

NIR

Virus Survey in Korean Water Supplies and Relations with Indicating Bacteria

Hyon-Mi Chung

National Institute of Environmental Research

Handwritten notes:
 9/14/93
 2/2/92

PURPOSE

- To investigate the national status of virus contamination (in source, treated and tap water in community WTPs)
- To have reliable data about virus contamination for development of management strategy, if necessary
- To find relations between enteric virus and current fecal indicator bacteria.

VIRUS OF SURVEY

BACKGROUND

- In general, enteric viruses have been found in SW, GW and even in treated DW.
- Increased concerns on sanitary quality of drinking water and public health in Korea
- Over 85.2% of our drinking water comes from public water supplies using surface water source.
- The status of virus contamination in our water supplies need to be addressed.

SUMMARY OF SURVEY

- Period : 1997.12 - 2001.5
- Method : ICR-TCVA
- Coordinated by NIER (H.M.Chung)
- Performed by KRIBB, KIST (S.H.Park), Kyunghee Univ (Y.S.Jeong), KNIH(J.D.Yoon, virus identification)
- (culturable viruses were further identified by RT-PCR, Neutralization test, etc)

Sites, Samples and Frequency

- 64 WTP in nationwide (total 589 WTPs in Korea)
- one time (Some were up to 4 times)

survey	WTPs		No. Samples		
	No.	Scale	Source	Finished	Tap
■ 1st	6	L	8	8	8
■ 2nd	20	L	18	20	40
■ 3rd	40	M,S	43	43	43
■ Additional	6	M,S	12	12	12
■ Total	64*		81	83	103

Results of Large WTPs

- Producing over 100,000 tons/day
- 1997.12 - 1999. 11, 1st and 2nd survey
- In source water,
 - Detection rate = 42%(10/24) by WTP,
 - 41%(11/27) by sample
 - The level ranged from 1.0-24.0 MPN/100L.
- In finished and tap water, viruses were not detected.

Results of Medium-Small WTPs

- Producing beyond 100,000 tons/day)
- 2000.5 - 2001. 5, 3rd and additional survey
- In source water,
 - Detection rate= 35%(14/40) by WTP, 42%(23/55) by sample
 - Level ranged from 1.0-1150 MPN/100L.
- In finished water,
 - Detection rate =10%(4/40) by WTP, 9%(5/55) by sample
- In tap water, viruses were detected.
 - Detection rate =10%(4/40) by WTP, 7.2%(4/55) by sample

Conclusion

- Results of virus survey initiated the Action Plan
 - ▶ Comprehensive Management Plans for Drinking Water Quality (2001. 5) launched in Korea

- Source water
 - Water treatment
 - Distribution system
- ⇒ ■ Introduction of treatment technique (Turbidity, CT req.)

**RELATION WITH
INDICATING BACTERIA**

BACKGROUND

- Routine monitoring of virus is not technically and economically feasible now and in a near future.
- We need alternative tools to take care of virus contamination
 - Bacterial indicators of fecal contamination has been used as a practical tools in source water management

BACKGROUND

- Many studies showed the irrelevancy of bacterial indicators for reflecting virus contamination in water : *micro-scale study*.
 - Excreting pattern in population, resistance to treatment, and persistence in the environment are different
- However, some studies report good relations between enteric virus and model organisms including bacterial indicators in fresh water (Havelaar *et al*, 1993): *macro-scale study*
 - The samples included wide-spectrum of contamination from sewage to recreational lake water, except drinking water source

MATERIALS & METHODS

- sample site & collection
 - Total 27 large WTPs in nationwide
 - Source water(=SW, 200-300L), finished water (FW)and tap water(=TAW,1200-1500L) samples
 - 1 to 3 times from March 1998 to Nov. 1999.
- Analysis of virus and indicator bacteria
 - Total culturable virus assay (ICR method, USEPA, 1996) using BGM cell
 - Total coliforms, fecal coliforms, and *E. coli* (APHA,1992), and Turbidity.
- Statistical Analysis
 - the values of BDL were set as 0.9.
 - The No.of values in the data set (Table 1).

Table 1. Number of samples with values below detection limits (BDL) and with missing values

Water	Type	Sample Numbers for Following Parameters				
		TCV ¹⁾	TC ²⁾	FC ³⁾	EC ⁴⁾	Turbidity
Tested Sample	Total ¹⁾	48	40	40	40	48
	River	27	25	25	25	27
	Lake	21	15	15	15	21
Below Detection Limit	Total	27	0	2	5	0
	River	9	0	1	2	0
	Lake	18	0	1	3	0
Missing Values	Total	0	8	8	8	0
	River	0	2	2	2	0
	Lake	0	6	6	6	0

¹⁾TCV=total culturable viruses; ²⁾TC=total coliforms; ³⁾FC=fecal coliforms; ⁴⁾EC=*E. coli*

RESULTS

- Pollution level of TCV
 - Of total 124 samples, no enteric viruses were detected in all 28 FW and 48 TAW.
 - 48 SW samples have viruses BDL-69 MPN/100L with geometric mean of 2.3 MPN/100L and median of BDL

		Geom Mean	Median	Range
Total	TCV (in 100L)	2.3	BDL ^{b)}	BDL~69
	TC (in 100mL)	710	840	4~30,000
	FC (in 100mL)	98	190	BDL~3,900
	EC (in 100mL)	28	41	BDL~2,800
	Turbidity(mg/L)	7.7	7.8	0.1~73

Table Occurrence range of virus in the source water

Level of viruses (MPN/100L)	Number of samples in			ICR data ¹⁾
	Total	River	Lake	
<1	27 (56%)	9 (33%)	18 (86%)	76%
1 ~ 10	11 (23%)	10 (37%)	1 (5%)	20%
10 ~ 100	10 (21%)	8 (30%)	2 (10%)	4%
>100	0 (0%)	0 (0%)	0 (0%)	0.5%

¹⁾ from 1997.7 to 1998.6 (USEPA, 1999)

•Relation with indicator bacteria

		Geom Mean	Median	Range
Total	TCV (in 100L)	2.3	BDL ¹⁾	BDL - 69
	TC (in 100mL)	710	840	4 - 30,000
	FC (in 100mL)	98	190	BDL - 3,900
	EC (in 100mL)	28	41	BDL - 2,800
	Turbidity (mg/L)	7.7	7.8	0.1 - 73
TCV-positive (n=21)	TC (in 100mL)	1,800	1,900	47 - 30,000
	FC (in 100mL)	200	510	BDL - 2,300
	EC (in 100mL)	48	100	BDL - 800
	Turbidity (mg/L)	9.9	12	2.3 - 73
TCV-negative (n=21)	TC (in 100mL)	330	320	4 - 6,500
	FC (in 100mL)	55	82	1 - 3,900
	EC (in 100mL)	17	15	BDL - 2,800
	Turbidity (mg/L)	6.3	6.6	0.1 - 45

The levels of total coliforms and fecal coliforms were significantly different between virus-positive and virus-negative water ($p < 0.01$, $p < 0.05$; Mann-Whitney U Test).

Table 4. Correlations between concentrations of TCV and indicator organisms.

	TVC	TC	FC	EC	Turbidity
TVC Corr. Coef.	1.000				0.180
Sig. (2-tailed)		0.001	0.009	0.024	0.220
N	48	40	40	40	48
TC Corr. Coef.		1.000	0.791	0.772	0.412
Sig. (2-tailed)			0.000	0.000	0.008
N		48	40	40	40
FC Corr. Coef.			1.000	0.900	0.476
Sig. (2-tailed)				0.000	0.002
N			48	40	40
EC Corr. Coef.				1.000	0.595
Sig. (2-tailed)					0.000
N				48	40
Turbidity Corr. Coef.					1.000
Sig. (2-tailed)					
N					48

Moderate spearman rank correlations with indicator bacteria (with $P < 0.05$), especially with total coliforms, but not with turbidity (Table 4).

■ Type of surface source water

- Surface water is major drinking water source (92%), and river water takes major of it (61%) in Korea.
- Lake are relatively well protected from fecal pollution
(Lake=>artificial lakes =>in middle to upper river
River=> middle/downstream for nearby large cities).
- Therefore, river source water needs to be more carefully studied to protect public health.

■ Relation with indicator bacteria

- Although BDL data of TCV (in 100L scale) or indicator such as *E. coli* (in 100ml scale) decreased the significance of correlation, there were still significant correlations btn TCV and indicator bacteria.
- Therefore, conventional bacteriological indicators may provide an acceptable estimate of virus pollution as site-based macro-scale source management tools, at least for the given water supplies.
