Incident Title	**Public Water Supply Contamination**	
Incident Type	Waterborne Disease	
Date	5th April 1993	
Country	USA	
Location	Milwaukee, WI	
Fatalities	**Injuries**	**Cost**
69 – Ref. 2	~ 403,000 – Ref. 1	$ 96 m (2003) – Ref. 3

Incident Description

Milwaukee city water is sourced from Lake Michigan and supplied by 2 water treatment plants (WTPs); Linwood WTP on the north side and Howard Avenue WTP on the south side. The treatment process at both involved adding chlorine (disinfectant) and polyaluminium chloride (coagulant), rapid mixing, mechanical flocculation, sedimentation and rapid sand filtration. The treated water was stored in a large clearwell before entering the distribution network. The filters were backflushed with treated water which was then recycled through the WTP. On 5th April 1993, widespread gastrointestinal illness and significant school and workplace absenteeism was reported among Milwaukee residents. A survey of diarrhoea cases in local nursing homes (geographically fixed populations) and testing of infected resident's stools for cryptosporidium revealed that the outbreak was concentrated on the south side. These results coupled with discovery of treated water turbidity problems at the Howard Avenue WTP over the preceding 2 weeks suggested that drinking water supplied by the Howard Avenue WTP could be implicated. The plant was shut down and the city mayor issued a boil water advisory.

Incident Analysis

Basic cause was breakthrough of cryptosporidium oocysts to finished water due to inadequate filtration at the Howard Avenue WTP. (Cryptosporidium oocysts are tiny protozoan parasites which can cause severe or fatal gastrointestinal illness, especially in immunodeficient people.)

Critical factors included: 1) Cryptosporidium oocysts are 3 - 6 µm diameter and highly resistant to chlorine (coagulation and filtration control crucial), 2) Severe spring storms (high source water turbidity and microbial load), 3) Turbidity of finished water was only measured every 8 hours (the minimum allowed by authorities), 4) Rapidly changing source water quality, long sampling lag time and limited operating history with polyaluminium chloride (replaced aluminium sulphate in Sep-92) made dosage optimisation difficult.

Root causes included: 1) Inadequate monitoring (testing for turbidity and cryptosporidium oocysts ineffective), 2) Inadequate process design (recycling filter backwash effluent without extra treatment), 3) Inadequate training (WTP operators), 4) Inadequate/inconsistent state water quality standards.

Lessons Learned

1) Filter backflush effluent recycling was discontinued at both WTPs (to break the "concentration loop"), 2) Continuous turbidity monitoring with alarms and automatic shutdowns was installed at each filter in both WTPs, 3) Ozonation units were installed at both WTPs to improve disinfection, 4) Procedures for turbidity monitoring and cryptosporidium sampling/testing in both source and finished water were improved and standardised across the industry, 5) Filter backflush effluent requires additional treatment (eg. lamella sedimentation) before recycling, 6) For WTPs where cryptosporidium breakthrough risk is high, additional disinfection (eg. ozonation, ultra-violet irradiation) is required.

More Information

1) "Cryptosporidium and the Milwaukee Incident", K. Fox and D. Lytle, US Environmental Protection Agency, Report No. EPA/600/A-94/251 (1994), 2) "Lessons from Waterborne Disease Outbreaks", Institute of Medicine (US) Forum on Microbial Threats, Washington (DC), National Academies Press (2009): https://www.ncbi.nlm.nih.gov/books/NBK28459/#ch2.s10, 3) "Costs of Illness in the 1993 Waterborne Cryptosporidium Outbreak, Milwaukee, Wisconsin", P.S. Corso et al, Emerging Infectious Diseases Journal Volume 9 (2003): https://dx.doi.org/10.3201/eid0904.020417.

Industry Sector	Process Type	Incident Type
Water	Water Treatment	Waterborne Disease
Equipment Category	**Equipment Class**	**Equipment Type**
Mechanical	Filters and Strainers	Sand Filter

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