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Viruses in Waste, Renovated, and Other Waters

1978 Literature Abstracts

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VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

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1978

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AUTHOR AND SUBJECT INDEXES

VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS now contains an *Author Index* and a *Subject Index*. Both listings may be found at the end of this volume. The Greek letters that appear above each abstract are the coding for the *Subject Index*. An explanation for their meanings is given on the first page of that index.

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1978

VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

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(Anonymous)(Editorial). (1978). *Viruses in Water.* **LANCET, 2(8104-5):**1352.

Enteric viruses are more resistant than coliform bacteria to sewage and water treatment procedures. The absence of coliform bacteria from such waters, therefore, does not guarantee the absence of a viral hazard.

Low level transmission of enteroviruses through waters are likely to be undetected by epidemiological means.

Although most sewage treatment processes destroy viruses, elimination of viruses from sewage requires extensive disinfection. Even here some viruses adsorbed within solids may survive.

Viruses discharged with sewage into rivers pose a threat to drinking water supplies (which in some countries contain viruses), irrigation and recreational waters, and to shellfish beds.

The time may have arrived for setting standards for viruses in drinking and other waters.

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Aizen, M. S., Kazantseva, V. A. (1978). *Conditions for Concentrating Enteroviruses and T1 Phages in Water by Membrane Filter Adsorption.* **GIG SANIT, 0(6):**71-2. **Russian.**

Seeded poliovirus 3 (Leon 12 a, b) and coliphage T1 were concentrated on membrane filters and recovered with greater efficiency from waters to which 0.05 moles/liter of Na_2HPO_4 had been added than from waters that did not contain the salt. The efficiencies of recovery were improved more in distilled and tap waters than in waters that contained sewage effluents.

Greater recoveries of polioviruses were achieved with tap water at pH 3 than at pH 5 or 7. Greater recoveries of the coliphage, however, were achieved at pH 7 than at the lower pH levels.

A meat extract at pH 7.8 eluted viruses from the filters better than either Hanks' balanced salt solution with 3% bovine serum or 1% polyethylene glycol (MW 6,000) did.

More viruses were eluted by mechanically agitating the meat extract on the filter for 30 minutes than by pipeting the elutant forcefully on the filter.

ξ ν ϱ

Akin, E. W., Jakubowski, W., Lucas, J. B., Pahren, H. R. *Health Hazards Associated with Wastewater Effluents and Sludge: Microbiological Considerations.* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978), 9-26.

The literature clearly shows that viruses, bacteria, and protozoa survive sewage treatment, albeit in reduced numbers, and at times are recovered from receiving soils. In the absence of more effective treatment processes and in the absence of recognized disease transmission from the land application of treated sewage, it would appear unrealistic to require all domestic wastes applied to land to be pathogen-free; no such absolute condition could be guaranteed. Therefore, the goal must be that of achieving and maintaining the microbial hazard from waste disposal on land at an acceptable risk level.

Traditional epidemiological approaches may not be helpful in evaluating such risk thereby forcing judgments on acceptable levels without supportive evidence. Nevertheless, the concept of *acceptable risk,* rather than that of *risk-free,* must be embraced as the only reasonable approach for grappling with environmental health questions.

Surveillance for increases in the occurrence of pathogens and the incidence of disease must be a primary public health measure. In addition, effective treatment of sewage before land application must be assured if a likelihood exists for intimate contact with man either directly or through foods produced on the application sites.

ν χ

Albrecht, H., Ahl, R., Strauch, D. (1978). *Rotating Aeration (System Fuchs) Treatment of Liquid Animal and Municipal Wastes. 7. Report: Further Investigations on the Effect of Aerobic Treatment on Bovine Enteroviruses.* **BERL MUNCH TIERAERZTL WSCHR, 91(18)**:360-5. German.

Seeded bovine enteroviruses (10^7 to 10^8 PFU/ml) were inactivated in aerated pig slurry at temperatures that precluded thermal inactivation. Inactivation occurred in a pH range of 6.5 to 7.5. The pH of the slurry increased to 9 during aeration. At pH 9, all of the seeded viruses were inactivated; the mean time needed for inactivation was 25.5 hours.

Viruses enclosed in "Visking" dialysis tubing suspended in aerated slurry and viruses suspended directly in the slurry were inactivated at about the same rate.

δ θ ι

Baer, G. M., Walker, J. A., Yager, P. A. (1977). *Studies of an Outbreak of Acute Hepatitis A:I. Complement Level Fluctuation.* **J. MED VIROL, 1(1)**:1-7.

Fifty cases of hepatitis A, 26 with jaundice, occurred in a rural Alabama school that obtained its drinking water from two small springs that received seepage from septic tanks. The outbreak occurred in the fall of 1972.

An epidemiologic investigation strongly correlated the outbreak with drinking water ($p = 0.047$) but not with eating in the cafeteria ($p = 0.32$). The outbreak was explosive and lasted for seven weeks. It peaked in the third week. Heavy rainfalls had occurred about 30 days before the onset of the outbreak, and evidence existed that the drinking water was probably not chlorinated during this period. Unchlorinated spring waters contained coliforms.

The levels of the third and fourth components of complement (C′3 and C′4) were reduced in the acute samples from the sick children but returned to normal in

the convalescent samples; the C'3 and C'4 levels in healthy matched controls were not reduced.

Antigen-antibody complexes were found in convalescent sera from some of the sick children.

γ

Bagdasaryan, G. A., Zotova, V. I. (1978). *Use of RNA-Containing Bacteriophages as Model of Intestinal Viruses in Experimental Studies.* **GIG SANIT, 0(3):86-8. Russian.**

In 30 minutes, 1.9 to 2.7 mg of chlorine/liter destroyed 99.5% of poliovirus 1 (LSc 2a,b), 97.5% of coliphage f2, 99% of coliphage MS2, and 98.4% of coliphage f52, all RNA viruses, and 99.8% of coliphage T1, a DNA virus.

ν

Balluz, S. A., Butler, M., Jones, H. H. (1978). *The Behaviour of f2 Coliphage in Activated Sludge Treatment.* **J HYG, 80(2):237-242.**

Coliphage f2, seeded into a model activated sludge treatment plant, was distributed in the solids and liquid fractions of the mixed liquor in the ratio 18:82; 20.4% of the virus in the influent was recovered in the effluent. After seeding of the virus ceased, the number of viruses in the solids fraction of the mixed liquor remained high and unaltered for up to 70 hours, whereas the number of viruses in the effluent fell to the background number originally present.

Comparisons of the data for coliphage f2 with those reported earlier for polioviruses suggested that the coliphage is not a good model for studies of the behavior of human enteroviruses.

η π

Baross, J. A., Liston, J., Morita, R. Y. (1978). *Incidence of* Vibrio parahaemolyticus *Bacteriophages and Other* Vibrio *Bacteriophages in Marine Samples.* **APPL ENVIRON MICROBIOL, 36(3):492-9.**

Vibrio bacteriophages were recovered from 177 of 643 samples of marine molluscan shellfish, crustaceans, seawater, and sediments. The predominant bacteriophage types recovered were specific for strains of *Vibrio parahaemolyticus.* A high frequency of phage recoveries occurred on agar-digesting vibrios (21 of 56) and psychrophilic vibrios (14 of 72). No *V. cholerae* phages were recovered.

Quantitative studies on the Pacific oyster *(Crassostrea gigas)* obtained from environments in Washington and Oregon showed that the numbers of *V. parahaemolyticus* bacteriophages increased with increasing seasonal water temperatures and that this increase was proportional to the numbers of mesophilic vibrios present and not to the numbers of *V. parahaemolyticus.* During the summer months, the numbers of *V. parahaemolyticus* bacteriophages occasionally exceeded 10^6/gram of oysters.

Specific *V. parahaemolyticus* bacteriophages were also recovered from market seafoods and from other marine samples that originated in cold environments where mesophilic vibrios are not usually found.

γ

Bates, R. C., Sutherland, S. M., Shaffer, P. T. B. *Development of Resistant Poliovirus by Repetitive Sublethal Exposure to Chlorine.* **In "Water Chlorination, Environmental Impact and Health Effects," Vol. 2, edited by R. L. Jolley, H. Gorchev, and D. H. Hamilton, Jr. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 471-82.

On continuous subculture in the presence of chlorine at pH levels of 5, 7, and 9, poliovirus 1 (LSc) became progressively more resistant to the disinfectant. The increased resistance was most marked after 10 subcultures of the virus in the presence of chlorine at pH 9.

See in 1977 Literature Abstracts: **Bates, R. C., Shaffer, P. T. B., Sutherland, S. M.** (1977). *Development of Poliovirus Having Increased Resistance to Chlorine Inactivation.* **APPL ENVIRON MICROBIOL, 34(6):849-53.**

v

Becker-Birck, J., Steinmann, J., Havemeister, G. (1978). *Importance of Chemical Flocculation of Wastewater on Sanitation (Microbiological and Virological Examinations in a Wastewater Treatment Plant).* **ZBL BAKT HYG, ORIG B, 167(1-2):104-14. German.**

In a small wastewater treatment plant, chemical flocculation reduced the total plate count and the number of total coliforms by 90 to 95%, phosphates by about 88%, BOD_5 by about 80%, and COD by about 50%. Polioviruses, always present in the influent, were never recovered from the effluent.

ι π

Bedford, A. J., Williams, G., Bellamy, A. R. (1978). *Virus Accumulation by the Rock Oyster* Crassostrea glomerata. **APPL ENVIRON MICROBIOL, 35(6):**1012-18.

In a static seawater system, the accumulation of radioactively-labeled reovirus 3 and Semliki Forest virus by the New Zealand rock oyster *Crassostrea glomerata* was less rapid than the accumulation of *Escherichia coli.* Uptake of the virus was unaffected by the presence of the marine alga *Dunaliella primolecta* in the seawater.

Accumulation depended on virus concentration; saturation was achieved at 4×10^{10} reovirus virions per oyster, implying that an oyster possesses a large but finite number of sites for virus adsorption.

Uptake of the lipoprotein-enveloped Semliki Forest virus was slower than uptake of the protein-enclosed reovirus. This observation, together with the finding that the oyster shell has a strong affinity for viruses, suggests that surface properties are the principal factors that govern the accumulation of viruses by filter-feeding marine bivalves.

γ ι

Berg, G. *The Indicator System.* **In "Indicators of Viruses in Water and Food," edited by G. Berg. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 1-13.

There is no completely adequate indicator system for viruses in water. In many circumstances, however, available indicator systems serve well for viruses and pathogenic bacteria as well.

The total coliforms are an invalid indicator system, but are useful nonetheless because they constitute a much larger group than the fecal coliforms (which are a valid indicator system) do and thereby add a measure of safety to evaluation. In a disinfected water, that margin of safety would be increased by an indicator system that included other vegetative bacteria.

However, when vegetative indicator bacteria are absent from a water, it is not certain that viruses are also absent. Thus, in the end, viruses may be the only totally safe indicator of viruses.

γ δ ϱ

Berg, G. *Viruses in the Environment: Criteria for Risk.* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978), 216-29.

Viruses occur in large quantities in domestic sludges. Stabilization by mesophilic anaerobic digestion (~35 C) as usually practiced does not destroy all viruses in those sludges. When discharged to the land or oceans, these sludges usually contain viruses. Because ammonia and other substances that interfere with disinfection by chlorine are present in sewage, treated chlorinated effluents discharged to waterways usually contain many viruses also.

Thus, viruses have been detected in ground waters and at water intakes in rivers many miles downstream of outfalls. To demonstrate transmission of disease by the water route is difficult, however, because the ingestion of a small number of viruses by an individual is likely to result in infection but not disease. Thus, the initial impact of viruses that enter a community is silent. Contacts of the index case may be infected subsequently by large quantities of excreted viruses and some of these contacts may suffer disease. But, here transmission follows a person-to-person pattern, and even if a disease outbreak occurs, its source is obscured and unrecognizable.

When there is no easy way to demonstrate that transmission of infection or disease is occurring, it is not acceptable to demand epidemiological proof of such transmission before a chain of possible transmission is interrupted. To deny that transmission may occur when viruses are present at water intakes, knowing as we do that plants break down from time to time, is unrealistic.

γ ι

Berg, G., Dahling, D. R., Brown, G. A., Berman, D. (1978). *Validity of Fecal Coliforms, Total Coliforms, and Fecal Streptococci as Indicators of Viruses in Chlorinated Primary Sewage Effluents.* **APPL ENVIRON MICROBIOL, 36(6):880-4.**

Quantities of combined chlorine that usually destroyed more than 99.999% of the indigenous fecal coliforms, total coliforms, and fecal streptococci in primary sewage effluents destroyed only 85 to 99% of the indigenous viruses present. Viruses were recovered from five of eight chlorinated primary effluents from which fecal coliforms were not recovered by standard most-probable-number procedures. The limited volumes of such chlorinated effluents that can be tested for indicator bacteria with currently available multiple-tube and membrane filter technics restrict the value of fecal coliforms, fecal streptococci, and even total coliforms as indicators of viruses in these effluents. Although fecal coliforms and fecal streptococci are useful indicators of viruses in effluents from which these bacteria are recovered, the absence of these bacteria and even total coliforms from disinfected effluents (in standard tests) does not assure that viruses are also absent.

ι

Berg, G., Metcalf, T. G. *Indicators of Viruses in Waters.* **In "Indicators of Viruses in Water and Food," edited by G. Berg. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 267-96.

Fecal coliforms and other enteric bacteria are excreted by most people in fairly uniform numbers; only infected people excrete viruses and in numbers that vary greatly. Also, viral infection rates vary with seasons, climates, socioeconomic

status of populations, and other factors. The ratios of indicator bacteria to viruses in environmental waters, therefore, cannot be constant. Moreover, viruses usually survive longer in environmental waters and are more resistant to disinfection than indicator bacteria.

Thus, the presence of fecal coliforms, fecal streptococci, and certain other indicator bacteria in an environmental water may be taken as an indication of the possible presence of human enteric viruses. The absence of these indicator bacteria, in standard tests, however, cannot be taken to mean that viruses are absent.

Nonetheless, because indicator bacteria are present in feces (and thereby in environmental waters that receive feces) in much larger numbers than viruses are, the development of methods that would permit detection of indicator bacteria in the hectoliter and kiloliter sample volumes now taken for viruses might eventually obviate the current concern for the validity of bacterial indicator systems.

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Bernardez, I., Toranzo, A. E., Mora, B., Barja, J. L. (1977). *Enterovirus Isolation Galician Littoral Water: Concentration Methods.* **REV INT OCEANOGR MED, 48**:27-31.

Samples of water taken from both sides of the Bay of Pontevedra were concentrated by an alum flocculation method, $(NH_4)_2SO_4$ precipitation, and by adsorption and elution of the virus to and from an organic compound followed by alum flocculation. The latter method gave the best overall recoveries.

The best specific method for recovering coxsackievirus B was the $(NH_4)_2SO_4$ procedure.

λ ω

Berry, J. W., Shaffer, P. T. B. (1978). *Viruses: Monitoring is the Key.* **WATER & WASTES ENGR, 15(1)**:14-17.

The authors discuss current methods for recovering viruses from large volumes of water and the application of these methods to studies on the Occoquan Reservoir in Fairfax, Va. where reports of the recoveries of viruses from the finished waters have given rise to a continuing dispute.

ν

Bitton, G., Monteith, C., Pancorbo, O., Gifford, G. E. (1977). *Virus Removal in Marine Aquaculture Systems.* **REV INT OCEANOGR MED, 48**:47-52.

About 99% of poliovirus 1 (LSc) seeded into seawater that contained from 0 to 40% sewage was removed by magnetic filtration. The viruses adsorbed to magnetite that had been added to the water. The concentration of magnetite was 1,000 mg/liter. The magnetite was recovered from the water by a magnetic field.

Treated waters supported the growth of marine diatoms and appeared suitable for use in aquacultures.

ν ϱ

Block, J. C., Joret, J. C., Morlot, M., Foliguet, J. M. (1978). *Persistence of Poliovirus 1 During the Freezing-Thawing of Hydroxide Sludges from a Water Treatment Plant Under Laboratory Conditions.* **EUROPEAN J APPL MICROBIOL BIOTECHNOL**, 5:331-40.

Dewatering ferric hydroxide sludges from water treatment plants by freezing and thawing may be a solution to disposing of such sludges. With the loss of hydrated water and the resulting extensive modification of the flocs, the risk of desorption of viral particles decreases. Moreover, when sludges are thickened

(solids concentrations up to 20 g/liter), the number of freeze-thaw cycles necessary for inactivating viruses is reduced from five to three.

Residues from lagooned sludges and from sludges treated by one cycle of industrial freezing may still contain viruses.

λ μ

Block, J.-C., Joret, J.-C., Morlot, M., Foliguet, J.-M. (1978). *Recovery of Enteroviruses in Surface Waters by Adsorption-Elution on Glass Microfibers.* **TSM-L'EAU, 73(3):181-4. French.**

With a Wallis and Melnick concentrator, 40 PFU of viruses/liter were recovered from the Marne River at its confluence with the Seine, 48 PFU/liter were recovered from the Moselle River at its confluence with the Meurthe, 56 PFU/liter were recovered from the Rhine River at Strasbourg, and 120 PFU/liter were recovered from the Seine River at it confluence with the Marne.

Twenty-liter volumes of water were sampled. The pH of the water was adjusted to 3.5 and $AlCl_3$ was added to a concentration of 0.0005 M before the water was filtered through the concentrator. The clarifying filters were polyethylene; the virus-adsorbing filters were fiberglass. The viruses were eluted from the filters with either 3% beef extract at pH 9 or with a glycine buffer at pH 11.5.

ξ ϱ

Braude, G., Sagik, B. P., Sorber, C. A. (1978). *Human Health Risk? Using Sludge for Crops.* WATER & SEW WORKS, 125(12):62-4.

The hazards to human health presented by viruses in wastewater sludges discharged to agricultural lands or to mariculture systems are discussed within a review of all health hazards posed by such use of sewage treatment wastes.

ι σ

Brown, K. W., Slowey, J. F., Wolf, H. W. *The Movement of Salts, Nutrients, Fecal Coliform and Virus Below Septic Leach Fields in Three Soils.* **In "Proceedings of National Home Sewage Treatment Symposium," December 12-13, 1977, Chicago, Illinois, ASAE Publication 5-77. ASAE, St. Joseph, Michigan** (1978), 208-17.

Lysimeter tests on the impact of septic field leachate on groundwater indicated that coliphages and fecal coliforms were removed by passage through approximately 100 cm of soil. Heavy metals accumulated immediately adjacent to the point of application in the soil. Phosphates moved slowly in the soil; their movement was greatest in sandy soils. Under reduced conditions, ammonia accumulated in the soils and moved about as far and as fast as phosphates moved. When soil oxidized, large quantities of nitrogen were converted to nitrate which rapidly leached to the groundwater.

Nitrate leachate is the greatest environmental hazard identified in this study. Nitrate accumulation may be reduced by limiting the number of septic fields in a given area, removing nitrogen from the effluent before it is applied, or perhaps by using vegetation to help remove nitrogen after application.

λ σ

Burge, W. D., Enkiri, N. K. (1978). *Adsorption Kinetics of Bacteriophage ϕX-174 on Soil.* J ENVIRON QUAL, 7(4):536-41

Two populations were distinguished within a seed preparation of coliphage ΦX-174 by soil adsorption and elution rate differentials.

NaCl promoted adsorption of the phage to soil. The optimal NaCl concentration for this purpose was 0.02 M.

Forty-six percent of adsorbed viruses were desorbed by diluting the soil 1:100 in 0.02 M NaCl.

α

Camann, D. E., Sorber, C. A., Sagik, B. P., Glennon, J. P., Johnson, D. E. *A Model for Predicting Pathogen Concentrations in Wastewater Aerosols.* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas (1978), 240-71.**

A dispersion model that predicts the dissemination of microflora downwind of sprayed wastewater has been developed that is believed to be a feasible means for estimating the level of human exposure to pathogens aerosolized by spray irrigation.

γ ι

Carlson, S., Hasselbarth, U., Sohn, F. W. (1976). *Studies on Virus Inactivation by Chlorine During Water Disinfection.* **ZBL BAKT HYG, ORIG B, 162:320-9. German.**

In chlorinated waters, oxidation-reduction potential (ORP) was a better indicator of virus inactivation than measurements of free chlorine.

Higher ORP values and longer periods of contact were needed for inactivating viruses than for inactivating bacteria.

To insure the inactivation of polioviruses in water that contained organic matter, an ORP of +750 mV (equivalent to about 0.3-0.6 mg of free chlorine/liter) must be maintained for 15 to 30 minutes.

Adenoviruses were about as resistant to inactivation as polioviruses.

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Chaudhuri, M., Koya, K. V. A., Sriramulu, N. (1977). *Some Notes on Virus Retention by Sand.* **J GEN APPL MICROBIOL, 23(6):337-44.**

Both rate of sorption to sand and sorptive capacity of coliphage MS2 decreased with increased system pH in the range of 6.0-8.4. However, the greatest quantity of sorption of viruses occurred at a pH of 7.8 with a natural ground water high in calcium and magnesium. Percolation or rapid filtration through sand removed the coliphage from water.

Viruses were not immobilized or inactivated by retention in sand or by removal by sand.

γ ι ζ

Cliver, D. O., Salo, R. J. *Indicators of Viruses in Foods Preserved by Heat.* **In "Indicators of Viruses in Water and Food," edited by G. Berg. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan (1978), 329-54.**

Conditions that affect the destruction of viruses in water by heat are briefly described within a discussion of indicators of viruses in foods preserved by heat.

γ ξ

Cook, B. *Using Iodine to Disinfect Water Supplies.* **In "Individual Onsite Wastewater Systems," Proceedings of the Fourth National Conference, 1977, edited by N. I. McClelland. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 217-26.

The effect upon health of prolonged use of iodine as a water disinfectant is extensively reviewed and discussed.

γ ι

Cottet, J. (1976). *The Disinfection of Drinking Waters and Sewage by UV Rays.* **L'EAU PURE, 39(3-4):20. French.**

This paper was listed in the 1977 edition of these abstracts. A translation was not then available.

Attenuated polioviruses 1 and 3, seeded at a concentration of 1,000 infective units/ml into turbid Seine River water, were destroyed by irradiation with UV light at a wavelength of 253.7 nm. All fecal indicator bacteria were also destroyed.

In spring and river waters, turbidity did not greatly reduce the effectiveness of UV irradiation, but organics dissolved in such waters did. *Vibrio cholera,* seeded into Seine River water at a concentration of 10^7 organisms/ml, were all destroyed by the UV irradiation.

Such irradiation also destroyed 99.9% of bacteria in activated sludge effluent.

γ ι

Cronier, S., Scarpino, P. V., Zink, M. L. *Chlorine Dioxide Destruction of Viruses and Bacteria in Water.* **In "Water Chlorination, Environmental Impact and Health Effects," Vol. 2, edited by R. L. Jolley, H. Gorchev, and D. H. Hamilton, Jr. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 651-8.

Chlorine dioxide is a better disinfectant than chlorine at the pH levels of most drinking waters.

Several enteroviruses and other viruses are more resistant to disinfectants than the fecal indicator *Escherichia coli.*

E. coli may be an inadequate indicator of disinfection.

μ σ

Derbyshire, J. B., Brown, E. G. (1978). *Isolation of Animal Viruses from Farm Livestock Waste, Soil and Water.* **J HYG, 81(2):**295-302.

Ten porcine enteroviruses, two porcine adenoviruses, and one coronavirus were recovered by direct inoculation from 32 samples of slurry collected from a pig fattening house. Concentration of the same samples by adsorption on the polyelectrolyte PE60 yielded 24 porcine enteroviruses and three porcine adenoviruses. By concentration on PE60, porcine enteroviruses were recovered from one of six slurry samples from a sow farrowing house. Viruses were not recovered from 12 samples of slurry from dairy cows or from six samples of slurry from a calf-rearing unit.

A porcine enterovirus was recovered on PE60 from soil samples collected one, two, and eight days after pig slurry had been spread on the soil, and two bovine enteroviruses were recovered from cattle feedlot run-off by adsorbing the viruses to layers of talc and celite and hydroextracting.

A porcine enterovirus was also recovered from one of 33 samples of surface waters collected on farms on which pig slurry was routinely spread on the land, but

no viruses were recovered from 36 samples of ground waters from the same farms. The surface water and ground water samples were concentrated by talc-celite adsorption and hydroextraction.

γ ξ

Drapeau, A. J., Paquin, G. (1977). *Destruction of Bacteria and Viruses by Ozone. Part 1: History.* **EAU DU QUEBEC, 10(1):34-6. French.**

The destruction of bacteria and the destruction of viruses by ozone are reviewed.

γ ξ

Drapeau, A. J., Paquin, G. (1977). *Destruction of Bacteria and Viruses by Ozone. Part 3: Virucidal Effect.* **EAU DU QUEBEC, 10(3):210-14.**

The destruction of bacteria and the destruction of viruses by ozone are reviewed.

μ ι γ ν

Edmond, T. D., Schaiberger, G. E., Gerba, C. P. (1978). *Detection of Enteroviruses Near Deep Marine Sewage Outfalls.* **MARINE POLLUT BULL, 9(9):246-9.**

Approximately 160 million gallons (608,000 m^3) of municipal sewage are discharged daily into the waters off the southeastern coast of Florida. With membrane filter adsorption technics, 21 to 42 PFU of viruses were recovered from 400-liter quantities of water in the vicinity of a deep marine outfall that discharged raw sewage, and 0 to 3 PFU of viruses were recovered from 400-liter quantities of water in the vicinity of two deep outfalls that discharged chlorinated secondary effluent.

About 10^4 fecal coliforms/100 ml of water were recovered consistently near the outfall that discharged raw sewage, but only 0 to 6 fecal coliforms/100 ml were recovered near the other two outfalls. Total coliform counts were a little higher than fecal coliform counts at all of the outfalls. The counts of fecal streptococci were about one log lower than the counts of fecal coliforms near the outfall that discharged raw sewage, but more than one log higher at the other two outfalls.

γ ι

Englebrecht, R. S., Greening, E. O. *Chlorine-Resistant Indicators.* **In "Indicators of Viruses in Water and Food," edited by G. Berg. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 243-65.

The usefulness of coliforms as indicators of viruses in disinfected wastewater effluents is questionable.

A yeast *(Candida parapsilosis)* and two acid-fast bacteria *(Mycobacterium fortuitum* and *Mycobacterium phlei),* recovered from chlorinated secondary wastewater effluents, were more resistant to chlorination than most bacteria. These organisms grew readily on well-defined media.

A mixed collection of yeasts or of acid-fast bacilli, naturally occurring in wastewaters, may be a valid indicator of viruses in disinfected effluents.

γ ι

Evison, L. M. (1978). *Inactivation of Enteroviruses and Coliphages with Ozone in Waters and Waste Waters.* **PROG WATER TECHNOL, 10(1-2):365-74.**

At 25 C, 99% of coxsackievirus B3 and poliovirus 3 were destroyed at pH 7 in about 10 minutes by 0.1 mg of ozone/liter. Coxsackievirus B3 and poliovirus 3

were more resistant to ozone than several other enteroviruses. A coliphage was less resistant. *Escherichia coli* was far less resistant than any of the viruses.

Organic and inorganic chemicals and waste water effluents exerted an ozone demand.

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Farrah, S. R., Bitton, G. (1978). *Elution of Poliovirus Adsorbed to Membrane Filters.* **APPL ENVIRON MICROBIOL, 36(6):**982-4.

Elution of poliovirus 1 (LSc), adsorbed to membrane filters from 40 ml of tap water seeded with 10^6 PFU of virus/ml, was best achieved with neutral and basic acids; acidic amino acids and organic acids were poor elutants.

The highest elution (93%) was achieved with 3% casein in 0.35 M Na^+. A 3% solution of beef extract with or without the Na^+ eluted about 76% of the virus from the filters.

v o

Farrah, S. R., Goyal, S. M., Gerba, C. P., Conklin, R. H., Smith, E. M. (1978). *Comparison Between Adsorption of Poliovirus and Rotavirus by Aluminum Hydroxide and Activated Sludge Flocs.* **APPL ENVIRON MICROBIOL, 35(2):**360-3.

Aluminum hydroxide flocs removed 99.9% of the poliovirus 1 (LSc) that had been seeded into tap water, but only 90% or less of a simian rotavirus (SA-11) that had been similarly seeded. The flocs did not remove a significant number of human rotavirus virions from a diluted stool suspension.

Activated sludge flocs removed from 50 to 99.6% of the poliovirus and 30 to 40% of the SA-11 virus from seeded tap water.

These studies indicate that a basic difference exists in the adsorptive behavior of enteroviruses and rotaviruses and that water and wastewater treatment processes that remove enteroviruses effectively may not effectively remove other groups of viruses.

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Farrah, S. R., Goyal, S. M., Gerba, C. P., Conklin, R. H., Wallis, C., Melnick, J. L., DuPont, H. L. (1978). *A Simple Method for Concentration of Enteroviruses and Rotaviruses from Cell Culture Harvests Using Membrane Filters.* **INTERVIROL, 9(1):**56-9.

Membrane-coating organic compounds in cell culture harvests prevented adsorption of enteroviruses and rotavirus SA-11 to membrane filters. These compounds could be removed with fluorocarbon. Enteroviruses and SA-11 in fluorocarbon-treated, acidified (pH 3.5) harvests adsorbed to epoxy-fiberglass filters.

At pH 9, tryptose phosphate broth eluted these viruses. At this same pH, 0.05 M glycine eluted only 52% of the adsorbed viruses. At pH 8, 10, and 11, few of the rotaviruses were recovered with 0.05 M glycine.

At pH 10, more than 90% of adsorbed poliovirus 1 (LSc), coxsackievirus B3, and echovirus 1 were eluted with 0.05 M glycine buffer.

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Farrah, S. R., Goyal, S. M., Gerba, C. P., Wallis, C., Melnick, J. L. (1978). *Concentration of Poliovirus from Tap Water onto Membrane Filters with Aluminum Chloride at Ambient pH Levels.* **APPL ENVIRON MICROBIOL, 35(3):**624-6.

Seeded poliovirus 1 (LSc) was removed by membrane filters more effectively from tap waters to which $AlCl_3$ had been added (final concentration 0.00002 M) than from tap waters that did not contain $AlCl_3$. Water became slightly turbid and slightly more acidic (0.5 pH unit) upon the addition of the salt. The virus was recovered from the membranes quantitatively by treating the membranes with a basic buffer. To reconcentrate it into a smaller volume of elutant, the virus was adsorbed onto aluminum hydroxide flocs and eluted.

With these procedures, polioviruses in 1,000 liters of water were concentrated into a final eluate of 20 to 80 ml. The mean recovery of the virus was 70%.

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Floyd, R., Sharp, D. G. (1978). *Viral Aggregation: Effects of Salts on the Aggregation of Poliovirus and Reovirus at Low pH.* **APPL ENVIRON MICROBIOL, 35(6):1084-94.**

The aggregation of poliovirus 1 (Mahoney) and reovirus 3 (Dearing) in solutions of monovalent, divalent, and trivalent cations, and monovalent and divalent anions was compared to the aggregation of those viruses at low pH alone. The numbers of virions in the test suspensions ranged from 0.5×10^9 to 1.0×10^9/ml.

Monovalent and divalent cations in concentrations that occur in natural waters generally decreased aggregation; divalent cations were more effective than monovalent cations. Trivalent cations in micromolar concentrations increased aggregation of virions. Anions, monovalent or divalent, did not prevent viral aggregation.

Although the activity of virions generally conforms to classical colloid theory, aggregation (when it occurs) must be taken into account in the design of experiments.

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Floyd, R., Sharp, D. G. (1978). *Viral Aggregation: Quantitation and Kinetics of the Aggregation of Poliovirus and Reovirus.* **APPL ENVIRON MICROBIOL, 35(6):1079-83.**

The aggregation of poliovirus 1 (Mahoney) and reovirus 3 (Dearing) were determined in buffers at various pH values by means of a single particle analysis (SPA) test. The SPA test used was modified from the original test reported earlier to prevent a disaggregation of virus clumps that might invalidate the results.

The modified SPA test demonstrated that the efficiency of aggregation, which is a measure of the percentage of collisions effective in producing an aggregate, may vary widely depending on the conditions in which the virus is placed.

The modified SPA test was also used to demonstrate that the kinetic features of viral aggregation follow the classical laws of colloid particle aggregation which in turn depend solely upon diffusion of particles by Brownian motion.

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Floyd, R., Sharp, D. G., Johnson, J. D. (1978). *Inactivation of Single Poliovirus Particles in Water by Hypobromite Ion, Molecular Bromine, Dibromamine, and Tribromamine.* **ENVIRON SCI & TECHNOL, 12(9):1031-5.**

In a dynamic flowing system of buffered water, Br_2 and NBr_3 inactivated single particles of poliovirus 1 (Mahoney) in a manner consistent with first order kinetics. Hypobromite ion (OBr^-) and $NHBr_2$ did not, even though more than 98% of the virions were dispersed as single particles. Aggregation of virions therefore could not be the factor responsible for the nonlinear inactivation kinetics. All forms

of free bromine and NBr_3 inactivated poliovirus more rapidly than equimolar concentrations of HOCl.

At a concentration of 10 μM, the initial inactivation rate for OBr^-, the linear inactivation rates for Br_2, NBr_3, and HOBr (taken from previously published data), and the initial inactivation rate for $NHBr_2$ were 3.85, 1.55, 0.15, 0.16, and 0.013 log_{10}/s, respectively.

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Fournier, J.-G., Rousset, S., Bouteille, M. (1978). *Application of Immuno-Electron Microscopy to the Detection of Virus in Water.* **C R ACAD SCI (PARIS), 286**:1637-9. **French.**

Adenoviruses seeded into demineralized and deionized waters were detected five days later by immunoelectronmicroscopy. Quantitation was limited by the heterogeneous dispersion of the particles on the grids.

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Fujioka, R. S., Loh, P. C. (1978). *Recycling of Water for Irrigation: Persistence of Enteroviruses in Sewage Effluent and Natural Waters Receiving the Effluent.* **WATER AIR SOIL POLLUT, 9(2)**:213-26.

Viruses were recovered from all of 11 raw sewage samples taken from a sewage treatment plant that provided chlorinated, activated sludge effluent for irrigating a two-year crop of sugarcane. The numbers of viruses recovered ranged from 27 to 19,000 PFU/liter. Fifty-eight percent of 53 chlorinated, activated sludge samples contained viruses in numbers that ranged from 2 to 750 PFU/liter.

Human enteroviruses were recovered from shallow flowing streams at distances up to 3 miles (5 km) from the closest sewage discharge entering a harbor. The viruses most often recovered were echovirus 7, coxsackieviruses B4 and B5, and polioviruses 1, 2, and 3.

Although activated sludge treatment followed by chlorination removed or destroyed about 90% of the viruses in raw sewage, the final effluent discharged into a stream used to irrigate sugarcane still contained a large number of viruses. Moreover, the recovery of enteroviruses from waterways at points distant from the sewage treatment plant indicated that sewage-borne viruses persisted in the natural water environment.

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Furuse, K., Sakurai, T., Hirashima, A., Katsuki, M., Ando, A., Watanabe, I. (1978). *Distribution of Ribonucleic Acid Coliphages in South and East Asia.* **APPL ENVIRON MICROBIOL, 35(6)**:995-1002.

Fifty of 221 raw sewage samples collected in the Philippines, Singapore, Indonesia, India, and Thailand in November 1976 contained RNA phages (52 strains). By serological analysis, 46 of the 52 strains belonged to phage group III. Thus, the most prevalent RNA phages in the Philippines, Singapore, and Indonesia were group III phages.

The most prevalent RNA phages in the sewage of mainland Japan (north of Kyushu) were group II phages. Group III phages predominated in the southern part of Japan, south of Amamiohshima Island.

A line appears to exist between Kyushu and Amamiohshima Island in the geographical distribution of RNA coliphages in the sewage of South and East Asia. One strain of phage (ID2) was partially inactivated by the antisera of four groups of RNA phages, a finding that may have evolutionary significance,

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Gartner, H. (1978). *Problems in Ecology and Hygiene of Coastal Waters (as Exemplified by the Baltic Sea).* **ZBL BAKT HYG, ORIG B, 166(2-3):222-43. German.**

Within a description of ecological and sanitary problems in coastal waters, especially on the Baltic Sea, bacterial indicators of viruses are discussed.

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Gaudin, O.-G., Meley, B., Chomel, J.-J., Viac, J. (1976). *Recovery of Viruses from River Water from an Urban District (Saint-Etienne).* **REV EPIDEMIOL SANTE PUBL, 24(5):423-36. French.**

In a survey from March, 1972 to February, 1973, 147 enterovirus strains were recovered from 54 samples of water collected from the Furan River below St. Etienne. Forty-four percent were polioviruses; virulent and attenuated strains of polioviruses 2 and 3 sometimes were recovered simultaneously. Only virulent strains of poliovirus 1 were recovered.

The numbers of enteroviruses recovered remained constant throughout the year. The numbers of coliphages recovered varied considerably from season to season, increasing notably in summer.

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Gerba, C. P., Farrah, S. R., Goyal, S. M., Wallis, C., Melnick, J. L. (1978). *Concentration of Enteroviruses from Large Volumes of Tap Water, Treated Sewage, and Seawater.* **APPL ENVIRON MICROBIOL, 35(3):540-8.**

Poliovirus 1 (LSc) seeded into waters in concentrations of about 3 to 1,000 PFU/liter were adsorbed to a 10-inch (ca. 25.4 cm) fiberglass depth cartridge filter and to a 10-inch pleated epoxy-fiberglass filter in series at flow rates up to 37.8 liters (10 gallons)/minute. The waters had been acidified to pH 3.5 and $AlCl_3$ had been added to a final concentration of 0.0005 M before filtration. Adsorbed viruses were eluted from the filters with glycine buffer (pH 10.5 to 11.5), and the eluates were reconcentrated by aluminum flocculation and then by hydroextraction.

With this procedure, polioviruses in large volumes of tap water, seawater, and sewage effluent were concentrated with an average efficiency of 52, 53, and 50%, respectively. This method detected surface solids-associated viruses that originated from sewage treatment plants.

When done on a batch basis or with an acid-salt injection technic, no differences in the recovery of viruses occurred.

This unified scheme for concentrating viruses permits high operating flow rates in an apparatus of low weight and small size.

θ λ ξ π χ

Gerba, C. P., Goyal, S. M. (1978). *Detection and Occurrence of Enteric Viruses in Shellfish: A Review.* **J FOOD PROT, 41(9):743-54.**

During feeding, bivalve mollusks (oysters, mussels, and clams) accumulate human enteric viruses from sewage-polluted seawater.

Hepatitis A virus is transmitted by consumption of raw or inadequately cooked shellfish. Because of lack of epidemiologic technics, transmission of other enteric viruses by shellfish has not been established; but, polioviruses, echoviruses, coxsackieviruses, and reoviruses have been recovered from shellfish.

Enteroviruses have been recovered from shellfish harvested from both approved and non-approved shellfish-growing waters. Enteric viruses survive for long periods in seawater and in shellfish.

Recent advances in methodology have led to development of more rapid and less expensive methods for detecting enteric viruses in shellfish.

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Gerba, C. P., Lance, J. C. (1978). *Poliovirus Removal from Primary and Secondary Sewage Effluent by Soil Filtration.* **APPL ENVIRON MICROBIOL, 36(2):**247-51.

Poliovirus 1 (LSc) seeded into primary and secondary effluents adsorbed to an equal degree in batches of soil and in columns of soil 240 cm long. The extent of desorption of viruses from soil columns flooded with either virus-seeded primary or virus-seeded secondary effluents was similar.

These results indicated that adsorption of poliovirus 1 from effluents and movement of this virus through soils were not affected by the different quantities of organics in primary and secondary sewage effluents.

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Gerba, C. P., Stagg, C. H., Abadie, M. G. (1978). *Characterization of Sewage Solid-Associated Viruses and Behavior in Natural Waters.* **WATER RES, 12(10):**805-12.

Solids-associated viruses in activated sludge and trickling filter effluents were collected on membrane filters that had been treated with fetal calf serum to prevent adsorption of freely suspended viruses and the viruses were eluted with pH 11.5, 0.05 M glycine buffer. The percentages of coliphages and animal viruses (recovered in BGM cells) in secondary sewage effluents associated with the solids ranged from <1.0 to 24% and 3 to 100%, respectively.

The largest quantities of solids-associated coliphages were attached to particles greater than 8.0 μm and less than 0.65 μm in size. Tap water, lake water, and estuarine water all eluted solids-associated coliphages. Elution of coliphages by marine waters appeared to be related to the salinity of the water. Coliphages eluted from sewage solids in seawater readsorbed to naturally occurring marine sediments.

λ ϱ τ

Glass, J. S., Van Sluis, R. J., Yanko, W. A. (1978). *Practical Method for Detecting Poliovirus in Anaerobic Digester Sludge.* **APPL ENVIRON MICROBIOL, 35(5):**983-5.

Under sonication, 3% beef extract at its natural pH eluted about 47% of poliovirus 1 (CHAT) from sewage treatment plant solids. The solids had adsorbed the virus from deionized water seeded at a level of 10^4 PFU/ml. Organic flocculation applied to such eluates recovered 60 to 65% of the viruses in the eluate.

Applied to dewatered composted solids, to undigested and anaerobically digested liquid sludges, and to dewatered digested sludges, the method yielded viruses from all 25 samples tested.

β ι μ π τ

Goyal, S. A., Gerba, C. P., Melnick, J. L. (1978). *Prevalence of Human Enteric Viruses in Coastal Canal Communities.* **J WATER POLLUT CONTROL FED, 50(10):**2247-56.

From 1 to 245 PFU of viruses were recovered from 400 liter-quantities of recreational coastal waters that received secondary sewage effluents. Those waters usually met bacteriological standards for recreational waters and shellfish harvesting.

The concentrations of viruses in the waters correlated well with presumptive total coliform MPN counts in the sediments. The physico-chemical characteristics of the waters (except possibly pH) did not correlate with the recoveries of viruses.

Poliovirus 1 was recovered in greatest numbers. Echoviruses 1, 5, 14, and 19, and coxsackievirus B6 were also recovered.

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Grabow, W. O. K. *South African Experience on Indicator Bacteria,* Pseudomonas aeruginosa, *and R⁺ Coliforms in Water Quality Control.* **In "Bacterial Indicators/ Health Hazards Associated With Water," ASTM STP 635, edited by A. W. Hoadley and B. J. Dutka, American Society for Testing and Materials** (1977), 168-81.

In South Africa, drinking waters from conventional sources and from reclaimed wastewater that were free of coliforms rarely contained *Pseudomonas aeruginosa,* fecal streptococci, *Clostridium perfringens, Staphylococcus aureus,* enteric viruses, or parasite ova. *P. aeruginosa* was occasionally recovered from waters from which no coliforms were recovered. *P. aeruginosa* should be included in some routine quality tests.

Epidemiological studies on an isolated community indicated that water which conforms to the criteria of 0 coliforms and 0 *P. aeruginosa*/100 ml, a standard plate count of less than 100/ml, and 0 detectable enteric viruses/10 liters will not transmit microbial diseases. The study included periods when drinking waters obtained by conventional methods were supplemented with supplies reclaimed from wastewater.

Hospital and city sewage, as well as a river and a reservoir polluted with secondary sewage effluent, contained large numbers of coliforms with transferable (R^+ factor) resistance to one or more of five common antimicrobial drugs. The survival of R^+ coliforms and the transfer of resistance during treatment of sewage and in polluted waters indicated that advanced treatment of wastewaters will be necessary to protect water resources from these organisms. Specifications that limit R^+ bacteria should be included in water quality standards.

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Grabow, W. O. K., Bateman, B. W., Burger, J. S. (1978). *Microbiological Quality Indicators for Routine Monitoring of Wastewater Reclamation Systems.* **PROG WATER TECHNOL, 10(5-6)**:317-27.

In South Africa, enteric viruses were not detected in two-phase polymer separation or in ultrafiltration concentrates of 286 samples that comprised a total volume of 1,788 liters of reclaimed water from the Windhoek plant or of 461 samples that comprised a total volume of 4,610 liters of reclaimed water from the Stander plant.

About 54 times more *Escherichia coli* B phages than enteric viruses were recovered from the raw waters of the Stander plant. Such phages were also detected by direct titration of samples from advanced treatment unit processes that did not yield enteric viruses from 10-liter volumes of water.

The microbiological standards used for routine monitoring of the reclamation plants were: total bacterial plate count, 100/ml; total coliforms, 0/100 ml; enteric viruses, 0/10 liters, and coliphages 0/10 ml. The plate count proved a highly sensitive indicator of microbiological pollution, and the coliphage test a rapid, economical, and simple method for screening removal of viruses. Over a period of more than seven years, the microbiological quality of reclaimed water was equivalent to or better than that of the best conventional supplies.

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Grabow, W. O. K., Middendorff, I. G., Basson, N. C. (1978). *Role of Lime Treatment in the Removal of Bacteria, Enteric Viruses, and Coliphages in a Wastewater Reclamation Plant.* **APPL ENVIRON MICROBIOL, 35(4):**663-9.

At pH 11.2, lime flocculation and sedimentation, the first unit process of a 4,500-m^3/day wastewater reclamation plant, reduced the numbers of microorganisms extensively. The efficiency of removal was much less at lower pH values, and some bacteria multiplied at pH 9.6.

Reductions in the numbers of enteric viruses were greater than reductions in the numbers of coliphages, enterococci, coliforms, and total numbers of bacteria, which indicated that the effectiveness of lime treatment in removing viruses could be monitored with coliphage and conventional bacteriological tests.

High pH lime treatment can contribute significantly in the multiple barrier concept in sanitary microbiology.

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Grigoryeva, L. V., Korchak, G. I., Ponomareva, L. V. (1976). *Detection of Bdellovibrios and Bacteriophages in the Sea Water Near the Shore.* **ZH MIKROBIOL EPIDEMIOL IMMUNOBIOL, (10):**41-4. **Russian.**

At contaminated sea shore sites, bdellovibrios were recovered from 73 to 100% of samples; bacteriophage were recovered from 75 to 83% of the samples. Some correlation existed among the bdellovibrio, bacteriophage, and coliform titers.

In the waters of less polluted shore regions, bdellovibrios were recovered from 15%, and bacteriophages from 21% of the samples.

There was no correlation between the numbers of coliforms and bdellovibrios in the waters off the shore area. Intestinal bacteriophages were a better indicator of pollution than the bdellovibrios.

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Hacker, D. S., Lockowitz, T. *Use of Ozone in the Disinfection of Coliphage T-7 Virus.* **In "Water—1976: I. Physical, Chemical Wastewater Treatment." AIChE Symposium Series No. 166, Vol. 73, edited by G. F. Bennett. American Institute of Chemical Engineers, New York, New York** (1977), 242-51.

Coliphage T7 was inactivated by ozone (O_3) in what appeared to be a two phase reaction. The first phase, identified with saturation of the solution by the disinfectant, was one in which mass transfer predominated; the second phase was kinetically a first-order reaction.

The reaction rate depended also on the viscosity and on the impurities in the media.

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Hattingh, W. H. J. (1977). *Reclaimed Water: A Health Hazard?* **WATER SA, 3(2):**104-112.

Within a detailed discussion of the quality of drinking waters in the Windhoek and Pretoria areas, raw water enterovirus levels of about 24,000 $TCID_{50}$/liter at the Stander water reclamation plant were reported reduced to 0/liter by treatment. Fecal coliform levels were reduced from about 600,000 CFU/100 ml to 0 CFU/100 ml and total coliform levels from about 1,300,000 CFU/100 ml to 0 CFU/100 ml; the numbers of other indicators were reduced by similar magnitudes.

Settled sewage at Windhoek contained about 56,000 $TCID_{50}$ of enteroviruses/liter; maturation plant effluents there contained only about 100 $TCID_{50}$ of enteroviruses/liter. The raw sewage contained about 2×10^7 CFU of fecal coliforms/100 ml. Maturation pond effluents contained only 80 CFU of fecal coliforms/100 ml.

In the Pretoria sewage treatment plant, the enterovirus level in the settled sewage was about 5,000 $TCID_{50}$/liter, and the fecal coliform level was about 7,000,000 CFU/liter.

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Hetrick, F. M. (1978). *Survival of Human Pathogenic Viruses in Estuarine and Marine Waters.* **ASM NEWS, 44(6)**:300-3.

The occurrence and survival of viruses in estuarine and marine waters are extensively reviewed.

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Hughes, M. B., Plissier, M., Torres, M. J.-P. (1977). *Disinfection of Wastewater by an Oxygen-Ozone Mixture.* **L'EAU & L'IND, 20(11)**:67-72.

In pilot plant studies in which tertiary wastewater effluents had been flocced with Fe^{++}, Ca^{++}, and a polyelectrolyte, 0.5 mg of O_3/liter destroyed >99.99% of seeded echovirus 1, *Salmonella typhimurium,* and *S. brancaster* in 10 minutes at pH 7.4. To maintain a residual of 0.5 mg of ozone/liter, it was necessary to apply 10 mg of O_3/liter.

An O_3 residual of 0.3 mg/liter destroyed >99.99% of the salmonellae, but not as large a proportion of the viruses.

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Hurst, C. J., Farrah, S. R., Gerba, C. P., Melnick, J. L. (1978). *Development of Quantitative Methods for the Detection of Enteroviruses in Sewage Sludges During Activation and Following Land Disposal.* **APPL ENVIRON MICROBIOL, 36(1)**:81-9.

Activated sludge solids were collected by centrifugation, and the solids-associated viruses in the sludge were eluted by mechanical agitation in pH 11 glycine buffer. Eluted viruses were adsorbed onto a floc that formed *de novo* upon adjustment of the pH of the glycine eluate to 3.5. Viruses that remained in the liquid phase after the pH of the glycine eluate had been lowered were concentrated by adsorption to and elution from membrane filters.

From seeded sludges, the method recovered 80% of poliovirus 1, 68% of echovirus 7, and 75% of coxsackievirus B3.

After disposal of sludge to the land, reductions of enterovirus numbers in sludge solids occurred at a rate of 2 $\log_{10}$/week.

λ μ ω

Jakubowski, W., Chang, S.-L., Ericksen, T. H., Lippy, E. C., Akin, E. W. (1978). *Large-Volume Sampling of Water Supplies for Microorganisms.* **J AMER WATER WORKS ASSN, 70(12)**:702-6.

The recovery of echovirus 8 from well water in one of four disease outbreaks suspected to have been waterborne is described. The recovery was made from one of several samples of 190 to 1,900 liters of water processed by large volume filtration technology.

Viruses were recovered from 13 of 27 samples of Ohio River water with the same technics. In all, 148 viruses were recovered from the river waters.

The portable apparatus used for processing the large volumes of water and some data on the recoveries of *Giardia* cysts and bacteria with the apparatus are also described.

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Johnson, D. E., Camann, D. E., Sorber, C. A., Sagik, B. P., Glennon, J. P. *Aerosol Monitoring for Microbial Organisms Near a Spray Irrigation Site.* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978), 231-9.

Enteroviruses were recovered from ambient air 50 meters downwind of a wastewater effluent spray irrigation site in Pleasanton, California. The number of enteroviruses recovered/m^3 of air equaled more than 10% of the viruses recovered in one ml of the wastewater effluent that was sprayed. The numbers of total coliforms, coliphages, and fecal streptococci/ml of sprayed wastewater were 4,900, 290, and 34, respectively, The numbers of those entities recovered/m^3 of air 50 meters downwind of the spray were 2.52, 0.51, and 0.34, respectively.

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Katzenelson, E. *Survival of Viruses.* **In "Indicators of Viruses in Water and Food," edited by G. Berg. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 39-50.

Viruses survive in the water environment for days—often many days. Humans excrete large numbers of viruses. Thus, the ability of viruses to survive for long periods in the water environment takes on a significance that must not be underestimated.

Kazantseva, V. A., Aizen, M. S., Drozdov, S. G. (1978) *Method of Determination of the Number of Enteroviruses Present in Natural Waters.* **VOPR VIRUSOL 0(4):**475-8. Translation presently not available. **Russian.**

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Kazantseva, V. A., Aizen, M. S., Drozdov, S. G., Kodkind, G. K. (1978). *Determination of the Number of Enteroviruses in Natural Water by Concentration of Virus Particles.* **GIG SANIT, 0(3):**79-83. **Russian.**

Enteroviruses seeded into water were concentrated by adsorption on membrane filters, on ion exchange resin AB-17-8 and on bentonite. The effectiveness of concentration depended upon the number of viruses seeded into the water. With membrane filters and on the ion exchange resin recoveries with the methods were greatest, 100 and 74%, respectively, when the seed virus concentration was lowest. Bentonite was most effective (60% recovery) when the seed concentration was highest (12.5 PFU/ml).

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Kedmi, S., Katzenelson, E. (1978). *A Rapid Quantitative Fluorescent Antibody Assay of Polioviruses Using Tragacanth Gum.* **ARCH VIROL, 56:**337-40.

Countable fluorescent foci formed in microcultures of cells infected with a poliovirus, suspended in a Tragacanth gum medium, dispensed on slides, incubated for 18-21 hours under CO_2 at 37 C, and stained with specific fluorescein isothiocyanate-labelled antipoliovirus rabbit gamma globulin. The numbers of fluorescent foci were about equal to the numbers of plaques in control assays.

Similar results were obtained with all three poliovirus types.

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Keswick, B. H., Fujioka, R. S., Burbank, N. C., Jr., Loh, P. C. (1978). *Comparative Disinfection Efficiency of Bromine Chloride and Chlorine for Poliovirus.* **J AMER WATER WORKS ASSN, 70(10):573-7.**

BrCl (measured as HOBr) destroyed poliovirus 1 (LSc) in buffer at pH 6 twice as rapidly as HOCl did. BrCl lost little effectiveness at pH levels up to 10 or more, and its activity was little affected by the presence of NH_3. The activity of HOCl against the poliovirus was reduced markedly by both elevated pH and NH_3.

Glycine sharply reduced the effectiveness of both BrCl and HOCl.

In sewage effluents, the demand for BrCl was satisfied at a level below that at which the demand for HOCl was satisfied.

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Kostenbader, K. D., Jr., Cliver, D. O. (1977). *Quest for Viruses Associated with Our Food Supply.* **J FOOD SCI, 42(5):1253-1268.**

A survey of sanitary sewers at nine meat packing and other food processing plants during the warmer months of the year yielded no viruses by the grab sample or gauze pad technics.

Viruses were not recovered from the finished food products from seven meat and vegetable product processing plants. Enteric viruses were recovered from incoming swine at one processing plant.

No viruses were recovered from 60 samples of market foods.

The virus recovery procedure included the inoculation of large volumes of samples on cell cultures and the transfer of inocula from one cell culture system to another.

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Kott, Y., Ben-Ari, H., Betzer, N. (1978). *Lagooned, Secondary Effluents as Water Source for Extended Agricultural Purposes.* **WATER RES, 12(12):1101-6.**

Storage of trickling filter effluents in a 70,000 m^3 pond (four m deep) for 73 days destroyed all viruses present.

In four hours, 20 mg of chlorine/liter destroyed more than 99% of the viruses and almost all of the coliforms in trickling filter effluents.

Seventy days of detention of wastewater may permit its use for agricultural purposes. The addition to the stored effluents of 20 mg of chlorine/liter (with a short holding time) may be expected to add a sufficient margin for safety.

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Kott, Y., Ben-Ari, H., Vinokur, L. (1978). *Coliphages Survival as Viral Indicator in Various Wastewater Quality Effluents.* **PROG WATER TECHNOL, 10(1-2):** 337-46.

In creeks and streams, the ratios of *Escherichia coli* B phages to enteroviruses ranged from 1:1 to 10:1. In heavily polluted waters, the ratios ranged up to 10^3:1. In oxidation pond effluents and in trickling filter effluents, coliphage numbers ranged to 10^6/100 ml.

Enterovirus counts varied considerably from season to season but coliphage counts did not. Although enteroviruses were not detected in secondary effluents 73 days after ponding, the numbers of coliphages in these effluents exceeded 1,000/100 ml.

Coliphage f2 survived longer than poliovirus 1 (LSc) in waters of different qualities. In dry sand, coliphage f2 survived for 217 days, the poliovirus did not.

These results suggest that phages of *E. coli* B may be useful indicators of human enteroviruses in wastewater.

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Landry, E. F., Vaughn, J. M., Thomas, M. Z., Vicale, T. J. (1978). *Efficiency of Beef Extract for the Recovery of Poliovirus from Wastewater Effluents.* **APPL ENVIRON MICROBIOL, 36(4):544-8.**

Poliovirus 1 (LSc) seeded into 20- to 25-gallon (ca. 75.6- to 95.6- liter) quantities of treated sewage effluent and adsorbed to fiberglass cartridge filters (K27), epoxy-fiberglass-asbestos filters (M780), or pleated cartridge filters were eluted more effectively with beef extract (pH 9.0) followed by organic flocculation than with 0.1 M glycine (pH 11.5) followed by inorganic flocculation. Elution with 3% beef extract and organic flocculation yielded a mean recovery efficiency of 85%. Elution with 0.1 M glycine (pH 11.5) and inorganic flocculation yielded a mean recovery efficiency of 36%.

Organic flocculation was more effective than inorganic flocculation for reconcentrating viruses recovered from seeded sewage effluents.

Beef extract concentrations of less than 3% were effective elutants of polioviruses recovered from renovated wastewater.

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Larkin, E. P. *Foods as Vehicles for the Transmission of Viral Diseases.* **In "Indicators of Viruses in Water and Food," edited by G. Berg. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 299-328.

Within a discussion of virus transmission by food, the viruses recovered from the feces and urine of humans and other animals are summarized.

ζ σ ϱ

Larkin, E. P., Tierney, J. T., Lovett, J., Van Donsel, D., Francis, D. W. *Land Application of Sewage Wastes: Potential for Contamination of Foodstuffs and Agricultural Soils by Viruses and Bacterial Pathogens.* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978), 102-15.

Poliovirus 1, *Salmonella typhimurium,* and *Mycobacterium tuberculosis* (BCG) seeded on crops and in soil survived for longer than the growing seasons of some crops. Viruses and bacterial pathogens can survive on crops for a time longer than that required for distributing crops to consumers.

Few sludges and effluents produced by sewage treatment plants are monitored for viruses or bacterial pathogens.

A number of states and territories have no regulations for control of discharge to the land of sewage sludges or effluents.

ζ μ ϱ χ

Larkin, E. P., Tierney, J. T., Sullivan, R. (1976). *Persistence of Virus on Sewage-Irrigated Vegetables.* **J ENVIRON ENGIN DIV, ASCE, 102:EE1:29-35.**

To reduce stream pollution, many municipalities are contemplating land disposal of primary and secondary sewage effluents. Enteroviruses, reoviruses, and adenoviruses have been recovered from such effluents and from the sludges of these effluents.

Vegetables spray-irrigated with poliovirus 1-inoculated sewage sludges and effluents yielded the virus for as long as 36 days, indicating the potential for contamination of vegetables when such spray-irrigation systems are used.

γ ι

Longley, K. E. (1978). *Turbulence Factors in Chlorine Disinfection of Wastewater.* **WATER RES, 12(10):813-22.**

At ambient temperatures (15 to 28 C), 31 and 47% of the coliphage f2 seeded into effluents at a full scale trickling filter plant were destroyed in 2 seconds and 10 seconds, respectively, by 4.5 mg/liter of dosed chlorine delivered through a conventional diffuser. In the same time-dose couplings, 86 and 99% of the indigenous total coliforms were destroyed. Under similar conditions, 17 mg/liter of dosed chlorine destroyed 71 and 77% of the seeded coliphage in 2 and 10 seconds, respectively, and 99.5 and 99.99% of the total coliforms after similar contact times.

Delivered through a venturi that produced rapid mixing into the same trickling filter effluent (but in an adjacent pilot plant facility) 4.3 and 17 mg/liter of dosed chlorine destroyed about 90 and 99.99%, respectively, of the indigenous total coliforms in the first several seconds of contact at 13 to 16 C.

Free chlorine was measurable in only the first few seconds after the effluents were dosed. Rapid mixing of chlorine into the effluents by means of a venturi allowed contact of free chlorine with viruses and bacteria before the chlorine dissipated into chloramines.

The pH of the effluents ranged from about 6 to 7.

ι ω

Mack, W. N. *Total Coliform Bacteria.* **In "Bacterial Indicators/Health Hazards Associated with Water," ASTM STP 635, edited by A. W. Hoadley and B. J. Dutka. American Society for Testing and Materials, Philadelphia, Pennsylvania** (1977), 59-64.

Although there are shortcomings to total coliform counts, they are our best indicator of microbiological health hazards in drinking water. Some of the shortcomings that exist can be corrected by tests to determine interference and to identify non-coliform lactose-fermenting organisms.

Occasionally, drinking water samples that contain viruses do not yield coliform bacteria by standard tests. Coliforms have been recovered from waters by methods used to concentrate viruses when the coliforms could not be recovered from the waters by standard tests.

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Mahnel, H. (1977). *Inactivation of Viruses in Drinking and Surface Water; A Contribution to the Decontamination of Water by Field Methods.* **ZBL BAKT HYG, ORIG B, 165(5-6):527-38. German.**

Under field conditions, drinking waters may be freed of viruses by both heat and chemical means.

A parvovirus (10^6 $TCID_{50}$/ml) in drinking water was not inactivated completely after one hour at 80 C. A reovirus was inactivated at 60 C in this period of time. A poliovirus, an echovirus, HCC virus, pseudorabies virus, Newcastle disease virus, and vaccinia virus lost their infectivities at 56 C within 60 minutes and at 60 C within 20 minutes.

Iodine, calcium hypochlorite, and potassium permanganate were effective disinfectants. Chloramine-T, hydrogen peroxide, and sodium peroxide were unsuitable drinking water disinfectants because the amounts necessary made water unfit to drink.

Heat was judged a less suitable method than chemical means for field disinfection of drinking water.

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Mahnel, H. (1978). *Inactivation of Viruses in Water by Anodic Oxidation.* **ZBL BAKT HYG, ORIG B, 166**:542-57. Translation presently not available. **German.**

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Malina, J. E., Jr. *The Effect of Unit Processes of Water and Wastewater Treatment on Virus Removal.* **In "Viruses and Trace Contaminants in Water and Wastewater," edited by J. A. Borchardt, J. K. Cleland, W. J. Redman, G. Olivier. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1977), 33-51.

Municipal wastewater treatment plants that incorporate primary sedimentation, biological treatment, and disinfection can produce effluents with less than 10 PFU of human enteric viruses/liter. Subjecting these effluents to advanced waste treatment methods should produce a water in which no viruses can be detected with the technics currently available for the concentration and enumeration of viruses.

γ

Mann, A. W., Vaccaro, R. F., Deese, P. L. (1978). *Controlled Chlorination in Agricultural Systems Irrigated with Secondary Wastewater Effluents.* **J WATER POLLUT CONTRL FED, 50(3)**:427-32.

Multiple regression analysis of seasonally-acquired data on the destruction of coliphage MS2 that had been seeded into a secondary effluent used for spray irrigation yielded mathematical expressions that may be useful in identifying the minimum chlorine dosages necessary for safely disinfecting such effluents.

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Meley, B. Gaudin, O.-G. (1976). *Viral Flora (Coliphages and Human Enteroviruses) in River Water Below a City (Saint-Etienne). I. Comparative Study of Four Simple and Inexpensive Methods for Concentration and Isolation of Viruses.* **REV** EPIDEMIOL SANTE PUBL, **24(5)**:415-22.

Polioviruses, 1, 2, and 3 seeded into river water were recovered in greater numbers by adsorption to the polyelectrolyte PE60, added to water samples in a concentration of 200 mg/liter, than by the same technic when the concentration of the PE60 was about 100 mg/liter. No viruses were recovered with the two-phase separation procedure.

δ ξ

Melnick, J. L. *Are Conventional Methods of Epidemiology Appropriate for Risk Assessment of Virus Contamination of Water?* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978), 61-75.

The epidemiology of waterborne virus infections is reviewed. The difficulties in demonstrating water transmission of virus infections are discussed.

The author argues that currently available expensive epidemiologic technics are not likely to yield important new information on the relationship between viruses in water and disease, and that new funds therefore should rather be expended on eliminating viruses from raw source waters and from drinking waters.

ξ π

Melnick, J. L., Gerba, C. P., Wallis, C. (1978). *Viruses in Water.* **BULL WHO, 56(4):499-508.**

The problems of viral contamination of water and shellfish are reviewed and discussed in light of growing needs for and probable recycling of wastewaters required to meet the demands of enlarging world populations and industries.

ι π

Metcalf, T. G. *Indicators of Viruses in Shellfish.* **In "Indicators of Viruses in Water and Food," edited by G. Berg. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 383-415.

Enteric viruses in fecally-polluted waters are filtered out by shellfish and carried within them for long periods of time.

The numbers of indicator bacteria in shellfish-growing waters often do not accurately reflect the presence of viruses in shellfish-growing waters or in shellfish.

ε ζ η π

Metcalf, T. G., Comeau, R., Mooney, R., Ryther, J. H. *Opportunities for Virus Transport within Aquatic and Terrestrial Environments.* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978), 77-101.

Within a mariculture system fed with secondary effluent, seeded poliovirus 1 and other enteric viruses were passively transmitted sequentially from shellfish to polychaete worms to flounder and lobsters. The transmission of viruses from worms to the flesh of flounder implied a passive route of transmission from sewage to man through a food chain.

Large and small millipedes, slugs, sowbugs, and worms fed poliovirus 2 in their food excreted the virus for at least three days, The large millipedes and slugs excreted the virus for six and seven days, respectively. The large millipedes still contained the virus on sacrifice seven days after the feeding. The recovery of the poliovirus from these soil macrovertibrates for periods up to seven days after the virus had been fed to them suggested that land disposal of sewage containing viruses might permit reinfection of man through the food chain.

ξ σ

Miller, F. P., Wolf, D. C. *Renovation of Sewage Effluents by the Soil.* **In "Individual Onsite Wastewater Systems." Proceedings of the Second National Conference, 1975, edited by N. I. McClelland. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1977), 89-117.

The movement and survival of viruses in soils is discussed within a comprehensive review of the factors that interplay in land treatment of wastewaters.

μ ν ϱ

Moore, B. E., Sagik, B. P., Sorber, C. A. *Land Application of Sludges: Minimizing the Impact of Viruses on Water Resources.* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978), 154-67.

More than 4,000 PFU of enteric viruses/gram of suspended solids were recovered from primary sludge. Almost 600 PFU of viruses were recovered/gram of digested solids.

In primary wastewater sludges, virus numbers ranged from 440 to 4,300 PFU/gm of solids. Coliphage levels ranged to 2 million PFU/gm of solids.

Raw wastewaters contained from 6 to 7,900 PFU of enteric viruses/liter. Retention of wastewater in an oxidation ditch reduced the numbers of enteric viruses by 57% to 99.9%. Trickling filters reduced the numbers of enteric viruses in wastewater by 59% to 95%.

In an anaerobic digester operating at 37 C, 71% to 92% of the viruses in primary sludges were destroyed in 40 days. Another 7% to 28% of these viruses were destroyed by sludge thickening at ambient temperatures for 60 days.

Viruses were recovered from soils at subsurface thickened raw and mesophilically-digested sludge injection sites. One virus was recovered from one such site six months after the last application of thickened raw sludge.

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Nestor, I. (1978). *Conditions of Inactivation of Viruses in Water with Chlorination.* **REV IG (BACTERIOL), 23(1)**:1-15. Translation presently not available. **Roumanian.**

μ ϱ

Nestor, I., Costin, L., Sovrea, D., Ionescu, N. (1978). *Enteric Viruses in the Danube River Water and Sludge.* **J HYG EPIDEMIOL MICROBIOL IMMUNOL, 22(2)**:144-151.

In a study from 1972 to 1974, viruses were recovered from 17.5% of 123 water samples and 116 dredge sludge samples collected from 20 locations along the Roumanian course of the Danube River. Viruses were concentrated by the gauze pad method. The frequency of virus recoveries from water samples and from sludge samples was about the same.

Viruses were concentrated on polyelectrolyte PE60 and yeast cells and recovered by inoculation into suckling mice and into cell cultures.

μ ω

Nestor, I., Costin, L., Sovrea, D., Ionescu, N. (1978). *Investigations on the Presence of Enteroviruses in Drinking Water.* **REV ROUM MED VIROL, 29(3)**:203-7.

Enteroviruses were recovered from 3.6% of 220 samples of tap water taken from eight population centers during the period from 1972 to 1977. Three of the viruses recovered were attenuated poliovirus 3, two were strains of coxsackievirus A4, and six were untyped.

The viruses were concentrated from the water by the gauze pad technic and reconcentrated from pad eluate by adsorption to polyelectrolyte PE60 or to yeast cells.

A variety of Roumanian rivers constituted the raw source waters of the contaminated supplies. The raw waters were treated by standard State treatment procedures and chlorinated to a residual of 0.1 to 0.25 mg of chlorine/liter.

δ θ

Newaskar, L. D., Vidwans, A. H., Vachha, S. M. (1978) *Outbreak of Viral Hepatitis Due to Water Pollution in Pimpri-Chinchwad Township.* **INDIAN J ENVIRON HEALTH, 20(1)**:79-83.

An outbreak of viral hepatitis in the Pimpri Chinchwad area peaked in March and April 1976. The peak occurred six weeks after a considerable increase occurred

in the pollution of the Pawana River, the raw water source for the Pimpri Chinchwad area. The number of cases of hepatitis reported appeared to be directly proportional to the extent of pollution of the river suggesting a relationship between the incidence of hepatitis and the pollution of the area's water source.

γ ν ξ

Nezu, N. (1976). *Removal, Inactivation, and Disinfection of Virus in Water.* **YOSUI TO HAISUI, 18(10):13-23. Chinese.**

The removal of viruses from water and wastewater and the destruction of viruses in those waters by disinfectants is reviewed.

γ

Nielson, N. E. *Ozonation, Irradiation, Chlorination and Combinations: A Discussion of the Practicalities of Their Use in Smaller Water/Wastewater Treatment Systems.* **In "Individual Onsite Wastewater Systems," Proceedings of the Fourth National Conference, 1977, edited by N. I. McClelland. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 189-216.

The need to destroy viruses and other pathogens in wastewater disinfection is alluded to briefly in an extensive discussion of chemical and physical methods, especially gamma irradiation, for disinfecting wastewaters.

γ

Parrella, A., Bianchetti, A., Aliberti, F., Gargiulo, E. (1977). *Antiviral Activity of ClO_2 and NaClO: Comparative Study.* **ING AMBIEN, 6:**(11-12):412-16. Translation presently not available. **Italian.**

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Payment, P., Trudelet M., Pavilanis, V. (1978). *Evaluation of the Efficiency and the Technique of Adsorption-Elution of Poliovirus 1 on Fiberglass Filters: Application to the Virologic Analysis of 100 ml to 1,000 Liters of Water.* **CAN J MICROBIOL, 24(11):**1413-16. **French.**

At pH 3.5, more than 99% of the poliovirus 1 seeded into tap water, river water, and sewage to which $AlCl_3$ had been added to a final concentration of 5×10^{-4} M adsorbed to fiberglass cartridge filters. Eighty-five to 95% of the adsorbed viruses were eluted from the filters with 3% beef extract at pH 9. The organic flocculation procedure reconcentrated the poliovirus into 1/20 of the elution volume with a 50 to 72% efficiency. The overall efficiency of the technic for 100 ml to 1,000 liters of the waters was 38 to 58%. Seeding concentrations for the poliovirus were 10^2 to 10^6 PFU.

γ

Peleg, M., Medar, D., Kalbo, R., Katzenelson, E., Shuval, H. *Chemical and Viricidal Investigation of the Ozonization of Wastewater Systems.* **In "Disinfection with Ozone," Proceedings of Forum on Ozone Disinfection, June 2-4, 1976, Chicago, Illinois, edited by E. G. Fochtman, R. G. Rich, and M. E. Browning. Ozone Press Internationale, Jamesville, New York** (1977), 193-204.

Within a paper on the reaction of ozone with chemical constituents of wastewaters, studies were alluded to that showed a true dose-response relationship between ozone and poliovirus 1 in reaction times of less than three seconds.

γ θ π

Peterson, D. A., Wolfe, L. G., Larkin, E. P., Deinhardt, F. W. (1978). *Thermal Treatment and Infectivity of Hepatitis A Virus in Human Feces.* **J MED VIROL, 2(3):**201-6.

Intramuscular or oral administration of hepatitis A virus (HAV) obtained from the feces of four patients with acute hepatitis induced hepatitis in 28 to 100% of inoculated white-lipped marmosets *(Saginus sp.).* Orally administered, a 1:3 dilution of a 10% (w/v) fecal pool prepared from the stools of two patients induced hepatitis in marmosets (2/4 with 1 ml; 2/2 with 3 ml). A baby food-raw oyster mixture seeded with HAV and fed to fasted marmosets induced hepatitis in 1/4 and seroconversion in 2/4 animals.

Four of six marmosets fed oysters that had been seeded with a fecal pool concentrate that contained HAV developed hepatitis and the other two marmosets seroconverted. One of seven marmosets fed the same fecal pool concentrate after it had been heated at 140 F for 19 minutes developed hepatitis and one other seroconverted. These data suggest that a pasteurization technic can be developed that will prevent shellfish-associated hepatitis A without destroying the palatability of the shellfish.

ι ξ

Petrilli, F. L. (1977). *Introduction to the Study of Viral Contamination of Sea Water.* **REV INT OCEANOGR MED, 48:**5-7.

The problem of viruses in seawater and the usefulness of indicator organisms are reviewed and discussed.

ι μ τ

Petrilli, F. L., De Flora, S. (1977). *Correlation Between Animal Viruses and Bacteria in Coastal Sea Waters and Sediments.* **REV INT OCEANOGR MED, 48:**33-6.

Enteroviruses (vaccine-like polioviruses, group B coxsackieviruses and echoviruses) were recovered from all sea water samples tested in which the MPN counts of *Escherichia coli* exceeded 920/100 ml. The numbers of enteroviruses correlated well with those of *E. coli* in the samples tested. However, the numbers of *E. coli* varied less than the numbers of viruses.

Counts of enteroviruses and reoviruses in concentrates of sand and slime collected at depths of 0.5 to 12 meters attained levels up to 40 TCD_{50}/100 ml of sediment suggesting that sediments may represent a transient reservoir for animal viruses.

The viruses were concentrated from all samples by the polyelectrolyte method.

λ ξ

Pietri, C. (1977). *Evaluation of the Validity of Virus Counts in the Sea.* **REV INT OCEANOGR MED, 48:**21-6. French.

Sampling, concentration, and culture systems for recovering viruses from seawater are described and discussed.

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Rao, V. C., Lakhe, S. B., Waghmare, S. V. (1978). *Developments in Environmental Virology in India.* **IAWPC TECH ANN (INDIA), 5:**1-16.

In India during the past decade, significant contributions have been made in water, wastewater, and food virology. These contributions include development of

simple and inexpensive methods for concentrating and enumerating viruses in raw sewage and effluents; development of an insight into diurnal and seasonal variations in the quantities of viruses in domestic wastewater; determination of the pattern of excretion of viruses by healthy children; development of an approach to collecting wastewater samples for optimum virus recovery; development of a method for preserving and transporting eluates from the field to the laboratory; evaluation of virus removal efficiencies of costly conventional sewage treatment systems and low-cost waste treatment plants; determination of the extent of virus removal during sewage reclamation for reuse; determination of the problem of uptake of viruses by shellfish that inhabit polluted waters; development of a method for recovering and quantifying viruses in food (clams and oysters); development of methods for concentrating and estimating numbers of viruses in large volumes of drinking water; and determinations of usefulness of bituminous coal in removal of viruses by filtration of water.

γ ζ ι

Rowley, D. B., Sullivan, R., Josephson, E. S. *Indicators of Viruses in Foods Preserved by Ionizing Radiation.* **In "Indicators of Viruses in Water and Food," edited by G. Berg. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 355-82.

The D-values for the destruction by gamma irradiation of adenoviruses, coxsackieviruses, echoviruses, and polioviruses in distilled water are listed within a discussion of indicators of viruses in foods preserved by ionizing radiation.

μ

Ruiter, G. G., Fujioka, R. S. (1978). *Human Enteric Viruses in Sewage and Their Discharge into the Ocean.* **WATER AIR SOIL POLLUT, 10(1):**95-103.

Over a 24-hour period, 8 × 10^{10} PFU of viruses were discharged with Honolulu's untreated sewage through an ocean outfall. Higher concentrations of viruses were consistently recovered from the sewage of Kuhio Park Terrace, a high density, low socioeconomic level community with a relatively high percentage of children, than from the sewage of Nuuanu, a low density, high socioeconomic level community with few children.

Composites of sewage sampled every hour or every two hours over a 24-hour period yielded equivalent quantities of viruses.

ζ ι χ

Sadovski, A. Y., Fattal, B., Goldberg, D., Katzenelson, E., Shuval, H. I. (1978). *High Levels of Microbial Contamination of Vegetables Irrigated with Wastewater by the Drip Method.* **APPL ENVIRON MICROBIOL, 36(6):**824-30.

Irrigation from drip lines covered by plastic sheets either on the soil surface or buried at a depth of 10 cm significantly reduced contamination of a cucumber crop by polioviruses 1, 2, and 3 and by *Escherichia coli* (with a drug resistant marker) seeded into oxidation pond effluent irrigation water. The polioviruses were seeded at a density of about 9 × 10^7 PFU/liter and the *E. coli* was seeded at a density of about 10^8/liter.

Viruses and marker coliforms were recovered repeatedly from the surfaces of cucumbers irrigated without benefit of plastic cover.

The viruses and the bacteria persisted in the irrigation pipes and in the soil for at least 8 and 18 days, respectively.

ξ ϱ

Sagik, B. P., Sorber, C. A. (1978). *Assessing Risk for Effluent Land Application.* **WATER & SEW WORKS, 125(10):**40-2.

The removal and destruction of viruses by wastewater and wastewater sludge treatment processes are described within a discussion of the assessment of the risk to health that accompanies the disposal of wastewaters and wastewater sludges to the land.

This paper is a summation of part of the **Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges, edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978).

ι λ μ

Sarrette, B., Danglot, C., Vilagines, R. (1977). *New Method Permitting the Quantitative Determination of Viruses Present in Surface Waters.* **C R ACAD SCI (PARIS) 285:**1359-61. **French.**

Poliovirus 1 (LSc) seeded into autoclaved river water was recovered by adjusting the pH of the water to 3.5, mixing the water with glass beads for 30 minutes, and eluting the virus adsorbed to the beads with glycine buffer at pH 11.5. About 34% of the seeded virus was recovered.

In field tests of waters collected from two sites on the Seine River and from one site on the Marne River, viruses were recovered in numbers up to 190 PFU/liter. There was no correlation between the numbers of viruses recovered and the numbers of total coliforms recovered.

η ξ

Sattar, S. A. "Viruses, Water and Health." University of Ottawa Press, Ottawa, Canada (1978), 1-106.

"Viruses, Water and Health" is a short textbook on the subject of viruses in water.

γ ν ϱ

Sattar, S. A., Ramia, S. (1978). *Viruses in Sewage: Effect of Phosphate Removal with Calcium Hydroxide (Lime).* **CAN J MICROBIOL, 24(8):**1004-6.

Ninety-nine percent of seeded poliovirus 1 (LSc) was removed from wastewaters when those waters were treated with lime at pH 9.5 to 10.5 to remove phosphate.

Storage of lime sludges at 28 C for up to 48 hours produced no appreciable reduction in virus numbers.

Viruses were recovered from all samples of lime sludges and from 80% of the samples of sewage and lime-treated effluent collected at a plant in Ontario; after chlorination, viruses were recovered from only 20% of the samples of lime-treated effluent.

Caution must be exercised in handling and disposal of lime-sludges.

γ μ

Sattar, S. A., Westwood, J. C. N. (1978). *Viral Pollution of Surface Waters Due to Chlorinated Primary Effluents.* **APPL ENVIRON MICROBIOL, 36(3):**427-31.

Over a two-year period, viruses were recovered in BSC1 cells from 80% (75/94) of raw sewage samples, 72% (68/94) of primary effluent samples, and 56% (53/94) of chlorinated effluent samples concentrated by the talc-celite technic. The samples came from two treatment plants that discharged into the

Ottawa River at Ottawa. Both raw sewage and primary effluent samples contained about 100 viral infective units (VIU)/100 ml.

Chlorination produced a 10- to 50-fold reduction in VIU leaving nearly 2.7 VIU/100 ml of chlorinated primary effluent. With a combined daily chlorinated primary effluent output of approximately 3.7×10^8 liters, these two plants discharged about 1.0×10^{10} VIU/day. Alone, these two sources produced a virus loading of 1.0 VIU/8 liters of river water. This river also receives at least 9.0×10^7 liters of raw sewage/day and undetermined but substantial amounts of storm waters and agricultural wastes. The river is used for recreation and is the raw water source of potable water for some 6.0×10^5 people.

In view of the potential of water for disease transmission, discharge of such wastes into the water environment needs to be minimized.

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Scarpino, P. V., *Bacteriophage Indicators.* **In "Indicators of Viruses in Water and Food," edited by G. Berg. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1978), 201-27.

Bacteriophage have a definite but restricted value as indicators of viruses. Phage, indigenous to environmental waters, that possess survival characteristics similar to human viruses may be useful indicators of the removal and inactivation by treatment processes of human viruses in such waters.

Careful studies must be made of the relative numbers of coliphages and enteric viruses in waters and of the fluctuations of their numbers in those waters before any phages can be promulgated as indicators of enteric viruses in environmental waters.

η λ

Schmidt, N. J., Ho, H. H., Riggs, J. L., Lennette, E. H. (1978). *Comparative Sensitivity of Various Cell Culture Systems for Isolation of Viruses from Wastewater and Fecal Samples.* **APPL ENVIRON MICROBIOL, 36(3):480-6.**

In parallel, 181 samples of wastewater were inoculated into tube cultures of several cell types and plaqued in bottle and petri dish cultures of three types of monkey kidney cells. Polioviruses were recovered most frequently in a line of human rhabdomyosarcoma cells (RD), group A coxsackieviruses in RD and human fetal diploid kidney (HFDK) cells, group B coxsackieviruses in the BGM line of African green monkey kidney cells, echoviruses in RD and primary rhesus monkey kidney (RhMK) cells, and reoviruses in RhMK cells. BGM cells were unsatisfactory for recovering viruses other than polioviruses and group B coxsackieviruses, and a line of fetal rhesus monkey kidney (MFK) was not a satisfactory substitute for primary RhMK. With RhMK cells, comparable numbers of viruses were recovered in tube cultures and in plaque assays in bottle cultures, but with BGM and MFK cells, fewer recoveries were made by plaquing than by inoculation of tube cultures.

In comparative plaque assays of fecal samples under three different overlays in bottle and plate cultures of RhMK, BGM, and MFK cells, plaquing in the most sensitive system, RhMK, was less efficient for recovering viruses than inoculation of tube cultures of RhMK or HFDK cells. Overall, plaque assays in petri dishes incubated under CO_2 yielded fewer viruses than parallel plaque assays in closed bottle cultures.

λ

Schwartzbrod, L., Lucena-Gutierrez, F. (1978). *Concentration of Enterovirus in Water by Adsorption on Glass Powder: Proposal for a Simplified Apparatus.* **MICROBIA, 4(1):55-68. French.**

A poliovirus seeded into tap water was recovered by adsorption onto powdered glass and elution from the glass with glycine buffer, pH 11.5. Adsorption onto the glass was accomplished at pH 3.5 in the presence of $AlCl_3$ (0.0005 M).

With this method, viruses were recovered from 50-liter volumes of water flowing through the powdered glass at a rate of about 80 liters/hour. Recoveries of viruses ranged from 36% to more than 100%.

λ

Selna, M. W., Miele, R. P. (1977). *Virus Sampling in Wastewater—Field Experiences.* **J ENVIRON ENGIN DIV, ASCE, 103:EE4:693-705.**

A California state code requires that reclaimed wastewater used for recreation must receive treatment beyond conventional secondary treatment. The code was designed to produce virologically safe effluents for recreational uses.

To test the effectiveness of tertiary treatment systems for removing viruses from secondary effluents, a modified Baylor system was innovated. Twenty- to 100-gallon samples of effluent seeded with poliovirus 1 were acidified to pH 3.5, $AlCl_3$ was added to a final (Al^{+3}) molarity of 0.005, and each effluent was pumped through a K27 fiberglass filter (pore size 3 μm) and then through Cox filters (porosities 1 μm and 0.45 μm). The viruses adsorbed to the filters were eluted with two or more liters of 0.05 M glycine, pH 11.5, which was quickly neutralized. The neutralized eluate was flocced with $AlCl_3$ and the flocced eluate was neutralized with Na_2CO_3. The settled floc was centrifuged, and viruses were eluted from the floc pellet with 0.05 M glycine, pH 11.5. The eluate was centrifuged, and the supernatant was filtered through an alginate filter. The alginate filter was dissolved in citrate, and the viruses that had been adsorbed to the alginate were recovered in cell cultures by the plaque technic. The average efficiency of recovery was about 20%.

λ

Shaffer, P. T. B. *Virus Detection Methods—Comparison and Evaluation.* **In "Viruses and Trace Contaminants in Water and Wastewater," edited by J. A. Borchardt, J. K. Cleland, W. J. Redman, and G. Oliver. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1977), 21-31.

Many problems may be encountered in efforts to recover small numbers of viruses from large volumes of waters.

In Canada and in the Northern United States, many waters are rich in acid-soluble humic acids which interfere with the concentration of viruses onto filter surfaces and then with the subsequent reconcentration of the viruses from eluates.

Variation from laboratory to laboratory with a single virus recovery procedure may produce recovery efficiencies of from less than 1 to more than 100%.

Data obtained under carefully controlled laboratory conditions often differ considerably from data obtained under field conditions. Data obtained with virus seeding experiments may vary considerably from data obtained with viruses indigenous to waters.

Dispersed viruses that adsorb to particulates in waters may not be recoverable to the same degree as viruses that remain dispersed.

Some viruses are inactivated at the high pH levels (11 to 11.5) that are used to elute viruses from filter surfaces.

β π ϕ

Shuval, H. I. (1978). *Studies on Bacterial and Viral Contamination of the Marine Environment.* **REV INT OCEANOGR MED, 50:43-50.**

Large numbers of viruses and bacteria enter the sea through sewage outfalls and survive long enough and in large enough numbers to infect people bathing in

sewage-contaminated waters or consuming sewage-contaminated shellfish.

Active control programs based on uniform standards for reducing sewage contamination at bathing beaches and shellfish-growing areas are a logical goal for all nations sharing the seas.

μ ν ι

Slade, J. S. (1978). *Enteroviruses in Slow Sand Filtered Water.* **J INST WATER ENGRS SCIENTISTS, 32(6):530-6.**

Viruses were recovered from slow sand-filtered waters of the Thames River for the first time. Poliovirus 2 and coxsackieviruses B1 and B5 were recovered in concentrations as high as 1 PFU/6 liters. The viruses were recovered during February and March 1977, but not during April. Viruses were recovered from the raw waters during February, March, and April of that year. Adequate disinfection of slow sand-filtered water is essential for public health.

At filtration rates between 1.12 and 4.15 m/day and temperatures of 6 to 11 C, a full scale slow sand filter removed from 97% to more than 99.8% of the viruses indigenous to the waters of the Thames River. The removal of *Escherichia coli* by the filter reliably indicated removal of viruses. The standard test for *E. coli,* however, was inadequate as an indicator of small numbers of viruses in large volumes of water.

τ χ

Smith, E. M., Gerba, C. P., Melnick, J. L. (1978). *Role of Sediment in the Persistence of Enteroviruses in the Estuarine Environment.* **APPL ENVIRON MICROBIOL, 35(4):685-9.**

Echovirus 1, coxsackieviruses B3 and A9, and poliovirus 1 survived longer in estuarine waters when associated with marine sediment than when suspended alone.

In estuarine waters polluted with secondary sewage effluent, the viruses survived for prolonged periods in sediments, but not in the overlying waters.

γ ξ

Smith, J. W. (1978). *Wastewater Disinfectants: Many Called—Few Chosen.* **WATER & WASTES ENGRG, 15(6):19-25.**

Within a review of wastewater disinfection, the removal and destruction of viruses in wastewater are briefly discussed.

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Sng, E. H., Lim, A. L., Yuen, W. S. (1978). *Method for the Recovery of Virus from Large Volume of Tap Water.* **ASIAN J INFECT DIS, 2:253-7.**

Poliovirus 1 seeded into 760 liters of tap water was recovered by adsorption onto pleated epoxy-fiberglass filters and subsequent elution therefrom. About $2\text{-}3 \times 10^4$ PFU of the virus were seeded. The pH of the seeded water was adjusted to 3.5 before it was filtered through the epoxy-fiberglass. The pore size of the filters was 3 μm. Adsorbed virions were eluted with 1 liter of glycine, pH 11.5. The volume of eluate was then reduced by a reconcentration procedure. The pH of the eluate was adjusted to 4.5, NaH_2PO_4 was added to a molarity of 0.005, $FeCl_3$ was added to a molarity of 0.001, the floc that formed was separated by centrifugation, and virions adsorbed to the floc were eluted with 20 ml of fetal calf serum.

Sixty-nine percent of the seeded virions was recovered. A concentration factor of 38,000-fold was achieved.

μ υ

Sobsey, M. D. (1978). *Field Survey of Enteric Viruses in Solid Waste Landfill Leachates.* **AMER J PUB HEALTH, 68(9):858-64.**

Only two viruses were recovered from a total of 21 solid waste landfill facilities in the United States and Canada. These facilities represented a broad range of landfill conditions. Leachate volumes of 10 to 18 liters were tested. The viruses, identified as polioviruses 1 and 3, were recovered from a 12-liter sample obtained from a site where landfill practices were poor.

The small number of enteric viruses detected in these leachate samples and the probability that further reductions in viral numbers would be brought about in the leachates by thermal inactivation, filtration through soil, and dilution in ground and surface waters suggest that leachates from properly operated solid waste landfills do not constitute a virus hazard to the public health.

λ π

Sobsey, M. D., Carrick, R. J., Jensen, H. R. (1978). *Improved Methods for Detecting Enteric Viruses in Oysters.* **APPL ENVIRON MICROBIOL, 36(1):121-8.**

Poliovirus 1 (LSc), reovirus 3 (Dearing), and simian adenovirus SV11 were each adsorbed to homogenized oyster meats by adjusting the pH of seeded homogenates to 5 and their conductivity to ≤2,000 mg of NaCl/liter. The oyster solids were sedimented and the viruses were eluted from the solids with a glycine-NaCl solution that had a pH of 7.5 and a conductivity of 8,000 mg of NaCl/liter. The viruses in the elutant were concentrated to small volumes by either ultrafiltration or by precipitation with acid at pH 4.5. The concentrates were then treated with antibiotics and inoculated into cell cultures. The efficiencies of virus recoveries averaged about 46%.

Except for virus assays, these methods were simple and inexpensive enough to be done in typical shellfish microbiology laboratories.

ξ

Sorber, C. A., Sagik, B. P. (1978). *Health Effects of Land Application of Wastewater and Sludge: What Are the Risks?* **WATER & SEW WORKS, 125(7):82-4.**

Within a summary of the "Conference on Risk Assessment and Health Effects of Municipal Wastewater and Sludge" held in San Antonio, Texas in December 1977, some of the papers on viruses in the environment are discussed. **Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges, edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978).

ν ξ ϱ

Sproul, O. J. *The Efficiency of Wastewater Unit Processes in Risk Reduction.* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978), 282-96.

The removal and destruction of viruses by wastewater treatment unit processes and by anaerobic digestion of sludges are reviewed and discussed.

γ τ

Stagg, C. H., Wallis, C., Ward, C. H., Gerba, C. P. (1978). *Chlorination of Solids-Associated Coliphages.* **PROG WATER TECHNOL, 10(1-2):381-7.**

Solids-associated coliphages in sewage effluents were more resistant to chlorination in a treatment plant than freely suspended coliphages were.

Laboratory studies showed that most of the solids-associated phages were adsorbed to the surfaces of the sewage solids.

ϱ χ

Stern, G., Farrell, J. B. *Sludge Disinfection Techniques.* **In "'Composting of Municipal Residues and Sludges," Proceedings of the 1977 National Conference, August 23-25. Information Transfer, Inc., Rockville, Maryland** (1978), 142-8.

In a study of the disinfection of wastewater sludges, 33% of the indigenous viruses survived storage for 24 weeks, at 4 C, and <3% survived such storage for eight weeks.

α γ ι μ χ

Teltsch, B., Katzenelson, E. (1978). *Airborne Enteric Bacteria and Viruses from Spray Irrigation with Wastewater.* **APPL ENVIRON MICROBIOL, 35(2):290-6.**

Coliforms aerosolized during spray irrigation were detected 20 m downwind of the sprinklers when the concentration of the organisms in the wastewater was 10^3/ml or more. The numbers of viable coliforms in the air increased when relative humidity increased. The numbers of bacteria in the air, however, were reduced by solar radiation. The numbers of bacteria detected in aerosols were up to 10 times greater during night irrigation than during day irrigation.

Wind velocity did not affect the survival of aerosolized bacteria.

Echovirus 7 was recovered from 4 of 12 air samples collected 40 m downwind of the sprinkler.

ι μ σ χ

Vaughn, J. M., Landry, E. F., Baranosky, L. J., Beckwith, C. A., Dahl, M. C., Delihas, N. C. (1978). *Survey of Human Virus Occurrence in Wastewater-Recharged Groundwater on Long Island.* **APPL ENVIRON MICROBIOL, 36(1):47-51.**

For a period of one year, treated wastewater effluents and groundwater observation wells from three sewage recharge installations located on Long Island were assayed monthly for human enteroviruses and coliform bacteria. Echoviruses, 9, 12, 21, 24, and 25 and some unidentified viruses were detected in groundwaters at sites where recharge basins were located less than 35 feet (ca. 10.6 m) above an aquifer. The numbers of viruses recovered ranged to 10.6 PFU/gallon (3.8 liters). The MPN of fecal coliforms recovered from the well water sample that contained 10.6 PFU of viruses/gallon was <3/100 ml.

Results from one of the sites indicated horizontal transfer of viable viruses through the aquifer.

γ

Vorobyeva, A. M., Kulskiy, L. A. Muzychuk, N. T., Matskevich, Y. S. (1978). *Study of the Complex Effect of Electric Current and Sodium Hypochlorite on Viruses in Water.* **GIG SANIT, 0(2):98-100. Russian.**

After exposure to electric current, the sensitivity of coxsackieviruses A21 and B6 to sodium hypochlorite (NaOCl) increased. When first subjected to a current of 60 V/cm for three minutes, both viruses were destroyed about 50 times more quickly by NaOCl than they were when not first exposed to the current.

In the presence of 82 mg of lanthanum chloride ($LaCl_3$)/liter, an electric current of 60 V/cm destroyed both viruses slowly.

λ

Walter, R., Bagdasaryan, G. A., Rudiger, S., Lovtsevich, E. L., Lepachina, N. K. (1978). *Comparative Evaluation of the Effectiveness of Two Methods for Concentrating Viruses from Surface Water and Potable Water.* **Z GES HYG, 24(8):598-601. German.**

Seeded poliovirus 1 (LSc) was recovered from potable waters better by adsorption to an ion exchange resin (A8-17-8) than by alum flocculation.

However, alum flocculation proved superior to the resin for recovering the virus from seeded surface waters.

γ

Ward, R. L., Ashley, C. S. (1978). *Comparative Effects of Ammonia and Related Compounds on Poliovirus.* **APPL ENVIRON MICROBIOL, 36(1):198-200.**

Ammonia and related compounds inactivated poliovirus 1 (Chat) at pH 9.5 in the following order of activity: ethylamine>propylamine, dimethylamine, methylamine>ammonia>2-methoxyethylamine.

γ Q

Ward, R. L., Ashley, C. S. (1978). *Heat Inactivation of Enteric Viruses in Dewatered Wastewater Sludge.* **APPL ENVIRON MICROBIOL, 36(6):898-905.**

The protective effect of raw sludge on poliovirus 1 (Chat) was enhanced in sludge dewatered by evaporation. Other enteroviruses were similarly protected. The state of dryness of the sludges did not seem to be important because in humus-deficient soil, a relatively inert material, dewatering did not alter significantly the rate of inactivation of poliovirus by heat. Substances in the sludge, such as detergents, which are concentrated by dewatering seemed to be responsible for the protection.

The ionic detergents in raw sludges accelerated the rate of inactivation of reovirions by heat. Dewatering of sludge partially reversed this virucidal effect. This reversal was brought about by an unidentified protective substance in sludge also concentrated by dewatering.

The effects of raw sludges on inactivation of poliovirions and reovirions by heat were greatly reduced by composting, a result that correlated with the degradation of detergents.

γ Q

Ward, R. L., Ashley, C. S. (1978). *Identification of Detergents as Components of Wastewater Sludge that Modify the Thermal Stability of Reovirus and Enteroviruses.* **APPL ENVIRON MICROBIOL, 36(6):889-97.**

An agent in wastewater sludge that reduced the heat required to inactivate reovirus 3 (Dearing) possessed an infrared spectrum similar to the spectra of commercial anionic detergents. Analyses of fractionated sludge samples demonstrated that anionic detergents in sludge were copurified with its virucidal activity.

Ionic detergents reduced the heat required to inactivate reovirions. Cationic detergents were more effective than anionic detergents. Nonionic detergents were inactive. Several detergents protected poliovirus 1, poliovirus 2, and coxsackievirus B1 against inactivation by heat.

Ionic detergents appear to be the major component in wastewater sludge that reduce the thermal stability of reovirions and increase the thermal stability of enteroviruses.

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Wellings, F. M., Lewis, A. L., Mountain, C. W. *Assessment of Health Risks Associated with Land Disposal of Municipal Effluents and Sludge.* **In "Proceedings of the Conference on Risk Assessment and Health Effects of Land Application of Municipal Wastewater and Sludges," edited by B. P. Sagik and C. A. Sorber. Center for Applied Research and Technology, University of Texas, San Antonio, Texas** (1978), 168-79.

Land disposal of effluents and sludges pose a risk to human health. The magnitude of that risk, however, cannot be assessed with the technics available today. Therefore, before discharging effluents and sludges to the land, especially in vulnerable areas, efforts should be directed towards reducing the numbers of viruses in those effluents and sludges to undetectable levels.

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Wellings, F. M., Mountain, C. W., Lewis, A. L. *Virus in Groundwater.* **In "Individual Onsite Wastewater Systems," Proceedings of the Second National Conference, 1975, edited by N. I. McClelland. Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan** (1977), 61-6.

Fifty-one cases of enterovirus disease, probably waterborne, occurred explosively in a migrant labor camp in Florida in March 1975. Fifteen cases of hepatitis A occurred in the same population with onset of the first cases about six weeks after the onset of the enterovirus outbreak.

Echovirus 22/23 was recovered by membrane filtration technics from 1 of 20 100-gallon samples of the camp's drinking water. The water contained a chlorine residual of 0.4 to 0.6 mg/liter. Water samples were not tested in newborn mice. Fecal coliforms were not recovered in standard tests.

Echovirus 22/23 and coxsackieviruses A2 and A6 were recovered from fecal cultures of patients.

The private utility that supplied the water obtained its raw waters from six 35 to 40 foot-deep wells. One of these wells was located approximately 100 feet from a solid waste disposal area and the other five were located in the center of an area served by septic tanks. Water pumped from the wells was chlorinated before distribution.

γξ

Yapijakis, C. (1978). *RX for H_2O.* **WATER & WASTES ENGRG. 15(5):33-7.**

The destruction of viruses by disinfectants is briefly discussed within a review of drinking water disinfection.

AUTHOR INDEX

SUBJECT INDEX

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