VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

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LITERATURE ABSTRACTS

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VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

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VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

AWAA Committee on Status of Waterborne Diseases in the US and Canada, Committee Report. (1975). *Status of Waterborne Disease in the US and Canada.* **J AMER WATER WORKS ASSN, 67(2)**:95–8.

Several waterborne outbreaks of hepatitis A and gastroenteritis (possibly viral) are noted within a documentation of waterborne disease outbreaks in the United States and Canada in the years 1971 and 1972.

Aizen, M. S., Pille, E. P. (1973). *Use of Polyethylene Glycol for Detection of Viruses in Food.* **LAB DELO, 0(9)**:550–2. **Russian.**

This paper was listed in the 1974 edition of these abstracts. A translation was not then available.

Twenty-five gm of cottage cheese, seeded with poliovirus 1, was homogenized in glycine (pH 9) or phosphate (8.2) buffer and Freon 113, $MgCl_2$ was added, the homogenate was centrifuged, and the virus was precipitated from the clarified fluid with polyethylene glycol (PEG-6000) and NaCl.

With seed concentrations of less than 100 PFU, from 35 to 100% of the virus was recovered. Less virus seemed to be recovered when seed concentrations were higher.

Akin, E. W., Hill, W. F., Jr., Clarke, N. A. *Mortality of Enteric Viruses in Marine and Other Waters.* **In "Discharge of Sewage from Sea Outfalls," edited by A. L. H. Gameson. Pergamon Press, Oxford, England**(1975), 227–36.

Wide variations occurred in the rates of inactivation of poliovirus 3 by marine waters of the same salinity collected at the same site on different days.

Some of the rate differences were attributed to differences among different viruses, some to factors in the water.

Rates of inactivation increased with increasing temperatures.

Amirhor, P., Engelbrecht, R. S. *Interaction of Virus and Polyelectrolyte in Wastewater Effluent.* **In "Advances in Water Pollution Research." Proceedings of the Seventh International Conference, Paris, September 1974. Pergamon Press, New York, New York** (1975), 677–86.

A rapid interaction occurred between coliphage MS2 and the cationic polyelectrolyte C-31; this interaction lead to the aggregation of virions.

Interfering substances hindered the interaction between the polyelectrolyte and the coliphage in wastewater effluents. The major interfering substances in wastewater effluents appeared to be high molecular weight compounds that contained large numbers of carboxyl moieties. Interference was reduced or eliminated by a high concentration of polyelectrolyte.

Amirhor, P., Engelbrecht, R. S. (1975). *Virus Removal by Polyelectrolyte-Aided Filtration.* **J AMER WATER WORKS ASSN, 67(4)**:187–92.

Coliphage MS2 was not removed efficiently from water filtered through uncoated diatomaceous earth (DE). Extensive removal of the virus was achieved by filtering the water through DE coated with a water soluble cationic polyelectrolyte (Purifloc C-31). Filtration of water that contained the polyelectrolyte through DE also achieved extensive removal of the virus. The DE removed more virus from waters that contained a concentration of 2 mg/liter of polyelectrolyte than from water with less polyelectrolyte.

In the pH range from 6 to 8, increasing pH improved the efficiency of virus removal by the polyelectrolyte-coated DE.

The greater the initial concentration of virus in water, the more rapid was its removal by the polyelectrolyte-coated DE.

Filtration of secondary wastewater effluent through polyelectrolyte-coated DE removed little seeded MS2 virus, but filtration of seeded effluent that contained the polyelectrolyte through DE removed significant quantities of the virus.

Bagdasaryan, G. A., Lovtsevich, E. L., Lepakhina, N. K. (1975). *Concentration of Viruses on Certain Natural and Artificial Sorbents.* **GIG SANIT, 0(4)**:106–7. **Translation presently not available. Russian.**

Bang, F. B., Bang, M. G., Bang, B. G. (1975). *Ecology of Respiratory Virus Transmission: A Comparison of Three Communities in West Bengal.* **AMER J TROP MED HYG, 24(2)**:326–46.

The transmission of respiratory viruses among children in West Bengal was studied in an isolated village, in a suburban village, and in a crowded urban community. In these three ecologically different low-income communities, contaminated pond water was used for bathing, irrigation of nasal passages, post-defecation washing of the anus, and for washing food utensils.

Open and tube wells, the sources of drinking water in the three communities, seemed unrelated to the transmission of respiratory viruses.

Berg, G. *Regional Problems with Sea Outfall Disposal of Sewage on the Coasts of the United States.* **In "Discharge of Sewage from Sea Outfalls," edited by A. L. H. Gameson. Pergamon Press, Oxford, England** (1975), 17–24.

Nutrients discharged with domestic sewage into the seas attract some fish which, along with the microflora that constitute part of the food chain, often thrive in such polluted waters. Some species of living things, however, disappear from newly polluted areas.

Even if the oceans do assimilate many non-toxic wastes, toxic effluents are clearly another matter. Diseases such as fin-rot (and possible tumors) seen in certain fish, even in some that thrive in polluted waters, are also a matter of concern. And, of course, the risk to the recreationalist constituted by the discharge of viruses and other pathogens into the seas, even within sewage that has undergone secondary treatment, is ubiquitous.

Moreover, there must be concern with the possible subtle, long-term, untoward effects upon living things that may be produced by sewage-contaminated seawater and that may not be easily detected.

Bitton, G. (1975). *Adsorption of Viruses Onto Surfaces in Soil and Water.* **WATER RES, 9(5–6)**:473–84.

Adsorption of viruses to solids in natural waters affects the survival and removal of viruses. In water treatment processes viruses are removed by adsorbents. Adsorbents are also used for concentrating and purifying viruses.

Burleson, G. R., Murray, T. M., Pollard, M. (1975). *Inactivation of Viruses and Bacteria by Ozone, With and Without Sonication.* **APPL MICROBIOL, 29(3)**:340–4.

Staphylococcus aureus, Pseudomonas fluorescens, Salmonella typhimurium, enteropathogenic *Escherichia coli, Vibrio cholerae,* and *Shigella flexneri* were inactivated at about equal rates in phosphate-buffered saline (PBS) by ozone and by ozone under sonication. In secondary effluent from a wastewater treatment plant, longer contact times were required for the same amount of inactivation. Sonication of ozonated effluent increased the rate at which the bacteria were inactivated. Sonication alone or sonication and oxygenation did not inactivate these microorganisms.

Vesicular stomatitis virus, encephalomyocarditis virus, and Theiler's GDVII virus, in PBS, were inactivated rapidly by ozone.

Clarke, N. A., Akin, E. W., Liu, O. C., Hoff, J. C., Hill, W. F., Jr., Brashear, D. A., Jakubowski, W. (1975). *Virus Study for Drinking-Water Supplies.* **J AMER WATER WORKS ASSN, 67(4)**:192–7.

An attenuated strain of poliovirus 3 was recovered from one of 80 finished water samples taken from 11 treatment plants in different parts of the United States. The one virus isolated was believed to be a laboratory contaminant.

Nematodes were recovered from most of the finished water samples tested.

Clarke, N. A., Chang, S. L. (1975). *Removal of Enteroviruses from Sewage by Bench-Scale Rotary-Tube Trickling Filters.* **APPL MICROBIOL, 30(2)**:223–8.

At filtration rates equivalent to about 10 million gallons/day (MGD)/acre (about 3,785 m^3/day/acre), a bench-scale rotary tube-type trickling filter removed 95% of poliovirus 1, 83% of echovirus 12, and 94% of coxsackievirus A9. Removals of total coliforms, fecal streptococci, biochemical oxygen demand (BOD), and chemical oxygen demand (COD) were similar, averaging 94, 92, 93, and 95%, respectively. At a filtration rate equivalent to about 23 MGD/acre (about 8,706 m^3/day/acre), 59% of the poliovirus 1, 63% of the echovirus 12, and 81% of the coxsackievirus A9 were removed. At this filtration rate, removals of total coliforms, fecal streptococci, BOD, and COD were 68, 75, 72, and 56%, respectively.

Attempts to disassociate viruses from the biological slime that grew in the filters were unsuccessful; this indicated that the slime-virus complex was very stable or that the viruses were inactivated.

The data indicated that coliform and fecal streptococci reductions in this type of sewage treatment process may be used as an index of virus reduction.

Cliver, D. O. (1975). *Virus Association with Wastewater Solids.* **ENVIRON LETTERS, 10(3)**:215–23.

The solids produced at an urban wastewater treatment plant, tested semiquantitatively, almost all contained human intestinal viruses. Reoviruses and five or more types of enteroviruses were recovered.

Sludges, digested anaerobically at 30 to 32 C, and grit contained viruses also.

Until reliable means for inactivating viruses in such solids have been developed and implemented, great care should be taken in disposing of solids from wastewater treatment plants.

Cookson, J. T., Jr., Robson, C. M. *Disinfection of Wastewater Effluents for Virus Inactivation.* **In "Disinfection — Water and Wastewater," edited by J. D. Johnson. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan** (1975) 391–417.

Although each process in a wastewater treatment flow stream achieves a certain level of virus removal, in the aggregate they serve only as pretreatment processes prior to terminal disinfection.

The only currently practical means for terminal disinfection is breakpoint chlorination. Ozonation may become practical when better dosing and control technology become available.

Direct monitoring of virus inactivation is difficult and expensive; therefore, accurate monitoring of secondary standards such as free chlorine residual is important.

Cooper, R. C. (1975). *Waste Water Management and Infectious Disease. Part II: Impact of Waste Water Treatment.* **J ENVIRON HLTH, 37(4)**:342–50.

The capabilities of biological and chemical treatment methods for the removal of viruses and bacteria from sewage are reviewed.

The effectiveness of the soil mantle in removing viruses is analyzed.

Cooper, R. C., Potter, J. L., Leong, C. (1975). *Virus Survival in Solid Waste Leachates.* **WATER RES, 9(8)**:733–9.

Viruses were recovered sporadically for up to 20 weeks from solid waste leachates generated by systems seeded with poliovirus 1 and also from systems that had not been seeded.

The leachates produced were not toxic to the poliovirus.

Couch, J. A. (1974). *Free and Occluded Virus, Similar to* Baculovirus, *in Hepatopancreas of Pink Shrimp.* **NATURE, 247(5438)**:229–31.

Viruses resembling members of the *Baculovirus* group were observed in cells of the hepatopancreas of pink shrimp (*Penaeus duorarum*) that had been exposed experimentally to Aroclor 1254, a polychlorinated biphenyl.

In the past, members of the *Baculovirus* group have been recovered only from insects and mites.

Crovari, P., DeFlora, S., Vannucci, A., Badolati, G. (1974). *The Virological Monitoring of Water. II. Sea Water.* **BOLL IST SIEROTER MILAN, 53(4)**:525–32.

Enteroviruses were recovered on the insoluble polyelectrolyte PE60 from all surface and deep seawater samples tested that contained *Escherichia coli* at levels greater than 1,000/100 ml. Polioviruses (T^-), coxsackieviruses B, and echoviruses were recovered.

The quantities of viruses recovered ranged up to 16 TCD_{50}/100 ml of seawater. The ratios of enteroviruses to *E. coli* ranged from 1:2,000 to about 1:500,000.

Dartevelle, Z., Desmet, L. (1975). *Shigella Research in the Sea and in an Estuary. Part 1. Frequency of Bacteriophages in Polluted Water.* **ANN MICROBIOL (PARIS), 126B(1)**:95–7. **Translation presently not available. French.**

DeFlora, S., DeRenzi, G. P., Badolati, G. (1975). *Detection of Animal Viruses in Coastal Seawater and Sediments.* **APPL MICROBIOL, 30(3)**:472–5.

Viruses were recovered from 5-liter seawater samples by the PE60 technic, and from bottom sand and slime by mechanical shaking of the solids in an equal volume of sterile seawater and subsequent adsorption of PE60. The viruses were recovered from 16 of the 17 samples taken.

The amounts of viruses recovered in African Green monkey kidney or KB cells ranged from 0.2 to 40 TCD_{50}/100 ml of water or sediment eluate. *Escherichia coli* counts in the water and bottom samples ranged from 170 to 9,200,000/100 ml.

Some of the samples were taken near sewage outfalls, others from relatively clean waters.

Denis, F. A. (1975). *Contamination of Shellfish with Strains of* Pseudomonas aeruginosa *and Specific Bacteriophages.* **CAN J MICROBIOL, 21(7)**:1055–7.

Forty-eight percent of 89 oyster samples (12 oysters/sample) and 74% of 35 mussel samples (20 mussels/sample) examined during the last half of 1973 contained *Pseudomonas aeruginosa*; serotype P_3 was predominant. Thirty-seven percent of the oyster samples and 40% of the mussel samples contained bacteriophages that multiplied in *P. aeruginosa.*

The percentage of oyster samples that contained bacteriophages which multiplied in *P. aeruginosa* increased as the year progressed — from 0 to 4% between January and May to 60% in November.

Denis, F., Brisou, J.-F., Dupuis, T. (1975). *Research on Inactivation of Enteroviruses in Seawater.* **COMP REND, 281(8)**:471–4. **French.**

Inactivation of 90% of poliovirus 2 and coxsackievirus B6 in sterile seawater occurred in 48 days at 4 C. Inactivation of 99.9% of poliovirus 2 and coxsackieviruses A9, B4, B5, and B6 in sterile seawater occurred in 30 to 40 days at 22 C.

Poliovirus 2 survived more than four times longer in autoclaved seawater than in natural seawater. The virus also survived longer in filter-*sterilized* seawater and in artificial seawater than in natural seawater which suggested that microorganisms in seawater are a factor responsible for inactivation of viruses in such waters.

DiGirolamo, R., Liston, J., Matches, J. (1975). *Uptake and Elimination of Poliovirus by West Coast Oysters.* **APPL MICROBIOL, 29(2)**:260–4.

In a stationary seawater system, accumulation and localization of poliovirus 1 in West Coast oysters followed the pattern observed earlier in East Coast species. However, uptake occurred more rapidly in the West Coast species than it did in East Coast species.

A gradual dispersion of viruses from the digestive areas into the bodies of the oysters occurred.

More rapid and more complete depuration of the oysters occurred under free-flow conditions than in the stationary system.

Ember, L. (1975). *The Specter of Cancer. Special Report.* **ENVIRON SCI & TECHN, 9(13)**:1116–21.

Within a discussion of environment-related cancer, the problems of viruses in water are briefly reviewed.

Fields, H. A., Metcalf, T. G. (1975). *Concentration of Adenovirus from Seawater.* **WATER RES, 9(4)**:357–64.

Some factors that influenced the recovery of adenovirus 5 from seawater by virus concentrator methods were evaluated. A 19,000-fold concentration of 25-gallon samples with a recovery efficiency of about 90% was achieved with a virus input multiplicity of 1,000 $TCID_{50}$/ ml.

The adenovirus passed through orlon and cellulose acetate clarifying filters that had been treated with beef extract or Tween 80 and adsorbed to textile and epoxy fiberglass filters at acid pH.

Adsorption to textile filters was enhanced in 0.05 M $MgCl_2$. Salt was unnecessary for adsorption of the virus to epoxy fiberglass filters.

The adenovirus was eluted from the adsorbent filters with 3% beef extract at pH 9 and reconcentrated from the beef extract by aqueous polymer phase separation.

Foliguet, J.-M., Doncoeur, F. (1975). *Elimination of Enteroviruses During Water Treatment by Coagulation-Flocculation-Filtration.* **WATER RES, 9(11)**:953–61. **French.**

Coagulation with 60 mg/liter of $FeCl_3$ and rapid sand filtration removed 99.83 to 99.99% of poliovirus 1 that had been seeded into synthetic water made turbid with montmorillonite clay. The extent to which viruses were removed was consistent at concentrations of montmorillonite that ranged from 25 to 200 mg/liter and over a pH range of 5 to 8.

A cationic polyelectrolyte, added to the water, stabilized the $FeCl_3$ floc, but did not influence the extent to which the viruses were removed.

Fugate, K. J., Cliver, D. O., Hatch, M. T. (1975). *Enteroviruses and Potential Bacterial Indicators in Gulf Coast Oysters.* **J MILK FOOD TECHN, 38(2)**:100–4.

Enteroviruses were recovered from oysters harvested from waters off the Texas and Louisiana Gulf Coast and from oysters imported from Japan.

Poliovirus 1 and echovirus 4 were recovered from one each of 17 samples (15 oysters/sample) of oysters harvested from approved waters along the coast of Texas. The sample that contained poliovirus 1 had a total coliform MPN of 78/100 gm of meat and an *Escherichia coli* MPN of 45/100 gm. The water from which the oysters had been harvested had a total coliform MPN of 46/100 ml. The sample that contained echovirus 4 had a total coliform MPN of 7,900/100 gm and an *E. coli* MPN of 20/100 gm. The waters from which these oysters had been harvested had a total coliform MPN of 2/100 ml.

Poliovirus 3 was recovered from one of 24 samples of oysters harvested from approved waters along the coast of Louisiana. The sample had a total coliform MPN of 18/100 gm of meat and contained no fecal coliforms. The waters from which the oysters had been harvested had a total coliform MPN of 350/100 ml.

Poliovirus 1 was recovered also from a 200 gm sample of frozen Japanese oysters. The total coliform MPN in this sample was 2/gm of meat. *E. coli* was not detected.

Vibrio parahemolyticus was recovered from 24 of the 41 oyster samples taken from the Texas and Louisiana coastal waters.

Furuse, K., Ando, A., Watanabe, I. (1975). *Isolation and Grouping of RNA Phages V. A Survey in the Islands in the Adjacent Seas of Japan.* **J KEIO MED SOC, 52(4)**:259–63. **Japanese.**

Following systematic surveys in Taiwan (1970), Brazil (1971), Thailand (1972), and Japan (1972), the distribution of *Escherichia coli* RNA phages in the Ogasawara Islands, and in the Hachijojima, Miyakejima, Niijima, Iki, and Tsushima Islands and in Japan proper was investigated.

Ninety-one strains of RNA phages, recovered from 160 sewage samples on the six islands, were classified into three serological groups: I (1 strain), II (43 strains), and III (47 strains).

Seventy-six strains of RNA phages (II, 56 strains, and III, 20 strains) were recovered from sewage samples collected on Japan proper.

Furuse, K., Ando, A., Watanabe, I. (1975). *Isolation and Grouping of RNA Phages VII. A Survey in Peru, Bolivia, Mexico, Kuwait, France, Australia, and the United States of America.* **J KEIO MED SOC, 52(5)**:355–61. **Japanese.**

Following systematic surveys in Taiwan (1970), Brazil (1971), and Japan (1972, 1975), and several islands (see above), the distribution of *Escherichia coli* RNA phages in the sewages of Peru, Bolivia, Mexico, Kuwait, France, Australia, and the United States of America were investigated.

Only three strains of RNA phages were recovered from 118 sewage samples taken in Peru, Bolivia, and Mexico. Two strains, recovered from Mexico, cross-reacted with serums from Groups III and IV. These two groups are now combined into a single Group B, and Groups I and II are now combined into a single Group A.

Larger numbers of RNA phages were recovered from sewages in Australia (Sydney) (Group II) and the United States (California) (Groups II and III primarily). In a study during the mid-1960's, only Group I phages were recovered from the United States.

Gaub, J., Ranek, L. (1973). *Epidemic Hepatitis Following Consumption of Imported Oysters.* **UGESKR LAEGER, 135(7)**:345–8. **Danish.**

Imported oysters may have been the source of an outbreak of hepatitis A in Denmark. Five cases of the disease were reported. This outbreak is the first of its kind reported in this country.

In some patients, acute gastroenteritis preceded the onset of hepatitis.

The oysters were probably contaminated in the waters from which they were harvested (Brittany). Brief periods in Danish depuration basins during winter months apparently did not cleanse the oysters of the virus.

Gerba, C. P., Schaiberger, G. E. (1975). *Aggregation as a Factor in Loss of Viral Titer in Seawater.* **WATER RES, 9(5–6)**:567–71.

The loss of viral titer and the extent of viral aggregation in artificial seawater increased as the salinity of the water increased. Aggregation also occurred in natural seawater, but not as extensively as in artificial seawater.

Viral clumps in both natural and artificial seawaters disaggregated as the amount of organic matter increased and as the salinity decreased.

Aggregation may be responsible for some of the reduction of infective units that occurs in seawater.

Gerba, C. P., Schaiberger, G. E. (1975). *Effect of Particulates on Virus Survival in Seawater.* **J WATER POLLUT CONTR FED, 47(1)**:93–103.

Coliphage T2 appeared to survive longer in natural and artificial seawaters that contained 500 mg of kaolinite/liter than in similar waters that did not contain kaolinite. The virus adsorbed better to kaolinite in artificial seawater than in natural seawater. The virus adsorbed well to natural clays, but poorly to natural sand.

Coliphage T2 adsorbed to kaolinite more efficiently at slightly alkaline pH levels than at acid pH levels.

The virus survived longer in filtered seawater than in unfiltered seawater.

Gerba, C. P., Sobsey, M. D., Wallis, C., Melnick, J. L. (1975). *Current Research. Adsorption of Poliovirus onto Activated Carbon in Wastewater.* **ENVIRON SCI & TECHN, 9(8)**:727–31.

Poliovirus 1 was removed from wastewater effluent by activated carbon in the laboratory more effectively at pH levels from 3.5 to 4.5 than at higher pH levels.

Activated carbon removed the virus from the effluent more effectively also when the amount of organics present in the effluent was first reduced by lime coagulation.

The amount of virus removed depended upon column length and on hydraulic loading. Virions and soluble organics that adsorbed to the carbon at low pH deadsorbed at higher pH levels.

Gerba, C. P., Wallis, C., Melnick, J. L. (1975). *Fate of Wastewater Bacteria and Viruses in Soil.* **J IRRIG & DRAIN DIV, ASCE, 101(9)**:157–74.

The survival of bacteria in soil is affected by moisture content, temperature, organic matter, and antagonism by soil microflora. Bacterial pathogens usually survive in soil for less than two to three months. Bacteria are removed from sewage during percolation through soil by straining, sedimentation, and adsorption, largely at the soil surface.

Removal of viruses by soil occurs largely by adsorption. Salt concentrations, pH, soil composition, organic matter, and the electronegativity of the virus and the soil influence the degree of retention of viruses by the soil. Viruses attached to soil particles may deadsorb with changes in water quality, resulting in greater subsurface travel of the virus particles.

Although large numbers of bacteria and viruses may be removed by filtration through a few feet of soil under normal conditions, bacteria and viruses, after entering underground aquifers, are known to have travelled as far as several hundred feet.

Viruses survive in soil for at least as long as pathogenic bacteria.

Gerba, C. P.; Wallis, C., Melnick, J. L. (1975). *Microbiological Hazards of Household Toilets: Droplet Production and the Fate of Residual Organisms.* **APPL MICROBIOL, 30(2)**:229–37.

Large numbers of bacteria and viruses seeded into household toilets remained in the bowl after flushing, and even continual flushing did not remove a persistent fraction. This fraction of organisms adsorbed to the porcelain surfaces of the bowl and some eluted with each flush.

Droplets produced by flushed toilets harbored bacteria and viruses that had been seeded. These airborne bacteria and viruses settled on surfaces throughout the bathroom.

Thus, it is possible for people to acquire infections from aerosols produced in toilets.

Gerba, C. P., Wallis, C., Melnick, J. L. (1975). *Viruses in Water: The Problem, Some Solutions.* **ENVIRON SCI & TECHN, 9(13)**:1122–6.

The problem of viruses in water is reviewed as a basis for arguments that standards for viruses in water should be deliberated.

Grabow, W. O. K., Prozesky, O. W., Appelbaum, P. C., Lecatsas, G. (1975). *Absence of Hepatitis B Antigens from Feces and Sewage as a Result of Enzymatic Destruction.* **J INFECT DIS, 131(6)**:658–64.

A sensitive affinity chromatography method combined with radioimmunoassay did not detect hepatitis B surface antigen (HB_sAg) in sewage. The antigen was not detected in the feces or urine of 23 patients with HB_sAg antigenemia either which indicates that HB_sAg is rarely discharged into sewage.

Enzyme antagonists and carboxypeptidase A in feces destroy HB_sAg. Antagonists that destroy the antigen were produced by three species of *Pseudomonas*, but were not produced by various other bacteria. HB_sAg was also destroyed by two subtilisin enzymes. When hepatitis B virus-containing serums were incubated with these enzymes or with the antagonists, small spherical particles, tubules, the coats of Dane particles, and subsequently, the cores of the Dane particles disappeared. The results of this study indicate that even Dane cores are not excreted in feces.

Although neither sewage nor activated sludge affected the stability of HB_sAg, sewage appears to play a negligible role in the dissemination of hepatitis B.

Hanson, B. R., Schipper, I. A. (1975). *Retention and Recovery of a Herpesvirus from North Dakota Natural Waters.* **PROC N DAKOTA ACAD SCI, 29(1)**:12.

Attenuated infectious bovine rhinotracheitis (IBR) virus, a herpesvirus, seeded into a flowing river, was recovered on cotton and fiberglass filters up to one mile from the point of introduction. The virus was viable in river water at 5 to 10 C for at least 12 hours.

IBR virus survives in native waters long enough to be carried a significant distance downstream where it may infect susceptible animals.

Homma, A., Schatzmayr, H. G., Frias, A. M., Mesquita, J. A. (1975). *Viral Pollution Evaluation of the Guanabara Bay.* **REV INST MED TROP SAO PAULO, 17(3)**:140–5. **Translation presently not available. Portuguese.**

Hughes, J. M., Merson, M. H., Craun, G. F., McCabe, L. J. (1975). *Outbreaks of Waterborne Disease in the United States, 1973.* **J INFECT DIS, 132(3)**:336–9.

Two waterborne outbreaks of hepatitis A are noted in a review of 24 waterborne disease outbreaks reported in 1973. Thirteen of the outbreaks, which accounted for 62% of the 1,720 illnesses that occurred, were of unknown etiology (*sewage poisoning*).

Il'Nitskii, A.P. (1966). *The Value of* Escherichia coli *as an Indicator of Adenovirus Contamination.* **GIG SANIT, 31(2)**:162–6. **Russian.**

Adenoviruses 3, 4, and 7a, seeded into water, retained infectivity for 13 to 130 days.

Chlorine and ozone inactivated several adenoviruses more rapidly than they inactivated *Escherichia coli.* Chlorine and ozone concentrations were determined iodometrically.

The chlorine sensitivity of adenoviruses varied with the adenovirus type.

E. coli is a satisfactory indicator of the disinfection by chlorine or ozone of adenovirus-containing water.

Jakubowski, W., Hill, W. F., Jr., Clarke, N. A. (1975). *Comparative Study of Four Microporous Filters for Concentrating Viruses from Drinking Water.* **APPL MICROBIOL, 30(1)**:58–65.

MF nitrocellulose membranes (293 mm), AA Cox M-780 epoxy-fiberglass-asbestos disks (267 mm), K-27 yarn-wound fiberglass cartridges + AA Cox M-780 disks (127 mm), and Balston epoxy-fiberglass tubes (24.5 by 63.5 mm) were about equally effective adsorbent filters for recovering poliovirus 1 from large volumes (380 liters) of seeded finished drinking water, the pH of which had been adjusted to 3.5. The virus was eluted from the filters with glycine-NaOH buffer at pH 11.5.

The Balston filters and holders were superior in size, weight, cost, and handling factors to those used for the other filter systems. Balston filters of 2- and 8-μm porosity were equally effective for recovering viruses.

The virus was detected with the Balston and the MF 293-mm filter systems at input levels of 12 to 22 PFU/1,900 liters.

Preliminary experiments indicated that an elution pH lower than 11.5 may be satisfactory.

Kahn, F. H., Visscher, B. R. (1975). *Water Disinfection in the Wilderness.* **WEST J MED, 122(5)**:450–3.

For travelers and hikers, aqueous iodine is an effective, palatable water disinfectant with rapid action and long shelf life. A near-saturated solution of iodine can be maintained by shaking 4 to 8 gm of iodine crystals in a one-ounce bottle of water. At 25 C, 12.5 ml of the near-saturated solution in one liter of water will inactivate pathogenic bacteria, amebic cysts, and viruses in 15 minutes. When the near-saturated solution of iodine is depleted, the water in the bottle that contains the iodine crystals may be replenished, and this procedure can be repeated almost 1,000 times without replenishing the iodine crystals.

This method is more effective than disinfection with Halazone tablets and other iodination methods.

Kalitina, T. A. (1975). *A Method for Isolating Enteroviruses from Meat.* **VOPR PITAN, 0(6)**:52–5. **Russian.**

Poliovirus 1 and echovirus 11 were recovered from seeded roast beef and from seeded cutlets by homogenizing 10 to 100 gm samples of meat in Hanks' balanced salt solution (BSS), homogenizing again in Freon 113 (trichlorotrifluoroethane), centrifuging down the solids and inoculating the supernatant onto appropriate cells.

When the ratio of BSS to meat was 2:1 (ml:gm), echovirus 11 was detected only in meat samples inoculated with more than 2×10^4 TCD_{50} of the virus. The proportion of virus recovered increased as the ratio of BSS to sample increased.

Almost all of the poliovirus 1 was recovered when the ratio of BSS to (raw or autoclaved) meat was 8 to 9:1 or greater.

Kalitina, T. A. (1975). *Experimental Materials Derived from Virological Investigation of Pasteurized Milk.* **VOPR PITAN, 0(4)**:69–73. **Russian.**

Poliovirus 1, seeded into sterile milk at a concentration of 30 PFU/ml, was detected by direct inoculation of the milk into primary monkey kidney cell cultures. The same level of virus was not detected in pasteurized milk inoculated directly, because bacteria overgrew the cell cultures before viral cytopathology appeared.

Small amounts of seeded virus were recovered from pasteurized milk, diluted 1:4 to 1:9 in Hanks' balanced salt solution, by treatment with 10% polyethylene glycol (MW 15,000) or polyvinyl pyrrolidone (MW 10,000). Three PFU of the virus/ml of milk was detected with this method. Recovery of the virus from 20 ml samples of pasteurized milk, seeded with small amounts of virus, ranged from 0 to 112% in different experiments.

An anionic (AB-17–8) and a cationic (Ky-21–8) exchange resin both adsorbed polioviruses from pasteurized milk; however, only a small amount of the adsorbed virus could be eluted from the Ky-21–8, and none at all could be eluted from the AB-17–8.

Konowalchuk, J., Speirs, J. I. (1975). *Survival of Enteric Viruses on Fresh Fruit.* **J MILK FOOD TECHN, 38(10)**:598–600.

In a humid atmosphere at 4 C, echovirus 7 and coxsackievirus B5 were almost completely stable for 4 to 6 days on the surfaces of cherries and peaches.

Suspended in feces, the viruses were almost equally stable on the fruits. In a dry atmosphere, under otherwise similar conditions, only occasionally did more than 1 to 2% of these viruses survive for more than one day.

Under these conditions, reovirus 1 was less stable than the two enteroviruses.

On strawberries, neither these viruses nor poliovirus 1 were very stable for even two days. In a humid atmosphere at 4 C, 87% of the echovirus survived in feces for 2 days on this fruit, but none of the other viruses survived for nearly as long under these conditions. In a dry atmosphere, the two-day survivals ranged from <1 to 8%.

Aqueous fruit infusions were antiviral. In general, the degree of antiviral activity correlated well with the loss of viruses from the surfaces of the fruits.

Kool, H. J. (1975). *Processes for Removal and Inactivation of Viruses in Water.* **H_2O, 17(8)**:351–5. **Dutch.**

The effectiveness of treatment processes throughout the world in removing or destroying viruses in sewage and drinking water are appraised.

Kott, H., Fishelson, L. (1974). *Survival of Enteroviruses on Vegetables Irrigated with Chlorinated Oxidation Pond Effluents.* **ISRAEL J OF TECHN, 12(5–6)**:290–7.

A factor in chlorinated and unchlorinated oxidation pond effluents, the effect of which was enhanced by solar radiation (a minimum of greater than 0.35 cal/cm^2 min), accelerated the rate of inactivation of poliovirus 1 on the surfaces of vegetables (tomatoes and parsley). The poliovirus had been seeded into the effluents.

The maximum percentages of viruses recovered from the surfaces of the vegetables six hours after they had been contaminated with the oxidation pond effluents were as follows: soaked in unchlorinated effluent and exposed to sunlight, 2.2%; soaked in chlorinated effluent and exposed to sunlight, 1.6%; soaked in unchlorinated effluent and kept in darkness, 12.7%; soaked in chlorinated effluent and kept in darkness, 8.45%.

When the vegetables were contaminated with a suspension of the virus in phosphate-buffered saline, 16.6% of the virus was recovered from vegetables subsequently held in darkness for six days, but none of the virus was recovered from vegetables subsequently exposed to light for 28 hours (including two radiation peaks).

Kott, Y. *Effluent Quality of Chlorinated Sewage Discharged from Sea Outfalls.* **In "Discharge of Sewage from Sea Outfalls," edited by A. L. H. Gameson. Pergamon Press, Oxford, England** (1975), 155–63.

Small amounts of chlorine kill few viruses in sewage. A concentration of about 40 mg of chlorine/liter is often required for destroying all viruses in sewage, and this destruction is better achieved at acidic pH levels.

Most seaside cities in the world discharge raw or treated effluents to the oceans, without chlorination. Whether effluents destined for discharge to the marine environment should be chlorinated depends upon the hazard to human health posed by unchlorinated effluents relative to the hazard to marine life posed by chlorinated effluents.

Kott, Y., Nupen, E. M., Ross, W. R. (1975). *The Effect of pH on the Efficiency of Chlorine Disinfection and Virus Enumeration.* **WATER RES, 9(10)**:869–72.

Poliovirus 2 appeared slightly more sensitive to HOCl (pH 6) than to OCl^- (pH 10). *Escherichia coli* was considerably more sensitive to HOCl than to OCl^- and more sensitive than the poliovirus to both chlorine entities.

The data appear to contradict those of an earlier study (Scarpino, P. V. *et al.*, **WATER RES,** 1972, **6**:959) in which OCl^- destroyed poliovirus 1 more rapidly than HOCl did.

Krejs, G. J., Gassner, M., Blum, A. L. (1974). *Epidemiology of Infectious Hepatitis.* **CLIN GASTROENTEROL, 3(2)**:277–303.

Water- and shellfish-borne hepatitis A are discussed briefly within an extensive review of infectious hepatitis.

Lal, S. M., Lund, E. *Recovery of Virus by Chemical Precipitation Followed by Eluation.* **In "Advances in Water Pollution Research." Proceedings of the Seventh International Conference, Paris, September 1974. Pergamon Press, New York, New York** (1975), 687–93.

A total of $10^{5.4}$ ID_{50} of coxsackievirus B3 that had been seeded into 400 ml of tap water was recovered by flocculation of the water with 200 mg of alum and subsequent elution of the virus from the floc by dissolving the floc at pH 9 in Tris buffer that contained EDTA.

The technic was equally effective with sewage when urea was added to the elutant.

Lime (at pH 6 to 7) and ferric chloride were almost as effective as alum for recovering coxsackievirus B3 that had been seeded into tap waters.

Lefler, E., Kott, Y. (1974). *Enteric Virus Behavior in Sand Dunes.* **ISRAEL J OF TECHN, 12(5–6)**:298–304.

Poliovirus 1 and coliphage f2, in distilled water, passed through sand quickly after they had been seeded into a 4 x 10 cm column of sand.

In tap water, high concentrations of monovalent cations (0.5% NaCl) did not increase adsorption of the viruses to the sand, but divalent cations increased adsorption considerably.

Ninety-five percent of the adsorbed viruses were retained in the upper part of the column.

All of the adsorbed poliovirus 1 was eluted from the sand by four successive washings with Tris buffer at pH 7. Distilled water and tap water, both at pH 7 and 10.5, and carbonate-bicarbonate buffer at pH 10.5 did not elute all of the virus from the sand, in some instances, even after 10 washings.

Lefler, E., Kott, Y. *Viability of Enteric Viruses in Hostile Environment.* **In "Proceedings of the Sixth Scientific Conference of the Israel Ecological Society," Tel-Aviv, June 1975, Department of Zoology, Tel-Aviv University** *(1975), 189–97.*

Only small fractions of coliphage f2 and poliovirus 1, introduced with tap water onto 20 cm sand columns, appeared in the filtrate even 81 days after initial applications. Most of the viruses adsorbed to the upper 20 cm of sand.

The sand columns removed only a small percentage of coliphage f2 from seeded trickling filter (high rate) effluent and a relatively small percentage of viruses indigenous to the effluent.

Efforts to recover Australia antigen from the wastewater effluents and from the sand columns were ineffective.

Lefler, E., Kott, Y. (1975). *Virus Survival in Water and Waste Water.* **ISRAEL J OF MED SCI, 11(5)**:511.

Attenuated poliovirus 1 and coliphage f2, each in a final concentration of 10^5 to 10^6 PFU/ml, were added to distilled water, tap water, oxidation pond effluent, and sewage, simultaneously. Aliquots of these suspensions were stored at room temperature (18 to 25 C) and in the refrigerator (4 to 8 C).

At 18 to 25 C, 99.9% of coliphage f2 were inactivated in seven days in tap water, 77 days in distilled water and in oxidation pond effluent, and 133 days in sewage. At 4 to 8 C, 99.9% of the phages were inactivated in 35 days in tap water. At these low temperatures, only a little more than 90% of the phages were inactivated in 231 days in distilled water, in oxidation pond effluent, and in sewage.

At 18 to 25 C, 99.9% of the polioviruses were inactivated in 42 days in sewage, 49 days in oxidation pond effluent, and 91 days in tap water. Ninety-nine percent of the polioviruses were inactivated in distilled water in 112 days. At 4 to 8 C, poliovirus 1 was completely stable in distilled and in tap water for 231 days. In the same period, more than 99% of the poliovirus was inactivated in oxidation pond effluent and more than 99.9% was inactivated in sewage.

Because viruses survive for a long time under adverse conditions, precautions should be taken with wastewaters that are to be reused.

Ludovici, P. P., Phillips, R. A., Jeter, W. S. *Comparative Inactivation of Bacteria and Viruses in Tertiary-Treated Wastewater by Chlorination.* **In "Disinfection — Water and Wastewater," edited by J. D. Johnson. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan** (1975), 359–90.

Effluents from a tertiary sewage treatment process, seeded with enteroviruses, were chlorinated with 2 or 4 mg of chlorine/liter for 30 minutes. The order of resistance to chlorine of seeded viruses and indigenous bacteria was appraised as follows: fecal streptococci > poliovirus 1 > coxsackievirus B1 > coliforms > coxsackievirus B2 > echovirus 13.

Malina, J. F., Jr., Ranganathan K. R., Sagik, B. P., Moore, B. E. (1975). *Poliovirus Inactivation by Activated Sludge.* **J WATER POLLUT CONTRL FED, 47(8)**:2178–83.

When tritium-labeled poliovirus 1 was adsorbed to activated sludge solids in batch experiments, some of the virions were inactivated and some non-infective virions were released into the suspending menstruum.

Many of the adsorbed virions remained infective for at least 24 hours implying a need for care in disposing of sludge solids.

Maurin, J., Mazoit, L. P., Dodin, A., Eschallier, G. (1974). *Practical Application of the Germicidal Power of Ultraviolet Irradiation to Drinking-Water.* **BULL WLD HLTH ORG, 51(1)**:35–9. **French.**

Ultraviolet radiation, of unspecified intensity at the target, inactivated varying quantities of fecal coliforms, fecal streptococci, *Vibrio cholerae*, a sulfite-reducing *Clostridium* and polioviruses 1 and 3 in raw and filtered river waters.

McDermott, J. H. (1975). *Virus Problems in Water Supplies. Part I.* **WATER & SEW WORKS, 122(5)**:71–3.

The important problem posed by the possible presence of viruses in water supplies is still ill-defined and deserves a high research priority.

Many outbreaks of waterborne illnesses are unreported, and the etiologies of many that are reported are undetermined.

The true extent of transmission of viruses by potable waters is obscured by the inadequacy of epidemiological data.

The safeness of domestic water supplies is not presently assured.

McDermott, J. H. (1975). *Virus Problems in Water Supplies. Part II.* **WATER & SEW WORKS, 122(6)**:76–7.

One cell culture PFU of virus may be an infective dose for man. Although difficult to prove, it is probable that such small amounts of viruses pass through our water treatment plants.

The inadequacy of our methods for sampling, detecting, identifying, and enumerating viruses in water constitutes a most important gap in the current technology that must be filled before the epidemiologist can successfully assess the virus threat from our water resources.

Metcalf, T. G. *Evaluation of Shellfish Sanitary Quality by Indicators of Sewage Pollution.* **In "Discharge of Sewage from Sea Outfalls," edited by A. L. H. Gameson. Pergamon Press, Oxford, England** (1975), 75–84.

The correlation between indicated and actual sanitary quality of marine waters was erratic when fecal coliform numbers were less than 70/100 ml in the water and less than 230/100 gm in shellfish. Viruses and salmonellae were recovered repeatedly from oysters, that contained few or no fecal coliforms, harvested from waters that contained few or no fecal coliforms by standard tests.

The disparity between the numbers of coliphages and the numbers of enteric viruses recovered made the usefulness of a coliphage index for enteric viruses doubtful.

Mitchell, R., Bitton, G., de Latour, C., Maxwell, E. *Magnetic Separation: A New Approach to Water and Waste Treatment.* **In "Advances in Water Pollution Research." Proceedings of the Seventh International Conference, Paris, September 1974. Pergamon Press, New York, New York** (1975), 349–55.

With a feed concentration of 10^4 PFU/ml, 98% of coliphage T7 were removed from water that contained 500 mg/liter of magnetite and 1,000 mg/liter of $CaCl_2$ by filtration through an iron mesh situated between super conducting magnets.

Phosphates, algae, and bacteria were also removed effectively by magnetic separation from waters that contained magnetite and, in some instances, alum and/or montmorillonite clay.

Mitchell, R., Chamberlin, C. *Factors Influencing the Survival of Enteric Microorganisms in the Sea: An Overview.* **In "Discharge of Sewage from Sea Outfalls," edited by A. L. H. Gameson. Pergamon Press, Oxford, England** (1975), 237–51.

Within a broad overview of the survival of enteric microorganisms in the sea, the factors that affect the survival of viruses in the marine environment are briefly reviewed.

Experimentally, large variations occur in the rates of inactivation of viruses in natural and artificial seawaters. These rates appear to be affected by the type of virus, temperature, and the chemical and biological composition of the water. Aggregation of viruses and adsorption of viruses to particulates appear to impact the rate of inactivation of viruses only negligibly. The rate of inactivation of viruses in seawater increases with increased temperature. Marine microorganisms appear to reduce the numbers of viruses in some instances, but not in others. Suspended organic matter protects viruses from inactivation. Some soluble organics accelerate the rate of inactivation of viruses in seawaters. The effects of solar radiation and sedimentation on the survival of viruses in marine waters is unknown.

Moore, B. *The Case Against Microbial Standards for Bathing Beaches.* **In "Discharge of Sewage from Sea Outfalls," edited by A. L. H. Gameson. Pergamon Press, Oxford, England** (1975), 103–14.

Microbial standards for bathing beaches are irrelevent to the public health because bathing beaches cannot be graded adequately by total coliform or fecal coliform counts and because good evidence of a quantitative relationship between coliform counts and health risks is not available.

The spur of public concern for beaches that are esthetically beyond reproach and the associate dictate for appropriate location of sewage disposal sites to meet this esthetic criterion may satisfy the public health requirement more effectively than unreliable microbiological parameters that are themselves unrelated to health risks.

Moore, B. E., Sagik, B. P., Malina, J. F., Jr. (1975). *Viral Association with Suspended Solids.* **WATER RES, 9(2)**:197–203.

Coliphages T2 and f2 readily adsorbed to clays in the presence of divalent cations. Coliphage T7 and poliovirus 1 adsorbed equally well to both organic and inorganic particulates. These viruses adsorbed in varying degrees to naturally-occurring suspended solids in primary and final sewage effluents. Maximum adsorption of all viruses occurred at pH 4 and 10.

With the exception of f2, the viruses tested produced infection while adsorbed.

Neither of the coliphages acceptably modeled the behavior of the poliovirus under laboratory or field conditions.

Any system used to monitor viruses in the environment must account not only for free virus, but also for viruses that are solids-associated.

Morin, R. A., Keller, J. W., Schaffernoth, T. J., Paquette, D. R. (1975). *Ozone Disinfection Pilot Plant Studies at Laconia, New Hampshire.* **J NEW ENG WATER WORKS ASSN, 89(3)**:206–24.

In batch tests with carbon-filtered lake water at ambient temperatures, 0.76 and 0.77 mg/liter of O_3 (residual) destroyed $>$ 99.99% of poliovirus 2 and 99% of coxsackievirus B3, respectively, in five minutes.

The ozone appeared to be even more effective in pilot plant studies.

Morris, J. C. *Aspects of the Quantitative Assessment of Germicidal Efficiency.* **In "Disinfection — Water and Wastewater," edited by J. D. Johnson. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan** (1975), 1–10.

There is need for new parameters to assess and compare the quantitative germicidal efficiencies of aqueous germicidal materials. The classic concept of complete destruction within a specified time is untenable theoretically and untestable practically. Specified times for a given percentage of kill are readily estimated practically for a given concentration of disinfectant; however, although sound theoretically, there has been no agreement on the percentage of kill to be used, the numbers obtained are inversely proportional to germicidal effectiveness, and the use of incomplete kills is unsatisfactory for public understanding. The logarithmic k value may be an acceptable parameter, but there needs to be some agreement on the slopes to be used and the types of judgment that are to be exercised in evaluating logarithmic traces that are generally non-linear.

A new parameter, *lethality*, has been developed from some derivations of H. A. Thomas in relation to radioactive decay. This new parameter expresses and evaluates the potency of germicides in terms of a *whole life concept*.

Mosley, J. W. *Epidemiological Aspects of Microbial Standards for Bathing Beaches.* **In "Discharge of Sewage from Sea Outfalls," edited by A. L. H. Gameson. Pergamon Press, Oxford, England** (1975), 85–93.

Microbial standards basically serve a surveillance function. When they predict the occurrence or non-occurrence of human infection, standards may be helpful for monitoring beaches and shellfish sanitation. The mere occurrence of pathogens in bathing water is not necessarily significant, but there is undoubtedly a level at which they become significant. Recovery of any human enteroviruses from shellfish, however, may indicate sufficient pollution to produce infections in humans.

Under any circumstance, the proper frame of reference for the value of microbial standards is always the epidemiologic one.

Nestor, I. (1975). *Methods Currently Used for the Isolation of Viruses from Water.* **IGIENA, 24(3)**:179–82. **Russian.**

The physical and chemical methods used for concentrating viruses from various waters are reviewed and analyzed.

Nikolaevskaya, Z. S., Aizen, M. S. (1974). *Detection of Minimal Concentrations of Viruses in Large Volumes.* **LAB DELO, 0(10)**:631–2. **Russian.**

Viruses in water or in other menstruums were concentrated and purified by two filtrations through asbestos filters that had been treated with 0.05% aqueous sodium alginate, and subsequent filtration through soluble La-Al-alginate ultrafilters.

A 100-fold increase in the concentration of viruses, and a 400– to 500-fold reduction in volume was achieved with this method.

The method has been used successfully for recovering viruses from wastewaters and from open reservoirs.

Nikolaevskaya, Z. S., Gipp, E. K. (1973). *Studies of Viruses in Waste and River Water by Ultrafiltration Through Soluble La-Al-Alginate Ultrafilters.* **GIG SANIT, 0(12)**:107. **Russian.**

From May 1967 to April 1968, cytopathic agents were detected in sewage, in the effluents of various stages of sewage treatment, and in 13 of 35 samples of final effluent. Cytopathic agents were also recovered from 14 of 31 3-liter samples of Volga River water. Cytopathic agents were recovered on La-Al-alginate ultrafilters.

Poliovirus 1 (13 strains) and poliovirus 3 (12 strains) were recovered from the river during the months from May to October 1968. Poliovirus 2 (2 strains) was recovered in August and September of that year. Echoviruses were also recovered. Three of the cytopathic agents recovered were not identified.

Olivares, A. L. (1974). *Distribution of Enteroviruses in Spain. Laboratory Methods for Their Study.* **REV SANID HIG PUB, (MADR), 48(11)**:1021–65. **Translation presently not available. Spanish.**

Olivieri, V. P., Kruse, C. W., Hsu, Y. C., Griffiths, A. C., Kawata, K. *The Comparative Mode of Action of Chlorine, Bromine, and Iodine on f2 Bacterial Virus.* **In "Disinfection — Water and Wastewater," edited by J. D. Johnson. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan** (1975), 145–62.

The halogens belong to a class of general protoplasmic poisons that destroy a wide spectrum of microorganisms. The mode of action of halogens on viruses, however, appears to differ from the modes of action of halogens on other microorganisms.

Iodine has almost no effect on the nucleic acid of viruses; rather, it iodinates the amino acid tyrosine in the protein moiety of the virus.

Bromine inactivates the nucleic acids of viruses, but does not appear able to penetrate the protein. Bromine apparently acts on the viral protein.

Chlorine apparently inactivates naked viral RNA just as it inactivates the RNA within the intact virion. The protein of an inactivated virion may still adsorb to host cells.

The relative resistance of coliphage f2 to hypochlorite ion appears to be due to an inability of this species of free chlorine to penetrate the coat protein of the virion.

Oza, P. P., Chaudhuri, M. (1975). *Removal of Viruses from Water by Sorption on Coal.* **WATER RES, 9(8)**:707–12.

Maximum sorption of coliphage T4 (about 70%) to bituminous coal (diameter 350 μm) occurred at pH 8. The optimum ionic strength for sorption was 0.015. Sorption capacity increased with increased temperature. The energy of activation was 30.3 kcal/mole. This energy of activation and low desorption values (6 to 10%) suggest irreversible chemisorption.

Proteinaceous matter competed with the virus for sorption sites on coal and reduced sorption by about 12%.

Equilibrium sorption occurred in 90 minutes and followed a kinetic pattern consistent with the Langmuir isotherm.

Palfi, A. (1974). *Effectiveness of Virus-Inactivation by Different Methods of Effluent Treatment.* **Z BAKT ORIG A, 227(1–4)**:389–91. **German.**

This paper was listed in the 1974 edition of these abstracts. A translation was not then available.

Virus levels were determined in 475 sewage samples from 15 activated sludge, trickling filter, and oxidation pond systems. The activated sludge systems appeared to be the most effective systems for removing viruses.

The viruses most frequently recovered were reovirus 1 (44%) and echovirus 7 (15%).

The average concentration of viruses was 18 MPNCU/liter in the influent samples and 2 MPNCU/liter in the effluent samples.

Polkhovski, I. V. (1973). *Determination of Mycobacteriophages in Manure and Sewage.* **VETERINARIIA, 4(4)**:31–3. **Translation presently not available. Russian.**

Portnoy, B. L., Mackowiak, P. A., Caraway, C. T., Walker, J. A., McKinley, T. W., Klein, C. A., Jr. (1975). *Oyster-Associated Hepatitis. Failure of Shellfish Certification Programs to Prevent Outbreaks.* **J AMER MED ASSN, 233(10)**:1065–8.

In October and November 1973, outbreaks of hepatitis A associated with the consumption of raw oysters occurred in Houston, Texas and Calhoun, Georgia. A total of 278 illnesses were reported. Eleven restaurants were involved in the outbreaks, but most of the cases were associated with just one.

The implicated oysters had been harvested from areas in Bay Crabe and Black Bay in the East Delta Marshes of Plaquemines Parish, Louisiana that had been approved for oyster harvesting under the guidelines of the National Shellfish Sanitation Program.

The only known contamination of the shellfish beds in the period immediately preceding the outbreaks occurred between April and July 1973 when flooding in the Mississippi valley spilled polluted waters into the bays. The pollution raised total coliform levels beyond Program standards and brought about closure of the shellfish beds. The total coliform MPN in these bays declined to $\leq$ 1.8/100 ml by mid-August 1973, but harvesting was not permitted again until after September 1. Thus, the adequacy of coliform and other bacterial systems as indicators of the purity of shellfish bed waters is in doubt.

Poynter, S. F. B., Jones, H. H., Slade, J. S. *Virus Concentration by Means of Soluble Ultrafilters.* **In "Some Methods for Microbiological Assay," edited by R. G. Board and D. W. Lovelock. The Society for Applied Bacteriology Technical Series No. 8. Academic Press, New York, New York** (1975), 65–74.

Attenuated poliovirus 1 was concentrated from volumes of up to 20 liters of seeded distilled water and from seeded Thames River water by filtration through lanthanum and aluminum alginate ultrafilters (Sartorius).

Maximum adsorption of the virus from distilled water occurred at pH 4 to 8 under a negative pressure of 400 mm Hg. The virus was recovered by dissolving the membrane in sodium citrate. The extent of recovery was not affected by the quantity of virus seeded (180 to 16,200 PFU/ml) or by temperature (4 to 24 C).

The optimum volume of sodium citrate for solubilizing each membrane was 4 to 10 ml.

The maximum efficiency of virus recovery from distilled water was 70% although viruses were never recovered from the filtrate or eluted from membrane-supporting structures.

The efficiency of virus recovery from seeded river water was only 50%.

Purcell, R. H., Dienstag, J. L., Feinstone, S. M., Kapikian, A. Z. (1975). *Relationship of Hepatitis A Antigen to Viral Hepatitis.* **AM J MED SCI, 270(1)**:61–71.

Hepatitis A antigen is associated with 27 nm virus-like particles in the livers and stools of animals experimentally infected with hepatitis A and in the stools of humans experimentally or naturally infected with the virus. The density of the antigen particles recovered from liver is 1.34, but antigen particles with densities ranging from 1.32 to 1.40 have been recovered from stools. However, antigens from the liver and from the stools appear to be related.

With immune electron microscopy, antibodies to hepatitis A antigens were detected in convalescent serums from 100% of patients experimentally or naturally infected with hepatitis A virus. In contrast, patients with hepatitis B, or with non-B hepatitis that was incompatible epidemiologically with a diagnosis of hepatitis A, did not respond serologically to hepatitis A antigen. Antibodies were detected in approximately 50% of normal individuals tested; the frequency was directly related to age.

On the basis of serologic comparisons, hepatitis A virus does not appear to be related to the GB agent of Deinhardt or to the fecal antigen of Cross.

Ranganathan, K. R., Malina, J. F., Jr., Sagik, B. P. *Inactivation of Enteric Virus During Biological Wastewater Treatment.* **In "Advances in Water Pollution Research." Proceedings of the Seventh International Conference, Paris, September 1974. Pergamon Press, New York, New York** (1975), 669–75.

The adsorption of polioviruses by biological flocs in wastewater treatment processes is reversible, but some adsorbed viruses are inactivated.

The amount of viruses adsorbed depends upon the concentration of the mixed liquor suspended solids and the period of contact (represented by aeration time) between the two.

Infective virions may be eluted from sludge with borate saline buffer solution.

More than 99% of the viruses were inactivated in an anaerobic pond, but the aerobic process was more effective.

Scarpino, P. V. *Human Enteric Viruses and Bacteriophages as Indicators of Sewage Pollution.* **In "Discharge of Sewage from Sea Outfalls," edited by A. L. H. Gameson. Pergamon Press, Oxford, England** (1975), 49–61.

The usefulness of polioviruses and bacteriophages as indicators of sewage pollution is reviewed and discussed.

Schaub, S. A., Sagik, B. P. (1975). *Association of Enteroviruses with Natural and Artifically Introduced Colloidal Solids in Water and Infectivity of Solids-Associated Virions.* **APPL MICROBIOL, 30(2)**:212–22.

Ninety-three to 99% of seeded encephalomyocarditis (EMC) viruses adsorbed to montmorillonite clay in water over a pH range of 3.5 to 9.5. These viruses adsorbed to organic and inorganic solids. Adsorption was greatest when cations were present.

EMC viruses adsorbed to clay-infected cells in culture and mice.

Sharp, D. G., Floyd, R., Johnson, J. D. (1975). *Nature of the Surviving Plaque-Forming Unit of Reovirus in Water Containing Bromine.* **APPL MICROBIOL, 29(1)**:94–101.

The initial rate of inactivation of a reovirus 3 in water that contained 3 to 7 μM of bromine as HOBr was very rapid. Extensive physical damage to the virions occurred within one minute, but none of the virions was degraded beyond recognition. As exposure to the HOBr continued, the reaction rate decreased toward a plateau of resistance, usually about the 10^{-4} survival level. Progeny grown from these apparently resistant PFU was no more resistant to HOBr than the parent virus.

The presence of small aggregates (adhering groups of two to ten virions counted by electron microscopy) apparently did not affect the level of persistent PFU, but the presence of large aggregates did. Sonic treatment (20 kHz) after exposure to bromine increased the number of PFU detected by 10– to 43-fold. Plateaus of resistance did not occur when virus preparations were centrifuged at low speeds before they were exposed to bromine. Surviving PFU sedimented faster in a shallow sucrose gradient than single virions did. Large aggregates were too few to be visualized by electron microscopy.

Inactivation of the virions that comprise aggregates must be achieved if waters containing them are to be disinfected.

Sherman, V. R., Kawata, K., Olivieri, V. P., Naparstek, J. D. (1975). *Virus Removals in Trickling Filter Plants.* **WATER & SEWAGE WORKS, 122(RN)**:R36–44.

When coliphage f2 was seeded into two trickling filter sewage treatment plants with capacities of 1.5 and 2.5 MGD, about 32 and 37% of the virus was removed in the primary sedimentation basin, 9 and 19% on the trickling filter beds, 28 and 30% in the secondary sedimentation basins, and 59 and 60% in the chlorine contact basin.

Shuval, H. I. *Disinfection of Wastewater for Agricultural Utilization.* **In "Advances in Water Pollution Research." Proceedings of the Seventh International Conference, Paris, September 1974. Pergamon Press, New York, New York** (1975), 857–67.

Shortages of water in arid and in temperate areas are increasing the demand to conserve water by reuse. Agricultural utilization of wastewater is the most common form of reuse throughout the world today. Such reuse also reduces the pollution load on surface waters.

Wastewaters contain many pathogenic organisms that are not removed by conventional treatment. Treated wastewaters must be disinfected to raise the quality of such waters to a level acceptable for agricultural use and especially for use in irrigation of food crops.

Ten to 20 mg/liter of chlorine, maintained in treated sewage effluents for one hour, consistently achieves coliform counts of about 100/100 ml. Regrowth of coliforms occurs, however, when effluents are held for a number of days in reservoirs and distribution systems. It is not clear whether regrowth of pathogenic bacteria also occurs after chlorination.

Rapid mixing of disinfectant and effluent and sufficient contact time may permit treated settled sewage to meet the bacteriological standards established for wastewater utilization in agriculture.

Although chlorine can be a powerful virucide, most enteric viruses are more resistant than coliforms to chlorination. Ozone also is a powerful virucide.

Monitoring effluents for viruses may become a prudent policy in the future.

Shuval, H. I. *The Case for Microbial Standards for Bathing Beaches.* **In "Discharge of Sewage from Sea Outfalls," edited by A. L. H. Gameson. Pergamon Press, New York, New York** (1975), 95–101.

Pathogens, particularly viruses, survive for sufficient time in sewage-contaminated seawater to appear at bathing beaches in detectable concentrations. Ingestion of a single virus may lead to infection. Bathers often ingest from 10 to 50 ml of seawater during a single day of swimming. Taken together, one must conclude that there is a risk of becoming infected if one bathes in sewage-contaminated water and that the risk of infection becomes greater as the level of sewage contamination increases.

A prudent policy of providing reasonable protection to the bathers at seaside beaches calls for the reduction of fecal microorganisms of sewage origin to the lowest feasible level even before definitive epidemiological evidence becomes available. For this, microbiological standards are necessary.

The fail-safe approach to public health requires that potential risks are identified and that preventive actions are taken before major outbreaks occur. Moreover, the modern public health approach calls for the establishment of multiple barriers of protection to block the transmission of disease by environmental vectors.

Šimková, A., Wallnerová, Z. (1973). *Isolations of Coxsackie Viruses from Danube River Water.* **ACTA VIROL, 17(4)**:363.

Several group A and B coxsackieviruses were recovered from 10-liter volumes of Danube River water taken from sites above and 300 meters below sewage outfalls during the period March to October 1972. The recoveries were made in two-day old suckling mice. The viruses were concentrated from the waters by adsorption onto suspended $CaHPO_4$ at pH 6 and eluted from the $CaHPO_4$ in phosphate buffer at pH 8.

Viruses were not recovered from river water samples taken in April, May, or July.

Detection of coxsackieviruses in river water above the residential area — distant from pollution sources — suggests that Danube River water may be a vehicle for virus transmission.

Šimková, A., Wallnerová, Z. (1973). *Survival of Small Amounts of Coxsackie A4 Virus in Danube River Water Under Laboratory Conditions.* **ACTA VIROL, 17(6)**:505–6. **Presently not available.**

Singh, P. K. (1973). *Occurrence and Distribution of Cyanophages in Ponds, Sewage, and Rice Fields.* **ARCH MIKROBIOL, 89(10)**:169–72.

Cyanophages and *Cyanophyceae* were recovered from ponds, sewage, and rice fields in Cuttack. Two distinct types of cyanophages, clear (virulent) and turbid (lysogenic) plaque-forming strains, were found in this natural habitat.

This is the first report of cyanophages in rice fields in India.

Sobsey, M. D. (1975). *Enteric Viruses and Drinking-Water Supplies.* **J AMER WATER WORKS ASSOC, 67(8)**:414–8.

It is impossible to remove all fecal contamination from drinking-water supplies.

Surveillance studies to determine the levels of enteric viruses in drinking waters that meet current microbial standards should be a major priority for research.

The two most promising methods for detecting viruses in potable waters have as their bases flow-through filter adsorption-elution and ultrafiltration.

Sobsey, M. D., Wallis, C., Melnick, J. L. (1975). *Development of a Simple Method for Concentrating Enteroviruses from Oysters.* **APPL MICROBIOL, 29(1)**:21–6.

Enteroviruses, seeded into oysters (*Crassostrea virginica*), were recovered by adsorbing the viruses to the homogenized oyster tissue solids at pH 5.5 (at low salt concentration), concentrating the solids by low-speed centrifugation, eluting the viruses by resuspending the solids in pH 3.5 glycine-buffered saline, removing the solids by low-speed centrifugation, filtering the virus-containing supernatant through a 0.2-μm diameter filter to remove bacteria and other small particulates, and reconcentrating the viruses into a volume of several ml by ultrafiltration. The concentrate was inoculated directly onto cell cultures for virus assay.

Efficiency of recovery of viruses averaged 63%.

Sobsey, M. D., Wallis, C., Melnick, J. L. (1975). *Studies on the Survival and Fate of Enteroviruses in an Experimental Model of a Municipal Solid Waste Landfill and Leachate.* **APPL MICROBIOL, 30(4)**:565–74.

Over a four-month period, viruses were not detected in the leachates of solid waste lysimeters that contained simulated refuse seeded with either laboratory or field strains of poliovirus 1 and echovirus 7. Viruses were not detected in the refuse contents of the lysimeters either after operation of the lysimeters had been terminated.

The rates of inactivation for these viruses in composite leachate samples and the rapid adsorption of these viruses to the components of municipal solid waste in a suspension that contained the major inorganic salts present in leachates suggested that inactivation and adsorption were mechanisms by which viruses were removed from solid waste landfills.

Sproul, O. J. (1975). *Virus Removal and Inactivation During Water Treatment.* **J NEW ENG WATER WORKS ASSN, 89(1)**:6–15.

Viruses may be present in treated drinking water. Research and development efforts should be directed at minimizing the risk to human health from this source.

Such efforts should include determination of the degree of protection against destruction afforded to viruses by clumping or adsorption to surfaces, determination of the incidences of infections and disease caused by low level virus transmission through water supplies, development of a virus standard for treated wastewater and drinking water, and reduction to practice of technics for determining concentrations of viruses in large volumes of water.

Thraenhart, O., Kuwert, E. (1975). *Comparative Studies on the Action of Chlorine and Ozone on Polioviruses in the Reprocessing of Drinking Water in Essen.* **Z BAKT HYG, 160(4–5)**:305–41. **German.**

Polioviruses that had been seeded into distilled, tap, and well water were destroyed about equally effectively by chlorine and ozone.

The rates of disinfection were different in each water and were pH-dependent with both chlorine and ozone.

Vaughn, J. M., Metcalf, T. G. (1975). *Coliphages as Indicators of Enteric Viruses in Shellfish and Shellfish Raising Estuarine Waters.* **WATER RES, 9(7)**:613–6.

Coliphages were widely distributed in sewage effluents, shellfish, and shellfish growing waters, examined concurrently; enteric viruses of human sources were detected relatively infrequently in the waters and shellfish that yielded coliphages.

During the summer months, replication of coliphages occurred in estuarine waters when host bacteria were present. Two major coliphage types were recovered (on different *Escherichia coli* strains) from field samples. A shift in dominant coliphage types occurred during the study.

Coliphages survived slightly longer in estuarine waters and were retained slightly longer in oysters than enteric viruses were. Under laboratory conditions, oysters accumulated more coliphages than enteric viruses.

The lack of correlation between coliphages and enteric viruses in sewage effluents, shellfish, and shellfish growing waters, and the changes that occurred in populations of dominant coliphage types suggest that coliphages are not good indicators of enteric viruses.

Verstraete, W., Voets, J.P. (1975). *Microorganisms as Indicators of Environmental Hygiene: Ecology, Taxonomy, and Enumeration.* **NATUURWET TIJDSCHR, 57(2)**:41–84. **Translation presently not available. Dutch.**

Wei, J. H., Chang, S. L. *A Multi-Poisson Distribution Model for Treating Disinfection Data.* **In "Disinfection — Water and Wastewater," edited by J. D. Johnson. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan** (1975), 11–47.

A multi-Poisson distribution model was developed to analyze disinfection data generated with viruses and other microorganisms that often occur in clumps of varying numbers. Rational values for k and good agreement between calculated and observed cyst clump size distributions were obtained when the model was used to treat data on the destruction of cysts of *Naeglaria gruberi* (in suspensions of known clump distributions) by I_2.

Subsequent application of the model to data on viruses and bacteria generally confirmed the validity of the model.

Wellings, F. M., Lewis, A. L., Mountain, C. W. (1975). *Pathogenic Viruses May Thwart Land Disposal.* **WATER & WASTES ENG, 12(3)**:70–4.

Experience with the recovery of viruses from 10- and 20-foot wells in areas that had been spray-irrigated with secondary effluents are recounted.

See in 1974 Literature Abstracts: **Wellings, F. M., Lewis, A. L., Mountain, C. W.** *Virus Survival Following Wastewater Spray Irrigation of Sandy Soils.* **In "Virus Survival in Water and Wastewater Systems," edited by J. F. Malina, Jr. and B. P. Sagik. Center for Research in Water Resources, The University of Texas, Austin** *(1974), 253–60.*

Wellings, F. M., Lewis, A. L., Mountain, C. W., Pierce, L. V. (1975). *Demonstration of Virus in Groundwater After Effluent Discharge onto Soil.* **APPL MICROBIOL, 29(6)**:751–7.

Viruses were recovered from water drawn from 10-foot deep wells in a cypress dome onto which secondary effluents had been discharged. The viruses were concentrated from the water by the membrane adsorption technic. Vertical and lateral movement of viruses were demonstrated.

Viruses survived within the dome for 28 days during a period of heavy rains when no effluent was applied. Because virus concentration procedures are inefficient, most of the viruses present were probably not demonstrated.

Wellings, F. M., Lewis, A. L., Mountain, C. W., Stark, L. M. (1975). *Virus Consideration in Land Disposal of Sewage Effluents and Sludge.* **FLORIDA SCI, 38(4)**:202–7.

Viruses were recovered from 10- and 20-foot wells in an area that had been spray-irrigated with secondary effluents.

Viruses were also recovered from 10-foot wells in a cyprus dome onto which secondary effluents had been discharged.

Both laboratory and field evidence now exist that viruses percolate through soils, adsorb to soils, desorb from soils and move with subsurface waters, and may survive in soils in the field for at least 28 days.

See in 1974 and in current Literature Abstracts: **Wellings, F. M., Lewis, A. L., Mountain, C. W.** *Virus Survival Following Wastewater Spray Irrigation of Sandy Soils.* **In "Virus Survival in Water and Wastewater Systems," edited by J. F. Malina, Jr. and B. P. Sagik. Center for Research in Water Resources, The University of Texas, Austin** *(1974), 253–60;* ***Wellings, F. M., Lewis, A. L., Mountain, C. W., Pierce, L. V.*** (1975). Demonstration of Virus in Groundwater After Effluent Discharge onto Soil. ***APPL MICROBIOL,*** 29(6):751–7.

White, G. C. (1975). *Disinfection: The Last Line of Defense for Potable Water.* **J AMER WATER WORKS ASSN, 67(8)**:410–3.

Waterborne viruses may cause illnesses, including gastroenteritis, most of which are not reportable.

The absence of coliform organisms from a chlorinated water is not infallible proof of disinfection. More resistant organisms must be sought.

Because chlorine reacts with ammonia and with certain organic compounds, and thereby is reduced in effectiveness, a maximum limit of 0.5 mg/liter of ammonia nitrogen and 0.3 mg/liter of organic nitrogen should be set for potable waters. Instrumentation specific for measuring undissociated HOCl should be developed for monitoring the effective chlorine residual of potable waters.

A disinfection standard should be based upon a chlorine concentration-contact time coupling that achieves at least 99.6% inactivation of a consensus virus. Water temperature and pH must be factored into such a standard so that extrapolations along a range of pH and water temperature levels can be made.

WHO Expert Committee on Fish and Shellfish Hygiene, Committee Report. (1975). *Fish and Shellfish Hygiene.* **WHO CHRON, 29(2)**:55–60.

Within a review of fish and shellfish-transmitted diseases, transmission of hepatitis A by shellfish is briefly noted.

Zdražílek, J., Jadrníčková, N., Jandásek, L., Kašová, V., Uvízl, M., Valihrach, J. (1974). *Presence of Poliovirus and Other Enteroviruses in Sewage.* **BULL WLD HLTH ORG, 50(6)**:562–3.

Polioviruses were recovered from the sewage collected from 43 nurseries and 22 main line sewers in a community in Czechoslovakia six to seven months after an oral vaccination program. Other enteroviruses were detected in the sewage of the community during the summer and autumn, after the presence of these viruses in the area had been established.

The detection of enteroviruses in sewage is an important part of the study of their spread and circulation among the population. The detection of polioviruses in the community is a permanent task of the poliomyelitis control program in Czechoslovakia.

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