Polish Journal of Environmental Studies Vol. 11, No. 6 (2002), 751-755

Letter to Editors

Presence of *Rotavirus hominis* in Sewage and Water

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Received: 13 January, 2002
Accepted: 16 July, 2002

Abstract

The presence of *Rotavirus hominis* and other rotaviruses in sewage and water is described. The problem of rotaviral world-wide infections causing severe or fatal disease of infants, children, adults and persons immunocompromised is discussed.

Keywords: waterborne rotaviruses, health hazard, rotaviral diseases

Why Is Interest in Rotaviruses Increasing?

The current great interest in rotaviruses and the necessity of widespead popularisation of knowledge of them have been provoked by their extremely hazardous features. *Rotavirus hominis* exhibits:

- the most common cause of viral worldwide stomach and intestinal inflammation (gastroenteritis),
- highest infectivity among waterborne viruses,
- highest known fatality from viral gastroenteritis,
- 100-fold greater fatality in the elderly,
- greater fatality in the immunocompromised,
- the strongest resistance to inactivation by UV radiation among all the enteric RNA-viruses [4].

Rotaviruses are widely spread in the world, causing waterborne severe infections in infants, small and older children, adults and immunocompromised persons, e.g. ill with AIDS. They are also very common in Poland. According to a ten-year survey by Bern et al. (1992) rotaviruses were responsible for the deaths of 4–5 persons in the world annually [2, 4]. In Third World countries over 125 million cases of rotaviral gastroenteritis occurred in children every year. There were at least nine waterborne outbreaks associated with direct fecal contamination of a water supply or improper water treatment that took place in the following countries [4]:

Sweden, 1997	Russia, 1981, 1989
Brazil, 1980	China, 1982,1983
Colorado, USA 1981	Israel, 1982
East Germany, 1981	

Rotaviruses were detected by Bishop and his associates [3], who used an electronic microscope nearly thirty years ago. The authors showed the presence of rotaviruses in samples of duodenum of children with acute gastroenteritis. Then rotaviruses were detected in faeces of patients by Flewett, Kapikian and Midleton [8, 20]. The publications that followed (impossible to count at the present time) greatly developed knowledge of rotaviruses. The first in Poland to initiate experimental studies on human rotaviruses was Jarz¹bek [8], who together with

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Szczepaniak [20] published a monograph concerning all problems connected with rotaviral disease, clinical symptoms, epidemiology, clinical symptoms, epidemiology, immunity, and the possibility to prepare vaccines [8, 20]. Many data on the clinical course of the disease in children were reported by Sadurska [18].

Gerba and his associates [4] defined the risks derived from waterborne rotaviruses. They described the nature of *Rotavirus hominis,* its unique characteristics, the disease it causes, clinical symptoms, range of hospitalization, morbidity, mortality and immunity.

Structure and Characteristics of Rotaviruses

Rotaviruses belonging to the Reoviridae family are nucleocapsid particles of 60–80 nm in diameter and represent RNA-viruses [9, 10, 13]. Their structure is complex and is reminiscent of the structure of a wheel in nega-tively stained preparations (Fig. 1), from which the name is derived from Latin "rota" [8, 9]. Rotaviruses exhibit greater resistance to inactivation by preformed chloramines and ozone than poliovirus type 1, but they are more sensitive to inactivation by chlorine and chlorine dioxide. Their resistance to pH values is high, in the pH 3.5 to 10 range [4].

Rotaviruses are capable of surviving secondary sewage treatment including conventional disinfection. They persist longer than poliovirus in many types of water. They survive in surface waters for 8–32 days and in tapwater for more than 64 days, depending on environmental conditions [4].

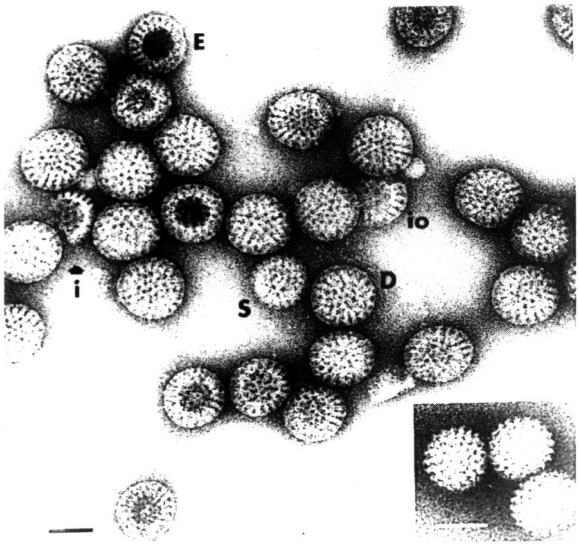

Fig. 1. Electron micrograph of a negatively stained preparation of human rotavirus. (D, double-shelled particles; S, single-shelledparticles; E, empty capsids; i, fragment of inner shell; io, fragments of a combination of inner and outer shell). Inset: single-shelled particles obtained by treatment of the viral preparation with sodium dodecyl sulfate, 100 μg/ml, immediately prior to processing for electron microscopy. Bars, 50 nm.(Courtesy of J. Esparza and F. Gil) - [9].

Clinical Course of Rotaviral Disease

The greatest number of illnesses from rotaviral infections occurs in winter and early spring in temperate climates [4, 9, 10, 18]. No seasonal variation has been noted in the tropics where the incidence of illness is the same year-round [4]. Rotaviruses are excreted to a sick persons' stool, where they remain stable at room temperature keeping infectvity for at least one week. In laboratory diagnosis rotaviruses are detected in stools collected earlier during the illness period and antibody titer is grown. In the stool appear up to 10^{10} particles of rotaviruses per gram. The incubation period of rotaviruses lasts 19 h to 2 days [4], and their excretion from ill patient usually takes 2–12 days [9], but it may be as long as 29 days in some cases [4]. Clinical symptoms vary from asymptomatic to severe and fatal. The first symptoms are vomiting and abdominal pain, then diarrhea of different frequency appears. Fever is moderate from 37.6^0C to 38.5^0C. Duration of illness is typically 5–8 days [4]. The illness leads to mild or acute dehydration associated with electrolyte imbalance [4, 7, 8, 20]. Respiratory symptoms appear more often in children and nosocomial infections are frequent. Symptomatic infections are most common in children of between 6 months and 2 years. Vaccines allowing for long-lasting protective immunity to rotaviruses have not yet been successful [4].

Routes of Rotaviruses Migration

Rotaviruses have been detected in wastewater [19], treated sewage [1], sewage sediments [6], surface waters [4, 11], groundwaters [22], marine waters [4], coastal swimming waters [5, 17], as well as in drinking waters [4, 11, 14, 16, 21]. They were first detected by Steinmann (1981) in wastewater [19], which was confirmed by Stewien (1993) and other authors. In treated sewage rotaviruses were found by Bates et al. [1] and Hejkal [9, 11]. In 1999 Green and Lewis [6] detected rotaviruses in sewage sediment using PCR-reaction (Polymerase Chain Reaction) – [6]. Occurrence of rotaviruses in different water environments is shown in Table 1.

Table 1. Occurrence of rotaviruses in sewage, activated sludge, treated sewage and sewage sediment [6, 11, 15, 19].

Sample tested	Viruses detected	Authors
Sewage	Rotaviruses	Steinmann, 1981
	Rotaviruses	Smith et al., 1982
	Rotaviruses	Bates et al., 1985
	Rotaviruses and Norwalk-agent	Clark et al., 1985
	Rotaviruses and HAV*	Green and Lewis, 1999
Activated sludge	Rotaviruses	Irving et al., 1984
Sewage treated by activated sludge	Reoviruses	Irving et al., 1981
Sewage sediment	Reoviruses and HAV*	Green and Lewis, 1999

*HAV – hepatitis virus type A

Table 2 illustrates the results of quantitative determination of *Rotavirus hominis* in raw sewage and Table 3 the results of determination in treated sewage, published by Gerba et al. [4].

Rotaviruses have been detected in surface waters worldwide with average concentrations ranging from 0.66 to 29 per liter. The highest concentrations have been reported in surface waters receiving untreated sewage [4]. Some examples of rotavirus occurrence in different waters waters are shown in Table 4 and in surface waters in Table 5.

There are many publications on the presence of rotaviruses in drinking waters [4, 9,11, 14, 16, 21] but very few quote data on quantitative determination. Some examples of the latter collected by Gerba et al. [4] have been shown briefly in Table 6.

The above numbers prove that drinking water plays a significant role in the spread of rotaviral infections. On the base of the presented facts it is evident that adequate precautions must be taken: besides strict hygiene and following the Polish [12] and WHO guidelines [16] application of the most effective sewage treatment is of special importance because sewage contains the highest amount of rotaviruses and carries them to water.

Table 2. Occurrence of *Rotavirus hominis* in raw sewage [4].

Country	Concentration/l		Remarks	Reference
	Range*	Average number		
Bolivia	100-250	163		Toranzos et al. (1988)
Colombia	10-2214	389		Toranzos et al. (1988)
Brazil	99-650,000 5090-96,000	90,700 30,700	1986 1987	Oragui et al. (1989)
Brazil	<3.0- 63,0	2.0	Obtained from a sewagepumping station	Mehnert and Stewien (1993)
Spain	25-653	156		Bosch et al. (1988)
United States	<1-321	9.8 (geometric)	Sensitivity of 1 per liter	Hejkal et al. (1984)
United States	<150-374	75	Sensitivity of 125 per liter	Smith and Gerba (1982)
Spain	1000-14,000	5407		Bosch et al. (1988)
United States	14-2980	443		Rao et al. (1987)
Spain	36-653	218		Bosch et al. (1988)

*Arithmetic average, including negative samples

Table 3. Occurrence of *Rotavirus hominis* in treated sewage [4].

Country	Concentration/l		Type of treatment	Reference
	Range*	Average number		
Brazil	180-8400 560-9000 180-8400 40-4300 0-18 0-26	733 670 733 529 2 6	Anaerobic, 5 day retention (1986) Anaerobic, 8 day retention (1987) Facultative, 5 day retention (1986) Facultative, 8 day retention After three maturation ponds, follow with anaerobic pond (1986); 15 day retention (1987) 15 day retention	Oragui et al. (1989)
South Africa	NA	NA	Detection limit of 1 TCID50 (treatment not specified)	Genthe et al. (1991)
United States	7.5-374	1687	Detection limit of 150 per liter	Smith and Gerba (1982)
United Kingdom	0-1500	750	Activated sludge, no disinfection	Bates et al. (1984)
United States	48-3228 0-32	1012 9.6	Activated sludge, unchlorinated	Rao et al. (1988)

NA= not available

Table 4. Different waters in which rotaviruses were detected [6,11,15].

Sample tested	Viruses detected	Authors
River water	Rotaviruses Rotaviruses Rotaviruses, HAV, enteroviruses	Smith et al., 1982 Raphael et al., 1985 Lewis et al., 1988
Rivers in Toyoma prefecture	Reoviruses	Matsura et al., 1988
Treated river water	Rotaviruses	Raphael et al., 1985
Coastal water	Rotaviruses	Green and Lewis, 1999
Groundwaters	Rotaviruses	Toranzos et al., 1988
Wellwater	Rotaviruses	Toranzos et al., 1988
Marine waters	Rotaviruses	Toranzos et al., 1988
Coastal waters and oysters	Rotaviruses, HAV, enteroviruses	Green and Lewis, 1999

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Table 5. Occurrence of rotaviruses in surface waters [4].

Country/state	Type of water	Concentration/l		Remarks	Reference
		Range	Average number		
South Africa	River	NA		1 TCID50 limit of detection	Genthe et al. (1991)
Arizona	River	0-2.15	0.24-0.25	Source of virus was swimmers; rotaviruses found at only two sites	Rose et al. (1987) Mullinax (1985)
Brazil	Creek	45-<3.0	2.6-2.9	Two creeks receiving untreated wastes	Mehnert and Stewien (1993)
Bolivia	River	present	present		Toranzos et al. (1986)
Colombia	River	4-6	5		Toranzos et al. (1988)
Mexico	Lake river	0-34.9	3.62	Intake to drinking water treatment plant	Rose (1985) Rose et al. (1986)
Canada	River	14.5-40.8	29	Ottawa River, source of drinking water	Raphael et al. (1985 a)
United States	Bayou	NA	NA	Bayou receives treated sewage, Houston, TX	Lewis and Metcalf (1988)

Table 6. Number of *Rotavirus hominis* occurring in drinking water [4].

Country/state	Method of treatment	Concentration/l		Authors
		Range of results	Average	
Columbia	conventional	0.5	0.065	Toranzos et al., 1986
Columbia	tapwater	0-0.7	0.13	Toranzos et al., 1986
Mexico	tapwater	1.3-62.5	4.85	Deetz et al., 1984
Mexico	conventional	0-100	1.99	Rose, 1985

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