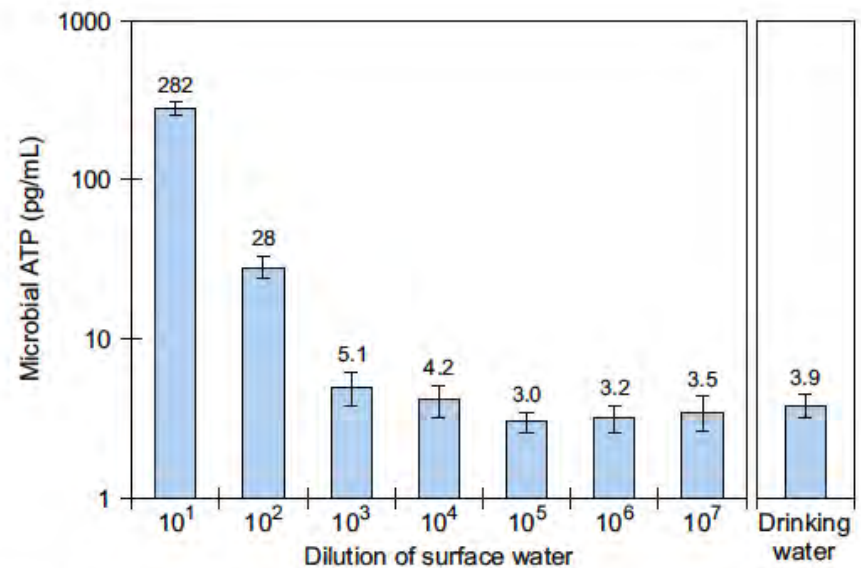


Fig. 4 – Microbial ATP concentrations (arithmetic mean with standard deviation given with error bars, N = 3) in drinking water and drinking water contaminated with surface water of various dilutions (LuminATE reagent kit).

\* Vang, O.K., Corfitzen C.B., Smith, C., Albrechtsen, H.-J., 2014. Water Research 64:309-320

# CONCLUSIONS AND DISCUSSION

# What I see

## HPCs as Water Quality Indicators

- HPCs are a direct measure of biological water quality
- HPCs are sensitive, in varying degrees, to disinfectants
- But counts can be highly variable and variations might have little to do with average water quality

## HPCs as Health Risk Indicators

- HPCs do not consistently correlate with
  - pathogens
  - coliforms
  - HPCs measured using different conditions
- HPCs in treated drinking water are unlikely to be frank pathogens and are unlikely in numbers likely to cause infections

# What do you see?

- Utilities – how do you use HPCs? Do you consider them an effective water quality indicator?
- Is there sufficient evidence to “overturn the call” and exclude HPCs as an alternative indication of detectable residual disinfectant?