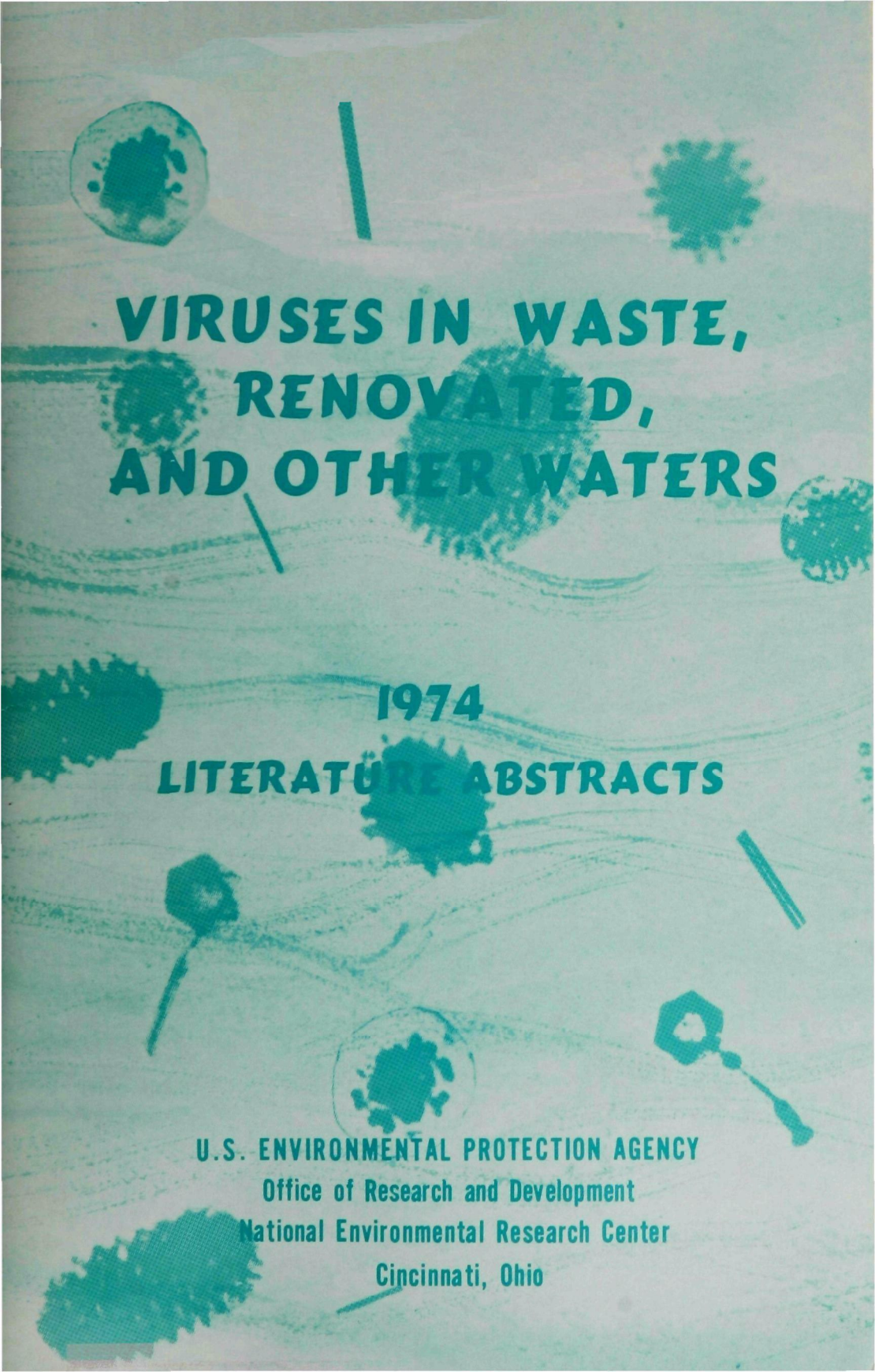

VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

1974 LITERATURE ABSTRACTS

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VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

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1974

VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

Aizen, M. S., Pille, E. P. (1973). *Use of Polyethylene Glycol for Detection of Viruses in Food.* **LAB DELO, 9**:550–2. **Translation presently not available.** Russian.

Albertsson, P. A. *Concentration of Virus by Phase Partition.* **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), 16–8.

Viruses and other particles and macromolecules can be concentrated by partition between the immiscible phases of polymers such as dextran and polyethylene glycol (PEG) in water. Such concentrations are achieved by minimizing the volume of the phase in which concentration occurs.

When salts such as NaCl, KCl, NaI, KI, NaSCN, and KSCN are added to a dextran-PEG system, the upper PEG phase becomes more negatively charged than the lower dextran phase, and the negatively-charged virus partitions into the dextran.

The tendency of viruses (and other particles and macromolecules) to concentrate in a polymer increases as the molecular weight of the polymer decreases.

If bis-trimethyl amino PEG (TMA-PEG) (positively charged) or PEG-sulfonate (PEG-S) (negatively charged) is added to a dextran-PEG system in which the ionic strength is low (<10 mM), a larger interfacial potential is produced. Both TMA-PEG and PEG-S favor the PEG phase and make it either more attractive to virus particles (TMA-PEG) or less attractive to virus particles (PEG-S).

Alternate partitioning of viruses in dextran-PEG to which TMA-PEG or PEG-S has been added may result in highly concentrated viral preparations.

Bagdasaryan, G. A., Talaeva, Yu. G., Lovtsevich, E. L. (1974). *Direct Detection in Water of Causative Agents of Intestinal Infections.* **GIG SANIT, 39(2)**:74–6. Russian.

Within a general discussion of methods for recovering pathogenic bacteria and viruses from environmental waters, several specific methods for recovering viruses are alluded to.

A gauze pad procedure is recommended for concentrating viruses from sewage; a gauze pad procedure, adsorption to ion-exchange resins, and flotation are recommended for concentrating viruses from reservoir water; and a gauze pad procedure and adsorption to ion-exchange resins are recommended for concentrating viruses from drinking waters.

Recommendations for periodic sampling of environmental waters are also made.

Belfort, G., Rotem, Y., Katzenelson, E. (1974). *Virus Concentration Using Hollow Fiber Membranes.* **WATER RES, 9(1)**:79–85.

Poliovirus 1 seeded into 5-liter volumes of water was recovered by ultrafiltration through cellulose acetate hollow fiber membranes.

An average of 85% of the virus was recovered and a 50-fold dehydration was achieved in about one hour. Some loss of virus resulted from intrusion of the virus into the fibers.

Berg, G. (1973). *Removal of Viruses from Sewage, Effluents, and Waters. 1: A Review.* **BULL WLD HLTH ORG, 49(5)**:451–60.

All sewage and water treatment processes remove or destroy viruses. Some treatment methods are better than others, but none is likely to remove all of the viruses present in sewage or in raw water.

Primary settling of solids probably removes a great many of the viruses in sewage because viruses are largely associated with the solids. Long storage of effluents or water is destructive to viruses. Activated sludge is the best biological method for removing viruses from sewage. Trickling filters and oxidation ponds are erratic, the latter probably because of short-circuiting.

Coagulation with metal ions is the most effective single treatment method for removing viruses from sewage and from raw waters, according to laboratory studies at least. Lime is the best coagulant for these purposes in the rapidly virucidal high pH range. Polyelectrolytes also can sediment viruses.

Rapid filtration through clean sand does not remove viruses, but filtration of coagulated effluents does, probably because the layering floc itself adsorbs viruses. Clays and carbon adsorb viruses to some extent but not efficiently.

Ultimately, disinfection must be depended upon to produce virus-free waters for drinking and virus-free effluents for discharge into waters with which man may come into contact. Disinfectants must be selected according to need. Effluents and waters containing solids can probably be disinfected only by heat or by penetrating radiation; effluents discharged into streams should not be disinfected with anything that will react with the effluent and produce compounds that injure or kill aquatic life (unless the toxic products can be neutralized), and drinking waters should carry a disinfecting residual.

Berg, G. (1973). *Removal of Viruses from Sewage, Effluents, and Waters. 2. Present and Future Trends.* **BULL WLD HLTH ORG, 49(5)**:461–9.

Because large variations occur in the concentrations of viruses that enter treatment plants from season to season and from place to place, and even during a 24-hour period, field studies on the removal of viruses by treatment processes require temporal coordination of sampling.

Quantitative methods for concentrating viruses must be developed to measure accurately the efficiency of virus removal by treatment processes in field situations.

Extended settling, and storage of sewage and raw waters, reduce virus levels and deserve further study. Oxidation ponds must be reevaluated with regard to temporal matching of influent and effluent samples and with special care to prevent short-circuiting. Conventional and modified activated sludge plants must be reassessed with temporal matching of samples.

Coagulation of viruses with metal ions requires field evaluation, and virus removal by filtration through sand and other media, under constant salt and organic loadings, needs both laboratory and field evaluation.

A comparative study of water disinfectants related to specific conditions is needed. The toxicity, carcinogenicity, and teratogenicity of products resulting from disinfection must also be assessed.

Other matters for investigation are: methods for quantitatively detecting viruses adsorbed on solids, the virus-removal capability of soils, better virus indicators, virus concentration in shellfish, the frequency of infection in man brought about by swallowing small numbers of viruses in water, the epidemiology of virus infection in man by the water route, the effect of viruses of nonhuman origin on man, and the occurrence of tumor-inducing agents in water.

Bishop, R. F., Davidson, G. P., Holmes, I. H., Ruck, B. J. (1974). *Detection of a New Virus by Electron Microscopy of Faecal Extracts from Children with Acute Gastroenteritis.* **LANCET, 1(7849)**:149–51.

Particles resembling orbiviruses were observed in electron micrographs of negatively stained extracts of the feces of 11 of 14 children with acute non-bacterial gastroenteritis. Such particles were not seen in extracts of feces from nine control children.

Orbivirus-like particles were seen in feces or in biopsed duodenal mucosa by electron microscopy in a total of 81% of children with gastroenteritis that occurred sporadically in Melbourne.

Extraction of feces by differential centrifugation is a simpler, faster, and more sensitive method for detecting viruses than duodenal biopsy.

Bitton, G., Mitchell, R. (1974). *Effect of Colloids on the Survival of Bacteriophages in Seawater.* **WATER RES, 8(4)**:227–9.

The biological inactivation of coliphage T7 in sea water was influenced by inorganic and organic colloids. Colloidal montmorillonite and *Escherichia coli* K cells protected the virus from inactivation in natural seawater.

Bitton, G., Mitchell, R. (1974). *The Removal of* Escherichia coli-*Bacteriophage T7 by Magnetic Filtration.* **WATER RES, 8(8)**:549–51.

Coliphage T7, adsorbed to magnetite in the presence of $CaCl_2$, was removed from suspension by filtration through a magnetic field.

Agitation of the phage with 400 mg/liter of magnetite and 250 mg/liter of $CaCl_2$ for 30 minutes before filtration resulted in the removal of nearly 99% of the phage. Lesser concentrations of the magnetite or the salt, or agitation for a shorter period resulted in reduced removal of the phage from suspension during magnetic filtration.

Blok, J., Loman, H. (1973). *The Effects of Gamma-Radiation in DNA.* **CURR TOP RADIAT RES, 9**:165–245.

Within a comprehensive analysis of the effects of gamma radiation on DNA, the probable mechanism of bacteriophage inactivation is discussed.

When bacteriophage are irradiated in an inorganic buffer, inactivation results from the reaction of free radicals, produced by the irradiation, with the coat protein of the phage.

In the presence of organic scavengers that react with and neutralize the free radicals, inactivation of phage results from hits that bring about single or double stranded breaks in the DNA, base damage, formation of cross links, or protein damage that prevents the virus from adsorbing to its host or from injecting its DNA into its host.

Brown, T. S., Malina, J. F., Jr., Moore, B. D. (1974). *Virus Removal by Diatomaceous-Earth Filtration—Part 1.* **J AMER WATER WORKS ASSN, 66(2)**:98–102.

Diatomaceous earth filters (Hyflo D) removed more than 99% of seeded coliphage T2 from dechlorinated tap water. Hyflo (also a diatomaceous earth) was equally effective only when coated with Purifloc C-31, a polyelectrolyte.

The optimal pH for adsorption of coliphage T2 to diatomaceous earth was 6.2. The optimal pH for desorption was 9.55.

Brown, T. S., Malina, J. F., Jr., Moore, B. D. (1974). *Virus Removal by Diatomaceous-Earth Filtration—Part 2.* **J AMER WATER WORKS ASSN, 66(12)**:735–8.

Filtration through Hyflo, a diatomite filter, coated with either the insoluble polymer PE60 or a polyelectrolyte, removed more than 98% of seeded coliphage T2 and poliovirus 1 from dechlorinated tap water. Pretreatment of the feed with the filter aid and the polyelectrolyte brought about removal of all detectable viruses. Uncoated diatomite was less effective in removing the viruses.

The optimal pH for coliphage T2 adsorption to PE60 in dechlorinated tap water was 6.25; the optimal elution level was 9.55. Maximum adsorption of the poliovirus to the PE60 occurred at pH 6.

Brown, T. S., Malina, J. F., Jr., Moore, B. D., Sagik, B. P. *Virus Removal by Diatomaceous Earth Filtration.* **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), 129–44.

More than 98% of poliovirus 1 and coliphage T2 seeded into sewage treatment plant effluent were removed by filtration through Hyflo (diatomite) coated with either ferric hydrate or C-31 polymer. The procedure used to coat the diatomite influenced its ability to remove viruses.

The seeded viruses were not detected in the filtrate of feed waters treated within the C-31 polymer.

Uncoated diatomite removed more than 90% of the viruses initially, but filtration efficiency diminished rapidly. Uncoated diatomite removed coliphage T2 more effectively than it removed the poliovirus.

The C-31 polymer was not virucidal.

Bryan, J. A., Lehmann, J. D., Setiady, I. F., Hatch, M. H. (1974). *An Outbreak of Hepatitis-A Associated with Recreational Lake Water.* **AMER J EPIDEMIOL, 99(2)**:145–54.

In a 15-day period during September 1969, 14 cases of hepatitis A occurred in members of a Boy Scout troop that had camped on an island in a lake recreation area approximately four weeks earlier.

The clustering of cases by onset date over a short time interval, the appearance of cases only among those troop members that attended the campout, the absence of known prior exposure to hepatitis A, and the absence of hepatitis B antigen in all but one of the patients suggested a common-source exposure to hepatitis A virus.

Grossly contaminated lake water, inadvertently consumed by many campers, appears to have been the transmitting vehicle for the virus.

Buras, N. (1974). *Recovery of Viruses from Waste-Water and Effluent by the Direct Inoculation Method.* **WATER RES, 8(1)**:19–22.

Summary appeared in the 1973 edition of these abstracts. The paper was published originally in **Proceedings of the Conference on Environmental Quality Research**, 19–31 (1973).

Caldwell, G. G., Lindsey, N. J., Wulff, H., Donnelly, D. D., Bohl, F. N. (1974). *Epidemic of Adenovirus Type 7 Acute Conjunctivitis in Swimmers.* **AMER J EPIDEMIOL, 99(3)**:230–4.

An epidemic of acute conjunctivitis occurred in members of a Kansas community swimming team during January 1973. The etiological agent was adenovirus 7. Manifestations of illness occurred mainly in the eye; other systems were affected to a lesser degree.

The swimming team used a local junior high school swimming pool in which adequate chlorine levels were not maintained after the pool filter and chlorinator had failed.

Cookson, J. T. *The Chemistry of Virus Concentration by Chemical Methods.* **In "Developments in Industrial Microbiology," Vol. 15. In the Symposium: Detection of Viruses in Waste and Other Waters, August 1973, Convener, G. Berg. Proceedings of the Thirtieth General Meeting of the Society for Industrial Microbiology. American Institute of Biological Sciences, Washington, D. C.** (1974), 160–73.

The concentration of viruses from dilute suspensions depends on physical and chemical factors. Before chemical interactions occur, a physical or transfer step must take place. Since physical transfer is easily optimized, efficiency of concentration is usually influenced greatly by the chemical step.

Understanding the basic chemical mechanisms involved in each concentration procedure is important for optimizing adsorption and release of viruses.

This paper explores the chemical characteristics of the aqueous phase and the surface characteristics of viruses and adsorbing solids that are involved in the concentration of viruses by chemical methods.

Cookson, J. T., Jr. (1974). *Virus and Water Supply.* **J AMER WATER WORKS ASSN, 66(12)**:707–11.

Viruses are present in surface waters, but epidemiological studies cannot be relied upon to illustrate virus hazards.

The technology to produce a virus-free water exists.

Process technology can be implemented to assure virus-free water. Neither monitoring for viruses nor establishment of a virus standard is necessary for this purpose.

Cooper, R. C., Potter, J. L., Leong, C. *Virus Survival in Solid Waste Treatment Systems.* **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), 218–32.

Poliovirus 1 was recovered from leachates of simulated sanitary landfills and open dumps that had been seeded with the virus. Leachates were relatively non-toxic to the poliovirus.

Culp, R. L. (1974). *Breakpoint Chlorination for Virus Inactivation.* **J AMER WATER WORKS ASSN, 66(12)**:699–703.

Three barriers exist or can be created for preventing the transmission of viruses in sewage to man. These are: 1. advanced waste treatment, including disinfection, which is capable of removing or destroying all viruses in a sewage, 2. the hostility of the water environment to viruses, and 3. disinfection (following pretreatment when necessary) of waters that are to be used for drinking.

The conditions required for adequate disinfection of a drinking water supply are: 1. turbidities must be below 1 JTU (preferably below 0.1 JTU), 2. the pH of water that contains ammonia must be above 7.5, and the pH of water free of ammonia must be below 7, 3. mixing of the chlorine into the water must be rapid and uniform, and 4. an HOCl concentration of 0.5 to 1.0 mg/liter must be maintained for 30 minutes.

Most water treatment facilities chlorinate marginally in practices unchanged for 50 years. Most modifications in chlorination practices have been directed at reducing tastes and odors and not at improving microbial quality. Since even 1 PFU of a virus may constitute an infective dose for man, all viruses must be removed from drinking waters to assure their safety.

The proposed new drinking water standards are a step in this direction in that they require adequate continuous chlorination of a public water supply, that all surface water sources are filtered, and that all storage reservoirs are covered.

Culp, R. L. *Breakpoint Chlorination for Virus Inactivation.* **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), 158–65.

Viruses can be inactivated in water and wastewater treatment plants by breakpoint chlorination. To achieve complete virus inactivation requires that the

turbidity of a water is reduced to 0.1 to 1.0 JTU, that the pH of waters that contain ammonia is adjusted to 7.5 and that the pH of ammonia-free waters is adjusted to 7, that the chlorine is rapidly mixed into the water, and that an HOCl residual of 0.5 to 1.0 mg/liter is maintained for 30 minutes.

D'Arca, S. U., Pana, A. (1973). *Concentration of Enteroviruses from Surface Waters by the Polyelectrolyte Method.* **NUOVI ANN IG MICROBIOL, 24(5)**:315–25. Italian.

Viruses were recovered from seeded distilled, tap, and river waters on the insoluble polyelectrolyte PE60. The pHs of the waters were adjusted to 5 to 6, and the PE60 was suspended in the waters.

With a PE60 concentration of 150 mg/liter, recoveries of poliovirus 1 averaged 63% from distilled water, 75% from tap water, and 82% from river water. Recoveries of coxsackievirus B3 were lower and more variable.

Viruses were eluted from the PE60 in 3% calf serum.

Dahling, D. R., Berg, G., Berman, D. (1974). *BGM, A Continuous Cell Line More Sensitive than Primary Rhesus and African Green Kidney Cells for the Recovery of Viruses from Water.* **HEALTH LAB SCI, 11(4)**:275–82.

A continuous cell line, BGM, derived from primary African green monkey kidney cells, was more sensitive than primary rhesus or African green monkey kidney cells to many enteroviruses and to reovirus 1. Comparative tests in BGM cells and in primary rhesus kidney cells showed that many enteroviruses and reovirus 1 multiplied to higher titers in BGM cells even after the viruses had been adapted to primary monkey kidney cells or to Vero cells.

In comparative studies with sewage, sewage effluents, and natural waters obtained from different parts of the country and at different points in time, many more viruses were usually recovered in BGM cells than in primary rhesus or in African green kidney cells.

The availability of the BGM cell line for research and clinical studies should considerably reduce the need for monkey sacrifice and bring about large cost savings to laboratories requiring such cells.

De Michele, E. *Water Reuse, Virus Removal, and Public Health.* **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), 45–56.

Reused treated water represents an increasing fraction of this nation's total water resources.

The number of waterborne disease outbreaks has not declined since 1955. From 1946 to 1970, more than 358 outbreaks affected more than 72,000 people.

Enteric viruses can be transmitted by the water route; standard analyses for bacteria cannot satisfactorily predict the presence of viruses.

Lack of adequate virus detection methods and inefficient disinfection processes mean that the degree of assurance needed for potable reuse of treated waters presently does not exist.

De Michele, E., Burke, G. W., Jr., Shane, M. S. (1974). *The Need for an Indicator Virus in Water Quality Testing.* **WATER & SEWAGE WORKS, 121(4)**:39.

The argument is made that an adequate biological indicator for viruses in various waters is not now available and should be sought.

Denis, F. (1973). *Epidemiological Consequences of Virus Contamination of Waters.* **REV EPIDEMIOL, 21(4)**:273–302. French.

This paper comprises a general review of the literature on viruses in drinking water and waste water.

The viruses encountered in various waters are discussed as are the spontaneous inactivation of viruses in water and the methods available for treating waters to remove or inactivate viruses.

Denis, F. (1974). *Viruses Pathogenic for Man in Seawaters and in Molluscs. Survival-Research-Distribution.* **MED MALADIES INFECT, 4–6**:325–34. French.

Viruses shed into sea water are inactivated at a rate dependent upon the nature, temperature, season, currents, and microbial population of the water, and upon the properties of the viruses involved.

Viruses in sea water may be a hazard to bathers and are clearly a danger to shellfish consumers. Viruses can survive for 30 to 130 days in sea water at 4 to 6 C; thus, sea currents may cause the contamination of shellfish beds many miles from sewage outfalls. Oysters and mussels can filter 50 to 100 liters of water daily and thereby concentrate viruses present in their environment. Viruses may then survive in shellfish for five months or more, especially in winter. Molluscs may thus serve as reservoirs of viruses. Recoveries of enteroviruses in 3 to 40% of oyster catches have been reported.

That no enterovirus epidemics derived from the ingestion of contaminated molluscs have been reported may be ascribed to the protean nature of such infections and to the fact that shellfish are usually a food of adults already immune to enterovirus infections. Molluscs, of course, have been incriminated in outbreaks of hepatitis A disease.

These findings provide further argument in favor of a total ban on all sewage discharge into rivers and streams because these eventually empty into the sea.

Denis, F. A., Blanchouin, E., DeLignieres, A., Flamen, P. (1974). *Coxsackie A16 Infection from Lake Water.* **J AMER MED ASSN, 228(11)**:1370–1.

Coxsackievirus A16 was recovered from the rectal swabs of two boys with gastrointestinal disease and from lake water in which they had bathed a few days before onset of illness.

Dhillon, E. K. S., Dhillon, T. S. %b(1974). *Synthesis of Indicator Strains and Density of Ribonucleic Acid-Containing Coliphages in Sewage.* **APPL MICROBIOL, 27(4)**:640–7.

Strains of *Escherichia coli* freshly isolated from natural sources were not infected by many coliphages present in sewage.

Four strains of *E. coli* recently recovered from clinical specimens were mutagenized to obtain *lac*$^-$ mutants. These mutants were infected with an F'*lac*$^+$ sex factor of *E. coli* K-12. Pairs of isogenic *lac*$^-$ and *lac*$^-$/F'*lac*$^+$ strains were effective selective hosts for enumeration of F-specific coliphage in sewage. Serological tests applied to a number of F-specific phages recovered showed that all of the coliphages tested fell into two distinguishable antigenic groups. Members of one group were related to RNA phage MS2 and those of the other were related to another RNA phage, namely, Q_β. MS2-related phages were more widely distributed than those related to the Q_β phages.

Most habitats sampled yielded only one or the other kind of phage. Single-stranded DNA F-specific phages were not detected.

Dowling, L. T. (1974). *Chlorine Dioxide in Potable Water Treatment.* **WATER TREAT & EXAM, 23(2)**:190–204.

The literature on the effect of chlorine dioxide on viruses and on the toxicity of chlorine dioxide and chlorite ion is reviewed.

Duboise, S. M., Sagik, B. P., Moore, B. E. D., Malina, J. F., Jr. *Virus Migration Through 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),233–40.

Approximately 10^6 PFU of poliovirus 1 (Chat) and coliphage T7 were seeded into non-sterile core samples (approximately 19 cm by 5.6 cm) of a sandy forest loam and washed in with deionized water passed through the cores

either continuously or intermittently. Both viruses traversed the core before the passage of one bed volume of water.

Under continuous flow conditions, coliphage T7 appeared in the first 1,200 ml of water at levels ranging from 3% up to almost 12% of the total PFU applied. Only about 0.5% of the total seeded poliovirus appeared in the first 400 ml of water. About 1.5% to 8% of the coliphage T7 appeared in the same volume.

Under intermittent flow conditions, only about 1.2% of the coliphage T7 and 0.5% of the seeded poliovirus were recovered in the first 700 ml of water.

Durham, D., Wolf, H. W. (1973). *Wastewater Chlorination: Panacea or Placebo?* **WATER & SEWAGE WORKS, 120(10)**:67–71.

Coliforms (total) were destroyed more rapidly than coliphage by chlorination in two trickling filter effluents.

Durkop, J. (1972). *Viruses in Agricultural Waters.* **Z GESAMTE HYG, 18(12)**:957–9. German.

Enteric viruses in sewage are not removed completely by conventional sewage treatment processes. If conventionally-treated effluents are used for irrigation, contamination of crops with viruses may result.

To obviate the risk of virus transmission by such crops, improved sewage treatment technology and continuous monitoring of treated effluents are necessary.

The risk of infection of humans with viruses from effluent-irrigated crops needs to be determined.

Engelbrecht, R. S., Foster, D. H., Greening, E. O., Lee, S. H. (1974). *New Microbial Indicators of Wastewater Chlorination Efficiency.* **Environmental Protection Technology Series, EPA-670/2–73–082, February 1974, Office of Research & Development, U. S. Environmental Protection Agency, Washington, D. C., 67 pages.**

Coliforms are less resistant to chlorine than enteric viruses and protozoan cysts. A yeast and two acid-fast bacilli recovered from sewage were resistant to chlorination at a level considered necessary for the inactivation of viruses. One acid-fast bacillus survived 2 mg/liter of free chlorine for 67 minutes and the other survived 1 mg/liter of free chlorine for 15 minutes. The yeast survived 1 mg/liter of free chlorine for 20 minutes. In comparison, a pure culture of *Escherichia coli* failed to survive five minutes of contact with 0.03 mg/liter of free chlorine.

Yeasts and acid-fast organisms were found in wastewater effluents and yeasts have been recovered from stools.

Certain characteristics of these yeasts and acid-fast bacilli, including their resistance to chlorine, suggest that they may be useful bioindicators of wastewater chlorination efficiency.

Engelbrecht, R. S., Weber, M. J., Amihor, P., Foster, D. H., LaRossa, D. *Biological Properties of Sanitary Landfill Leachate.* **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), 201–17.

The survival and movement of bacteria and viruses were followed in a large scale lysimeter that contained 3358 lb. of milled municipal solid wastes seeded with poliovirus 1 (LSc).

The concentrations of aerobic bacteria (total plate count), total coliforms, fecal coliforms, and fecal streptococci in the leachate decreased progressively with the time of lysimeter operation (270 days).

Viruses were not recovered from the leachate.

The leachate inactivated *Salmonella typhimurium*, fecal coliforms, fecal streptococci, and poliovirus 1 when these organisms were exposed to it.

England, B. *Recovery of Viruses from Waste and Other Waters by Chemical Methods.* **In "Developments in Industrial Microbiology," Vol. 15. In the Symposium: Detection of Viruses in Waste and Other Waters, August 1973, Convener, G. Berg. Proceedings of the Thirtieth General Meeting of the Society for Industrial Microbiology. American Institute of Biological Sciences, Washington, D. C.** (1974), 174–83.

Concentration of viruses in water and sewage permits the recovery of viruses that otherwise would go undetected. Technics currently available include adsorption of viruses to various substances, followed by desorption of the viruses into a small volume of elutant.

Early work in 1953 made use of an ion-exchange resin for adsorption of viruses, and subsequent years have seen methods developed for adsorption of viruses to, and elution from, insoluble polyelectrolytes, iron oxide, and insoluble salts such as aluminum hydroxide and calcium phosphate. Elutants generally consist of alkaline buffers or solutions containing serum or other proteinaceous substances. Another technic that has found wide use employs separation by aqueous polymer two-phase systems such as dextran and polyethylene glycol. Certain viruses can be concentrated from albumin-supplemented waters by treatment with protamine sulfate, the virus being recovered by dissolving the resultant precipitate in a small volume of NaCl.

Most of these concentration methods are efficient and practical for sample volumes of several liters or less, quantities that suffice for testing raw

sewage or grossly contaminated waters; few of these methods are useful with the many-gallon samples necessary for testing highly treated potable or recreational waters.

Ergasheva, L. E., Artykov, M. S., Ilyinsky, I. I. (1972). *Sanitary-Virologic Features of Sewage in Certain Urban Sewerage Systems of Uzbek SSR.* **GIG SANIT, 37(9)**:90–1. Russian.

This paper was listed in the 1972 edition of these abstracts. A translation was not then available.

Polioviruses have not been recovered from the sewage in Chirchik, Yangiyul, or Tashkent since 1968 and few coxsackieviruses have been recovered either. The predominant viruses recovered in recent years have been echoviruses.

From 1965 to 1969, the frequency of enterovirus recovery was greatest in the fall and lowest in the winter and spring. Seasonal fluctuations did not occur in 1970, a year of low virus recoveries.

Farrar, L., Hedrick, H. G. *Recovery of Enteric Viruses from Sewage Effluent by Polyelectrolyte Adsorption.* **In "Developments in Industrial Microbiology," Vol. 14. American Institute of Biological Sciences, Washington, D. C.** (1973), 376–84.

Filtered secondary clarifier effluent was mixed with the insoluble polyelectrolyte PE60 at pH 5 to 6. The PE60 was recovered by filtration and the adsorbed viruses were eluted with 10% calf serum at pH 8 and inoculated into 10– to 12-day old embryonated chicken eggs by the allantoic, amniotic, and chorioallantoic route.

Pocks and infected foci of different sizes and shapes occurred on all membranes but were present in greatest numbers on the chorioallantoic membrane. The greatest numbers of pocks and foci and the greatest varieties of sizes and shapes (interpreted as different enteric virus types) were found on membranes inoculated with concentrates of samples taken during the warmer months of the year.

Fattal, B., Katzenelson, E., Nevo, M., Shuval, H. I. *Evaluation of Different Methods for the Detection and Concentration of Small Quantities of Viruses in Water.* **In Proceedings of the Fourth Scientific Conference of the Israel Ecological Society, Tel-Aviv, April 1973.**

See: **Fattal, B., Katzenelson, E., Shuval, H. I.** *Comparison of Methods for Isolation of Viruses in Water.* **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), 19–30.

Fattal, B., Katzenelson, E., Shuval, H. I. *Comparison of Methods for Isolation of Viruses in Water.* **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), 19–30.

Five methods for recovering viruses seeded into tap water were compared in parallel: adsorption to aluminum alginate membranes, to cellulose nitrate membranes, to $Al(OH)_3$ precipitate, to gauze pads in a flow-through system, and phase separation. The systems were compared with attenuated poliovirus 1, echovirus 7, and enteroviruses recovered from sewage.

Recovery efficiencies from 5-liter volumes were as follows: For poliovirus 1 – adsorption to aluminum alginate membranes, 202%; to cellulose nitrate membranes, 64%; to $Al(OH)_3$, 185%; phase separation, 100%; to gauze pads, 1%; for echovirus 7 – adsorption to aluminum alginate, 101%; to cellulose nitrate, 22%; to $Al(OH)_3$, 54%; phase separation, 125%; to gauze pads, 0.5%; for an enterovirus from sewage – adsorption to aluminum alginate, 47%; to cellulose nitrate, 15%; to $Al(OH)_3$, 34%; phase separation, 5%.

Apparent recoveries of more than 100% were attributed to probable deaggregation of viral clumps by some of the test procedures.

Fish, H. (1973). *Quality of Public Water Supply.* **EFFL & WATER TREAT J, 13(7)**:420–34.

Within a general discussion of the problems of water supply, the viruses that may be waterborne are briefly discussed.

Foliguet, J. M., Doncoeur, F. (1974). *Removal of Viruses from Water by "Break-Point" Prechlorination.* **WATER RES, 8(9)**:651–7. French.

In a pilot plant study, breakpoint prechlorination at acid pH levels, with rapid mixing, followed by ferric chloride coagulation, flocculation, and rapid sand filtration resulted in inactivation or removal of all of the poliovirus 1 that had been seeded into water. The virus could not be recovered from the treatment sludges.

Gentles, J. C., Evans, E. G. V., Jones, G. R. (1974). *Control of* Tinea pedis *in a Swimming Bath.* **BR MED J, 2(1519)**:577–80.

Randomly selected bathers at a swimming pool were examined for *Tinea pedis* and verruca before and at intervals subsequent to the distribution of individual sachets of foot powder to all bathers.

The incidence of *Tinea pedis* infection decreased from 8.5% to 2.1% over a 3.5-year period. In adult males, the incidence decreased from 21.5% to 6.9%.

The incidence of infection with *Trichophyton mentagrophytes* var. *interdigitale* decreased from 5.3% to 0.5%. The incidences of infection with *T. rubrum* (from 1.2% to 1.1%) and *Epidermophyton floccosum* (from 0.9% to 0.5%) did not change significantly. The incidence of verruca decreased from 4.8% to 1.2%.

The application of the foot powder is believed to have reduced the spread of infection.

Gerba, C. P., Sobsey, M. D., Wallis, C., Melnick, J. L. *Enhancement of Poliovirus Adsorption in Wastewater onto Activated Carbon.* **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), 115–26.

In the presence of organics, poliovirus 1 (LSc) was removed from sewage effluents more efficiently by activated carbon at pH 3.5 to 4.5 than at higher pH levels. Removal of organics by lime coagulation increased subsequent adsorption of the virus to carbon at pH 3.5.

Batch studies indicated that adsorption of the virus to activated carbon in wastewater could be described by a Freundlich isotherm.

In column experiments, the removal of viruses by adsorption to carbon was dependent on column length and on hydraulic loading.

Graeser, H. J. (1974). *Water Reuse: Resource of the Future.* **J AMER WATER WORKS ASSN, 66(10)**:575–8.

In a paper discussing water reuse, experiments are described in which large amounts of poliovirus 1 and coliphage f2 were removed from secondary effluents with alum or lime in an experimental advanced waste treatment plant. Actual data are not presented.

Herrmann, J. E., Kostenbader, K. D., Jr., Cliver, D. O. (1974). *Persistence of Enteroviruses in Lake Water.* **APPL MICROBIOL, 28(5)**:895–6.

Poliovirus 1 and coxsackievirus A9 were inactivated more rapidly in natural lake water than in membrane-filtered lake water.

The poliovirus remained viable for longer than the coxsackievirus did.

The coat proteins of the viruses were degraded and may have been utilized by microorganisms.

Hill, W. F., Jr., Akin, E. W., Benton, W. H., Mayhew, C. J., Jakubowski, W. (1974). *Apparatus for Conditioning Unlimited Quantities of Finished Waters for Enteric Virus Detection.* **APPL MICROBIOL, 27(6)**:1177–8.

A modified version of the water conditioning segment of the Wallis-Melnick virus concentrator is described. The apparatus adjusts pH and cation

concentration of intake waters by dosing chemicals in with a proportioner pump driven by the water flow.

Hill, W. F., Jr., Akin, E. W., Benton, W. H., Mayhew, C. J., Metcalf, T. G. (1974). *Recovery of Poliovirus from Turbid Estuarine Water on Microporous Filters by the Use of Celite.* **APPL MICROBIOL, 27(3)**:506–12.

With turbid waters, the addition of Celite improved the filtration flux through cellulose nitrate (Millipore) and asbestos-fiberglass (Cox) membrane filters.

In laboratory experiments with 200-ml volumes of poliovirus 1-seeded water of controlled turbidity, and under simulated field conditions with 15– to 100-gallon volumes of virus-seeded estuarine water of variable turbidity, the pH of the water was adjusted to 3.5, $AlCl_3$ was added to a final concentration of 0.0005 M, Celite was added to a final concentration of 0.1%, and the mixture was passed through either an HE Cox M-780 microfilter or a cellulose nitrate membrane filter. The virus was eluted from the Celite-filter complex *in situ* at pH 9 with 5X nutrient broth.

In the 200-ml volume experiments, with turbidities adjusted to 5 to 30 JTU, recoveries of virus ranged from 66 to 89%. In the higher volume experiments, when turbidities ranged from 8.5 to 80 JTU, recoveries of viruses ranged from < 1 to 74%, depending upon the initial concentrations of virus and upon the level of turbidity.

Hilleman, M. R., Provost, P. J., Wolanski, B. S., Miller, W. J., Ittensohn, O. L., McAleer, W. J. *Characterization of CR326 Human Hepatitis A Virus, A Probable Enterovirus.* **In Proceedings of International Association of Biological Standardization (IABS), Symposium on Viral Hepatitis, Milan, Italy, December 1974.**

CR326, a virus recovered in marmosets from a Costa Rican child ill with hepatitis, was found to be 27 nm in diameter and acid stable.

In sections of infected marmoset liver, viral particles were seen in the cytoplasm but not in the nucleus. CR326 stained orange-red with acridine orange and its infectivity was reduced by pancreatic RNase indicating that its nucleic acid is an RNA.

The virus, highly infectious for marmosets, was neutralized by convalescent serums from patients at Willowbrook with hepatitis A but not by their acute phase serums.

Thus, CR326 appears to be an enterovirus and an etiological agent of hepatitis A.

Horst, H. (1974). *Isolation of Hepatitis-B-Antigen from Water and Sewage by Means of Immuno-Adsorption in a Continuous Flow Procedure.* **ZBL BAKT HYG, 158(6)**:578–82. German.

Hepatitis B antigen was recovered from two of nine sewage-contaminated surface waters.

Recoveries were achieved with a continuous flow immunoadsorption technic on antibody-coated Sepharose 4B. The antigen was eluted in a glycine-HCl buffer at pH 1.8 and corroborated by agar gel diffusion assay.

Jakubowski, W. J., Hoff, J. C., Anthony, N. C., Hill, W. F., Jr. (1974). *Epoxy-Fiberglass Adsorbent for Concentrating Viruses from Large Volumes of Potable Water.* **APPL MICROBIOL, 28(3)**:501–2.

Recoveries of 42 to 57% of poliovirus 1 from 100-gallon quantities of tap water seeded with small amounts of the virus were achieved with a modified Wallis-Melnick virus concentrator.

The concentrator consisted of two or three epoxy-fiberglass filters (Balston Co.), with nominal porosities of 8μm, arranged in parallel. The pH of the tap water was adjusted to 3.5 with HCl.

The viruses were eluted from the filters in glycine at pH 11.5, reconcentrated by adsorption to epoxy-fiberglass disk filters (Cox) at pH 3.5 in the presence of $AlCl_3$, and eluted again.

Kalter, S. S., Millstein, C. H. *Efficacy of Methods for the Detection of Viruses in Treated and Untreated Sewage.* **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), 33–44.

In comparative studies, PE60, $Al(OH)_3$, Celite, Kaolin, activated carbon, talcum powder (Talc, U.S.P.), and Sephadex A-25, sandwiched between two filter pads, were tested for their ability to adsorb viruses from water. PE60 was more effective than talcum powder and talcum powder was more effective than any of the other adsorbents.

Viruses were eluted from adsorbents more efficiently with 10% calf serum in 0.05 M barbital buffer and with 2% casein in 0.05 M Tris-HCl buffer than with 10% calf serum in 0.05 M borate-saline.

Enteroviruses were recovered from seeded waters more readily than herpesviruses 1 and 2, Newcastle disease virus, and vaccinia virus.

Katzenelson, E., Kletter, B., Shuval, H. I. (1974). *Inactivation Kinetics of Viruses and Bacteria in Water by Use of Ozone.* **J AMER WATER WORKS ASSN, 66(12)**:725–29.

Ozone, at concentrations from 0.2 to 1.0 mg/liter, destroyed 99.5 to 99.9% of poliovirus 1 in 40 seconds at 5 C. Data with lesser concentrations of

ozone were equivocal. Concentrations of ozone greater than 1 mg/liter did not appear to appreciably increase the rate of inactivation.

At 1 C, 0.09 mg/liter of O_3 inactivated 99.9% of coliphage T2, and 0.07 mg/liter of O_3 inactivated 99.9% of *Escherichia coli* in 10 seconds.

All death rate curves were characterized by rapid initial die-offs followed by long tailings.

Virus preparations stored at –20 C appeared to be more resistant to ozone than preparations stored at –70 C. Aggregation of viruses at –20 C may have been responsible for the apparent differences in resistance.

Redox potentials increased rapidly at ozone concentrations from 0.05 to 0.2 mg/liter and then increased very slowly as ozone concentrations increased beyond the latter level.

Kenard, R. P., Valentine, R. S. (1974). *Rapid Determination of the Presence of Enteric Bacteria in Water.* **APPL MICROBIOL, 27(3)**:484–7.

A high degree of correlation between fecal coliforms and coliphage occurred in more than 150 water samples taken over a period of several years from several different geographical areas.

With such high correlations between fecal coliform and coliphage counts, fecal coliform counts are predictable from the phage counts.

When large numbers of sensitive bacteria were added to test waters, virulent phage could be demonstrated in six to eight hours.

Konowalchuk, J., Speirs, J. I., Pontefract, R. D., Bergeron, G. (1974). *Concentration of Enteric Viruses from Water with Lettuce Extract.* **APPL MICROBIOL, 28(4)**:717–9.

Enteroviruses, adenoviruses, and reoviruses were recovered from water with lettuce extract.

Lettuce extract at pH 8.5 was added to samples and the pHs were reduced to 4.0 to 4.5. with hydrochloric acid. The flocculent lettuce extract particles and the adsorbed viruses were readily removed from suspension by low-speed centrifugation.

Electron microscopy suggested that, under conditions suitable for adsorption, virus particles were coated with the lettuce extract colloid.

Kott, Y., Roze, N., Sperber, S., Betzer, N. (1974). *Bacteriophages as Viral Pollution Indicators.* **WATER RES, 8(3)**:165–71.

Ratios of coliphages to human enteric viruses in flood waters ranged from 1:1 to 10^3:1; in wastewaters in different seasons the ratio was 10^5:1; in trickling filter effluents the ratios were 10^4:1 in winter, 10^5:1 in spring, and

10^4:1 in summer and fall; in oxidation pond effluents the ratios were 10^3:1 in winter, 10^4:1 in spring, and 10^3:1 in summer and fall.

Both coliphages and enteric viruses were found in water supplies where treatment procedures had broken down.

In oxidation pond effluents coliphages were at least as resistant to chlorine as human enteric viruses.

Poliovirus 1 (LSc) and coliphage f2, introduced daily into a 350-liter experimental oxidation pond, did not decrease in numbers.

Kretschmer, E. (1972). *Water and Sewage as Transmission Factors in Viral Hepatitis.* **Z ARZTL FORTBILD, 66(10)**:1065–70. German.

This paper was listed in the 1973 edition of these abstracts. A translation was not then available.

An outbreak of hepatitis A in 1968 in Langenau (Germany) is described in which food, contaminated with sewage during heavy rains and floods, is believed to have been the transmitting vehicle.

Kutsar, K. K. (1973). *Certain Principles Governing the Distribution of Enteroviruses in Sewage.* **GIG SANIT, 38(11)**: 102–3. Russian.

Viruses were recovered from sewage in the Estonian SSR during a survey that started in 1967 and ended in 1971. Viruses began to appear in sewage during March and increased in numbers during the springs when they were recovered from 32% of the samples taken. Recoveries were made from more than 33% of the samples taken during the summers. Viruses were recovered from more than 52% of the samples in September. No recoveries were made in January or February.

Viruses were not recovered from sewage contaminated with industrial wastes.

Different viruses were predominant in sewage in different years. Polioviruses were rarely recovered during the entire study period.

The incidences of virus recoveries did not correlate with the occurrences of diseases in the source areas, but did correlate with the occurrences of infections in children.

Laveran, H., Beytout, D., Cluzel, R., Joly, B., Herail, M. (1974). *Demonstrating Human Enteric Viruses in Waste Waters. Comparison of Three Methods of Virus Concentration.* **MED MAL INFECT, 4(2)**:69–78. French.

Viruses were recovered from the influents and from the unchlorinated effluents of an activated sludge plant by direct inoculation of influent and effluent, the $AlPO_4$ precipitate method, the insoluble polyelectrolyte (PE60)

method, and the alginate filtration method. In the concentration methods, 250-ml volumes of sewage were processed.

Viruses were recovered from eight influent samples by the alginate filter method, from seven samples by the PE60 method, from six samples by the $AlPO_4$ method, and from two samples by the direct inoculation technic.

Viruses were recovered from 10 effluent samples by the alginate filter method, from six samples by the PE60 method, from two samples by the $AlPO_4$ method, and from none of the samples by the direct inoculation method.

More recoveries were achieved in primary monkey kidney cells (*Papio papio*) than in Vero cells. Few recoveries were made in suckling mice.

The tube assay technic was more sensitive than the plaque technic.

Lefler, E., Kott, Y. *Virus Retention and Survival in Sand.* **In "Virus Survival in Water and Wastewater Systems," J. F. Malina, Jr. and B. P. Sagik. Center for Research in Water Resources, The University of Texas, Austin** (1974), 84–91.

In the presence of the bivalent cations Ca^{++}, or Mg^{++} (0.01 N), poliovirus 1 (LSc) and coliphage f2 were retained in the upper part of a 10-cm deep sand column. Na^{+}, at a concentration of 0.5 N, affected little retention of the viruses.

Survival experiments showed that the poliovirus may survive in sand for about 90 days at room temperatures and for more than 175 days at 4 to 8 C.

Longley, K. E., Olivieri, V. P., Kruse, C. W., Kawata, K. *Enhancement of Terminal Disinfection of a Wastewater Treatment System.* **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), 166–79.

Coliphage f2, seeded into secondary effluents, was inactivated by chlorine much more rapidly at pH 3 than at pH 6.8. The more rapid inactivation rates at the lower pH were attributed to the slower chloramine formation at that pH and thereby to a prolonged availability of HOCl.

The rates of inactivation by chlorine of viruses and bacteria in secondary effluents were increased considerably by rapid mixing which presumedly increased the numbers of HOCl-microbe contacts before the HOCl was consumed in chloramine formation.

Although dose-response with ozone was erratic in secondary effluents, ozone, on a weight basis, appeared to inactivate coliphage f2 more rapidly than chlorine did. However, at applied doses of 6.7 and 8.7 mg/liter, ozone appeared to inactivate relatively few coliforms in these effluents.

Lovtsevich, E. L. (1973). *Inactivation of Enteroviruses with Chlorine.* **GIG SANIT, 38(11):**11–15. Russian.

A poliovirus, inactivated in the course of water chlorination, could not be reactivated.

The residual chlorine in the water of a distribution system did not inactivate viruses introduced into the water with secondary contamination.

Inactivation of viruses by chlorine was not exponential with the time. A part of the virus population (0.5 to 1 %) that appeared resistant to chlorine was not genetically homogeneous and did not consist of biologically active RNA. The apparently resistant fraction probably constituted aggregations of virus particles.

Mahoney, P., Fleischner, G., Millman, I., London, W. T., Blumberg, B. S., Arias, I. M. (1974). *Australia Antigen: Detection and Transmission in Shellfish.* **SCIENCE, 183(4120)**:80–1.

Australia antigen was found in clams contaminated by drainage of untreated sewage from a coastal hospital.

In closed-system aquariums, Australia antigen was ingested by clams and transmitted to uninfected clams. In open-system aquariums, the quantity of Australia antigen decreased with time, suggesting viral concentration rather than replication.

Majumdar, S. B., Ceckler, W. H., Sproul, O. J. (1974). *Inactivation of Poliovirus in Water by Ozonation.* **J WATER POLLUT CONTRL FED, 46(8)**:2048–55.

The original paper with this title appeared in the 1973 edition of these abstracts. (J WATER POLLUT CONTRL FED, 45, 2433, 1973.) *However, important errors were made in the* Discussion and Results *section. The current reference contains a corrected version of this section.*

Malina, J. F., Jr. (1973). *Application of Oxygen to Treat Waste from Military Field Installations.* **Technical Report CRWR-99, University of Texas at Austin, 82 pages.**

Four laboratory-scale waste stabilization pond systems were operated in parallel at organic loadings of 60 to 250 lb BOD/day/acre. Municipal wastewater and methanol were used as influents.

In the pond operating at a loading of 250 lb BOD/day/acre, 98% BOD, 93% COD, 84% TOD, and 80% TOC were removed. In this pond, 88% of the coliphage, 94% of the animal viruses and $>98\%$ of the total coliforms, fecal coliforms, and fecal streptococci were removed.

The introduction of oxygen into this waste stabilization pond system increased the efficiency of removal of BOD, COD, TOD, and TOC to about 99%, 95%, 89%, and 90%, respectively. All of the enteric viruses in the effluents of the pond systems apparently were inactivated by a chlorine residual of 0.5 mg/liter after 30 minutes of contact.

Malina, J. F., Jr., Ranganathan, K. R., Moore, B. E. D., Sagik, B. P. *Poliovirus Inactivation by Activated Sludge.* **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), 95–106.

Tritium-labeled poliovirus 1 (Mahoney) adsorbed to the solids in the mixed liquor of batch-type, activated sludge units almost immediately; 95% of the labeled virus was associated with the sludge solids after 10 minutes of contact.

The level of radioactivity in the sludge remained essentially unchanged subsequently during 15 hours of aeration. The infectivity of the poliovirus in the supernatant decreased rapidly during this 15-hour aeration period to a concentration 0.1% of the initial level. However, infectivity of the poliovirus in the sludge was lost at a much slower rate.

After the 15-hour aeration period, almost all of the radioactivity was recovered from the sludge solids. About 20% of the infectivity was recovered at the same time.

Markov, A. P. (1972). *Experience in the Sanitary-Virological Examination of Waste Waters.* **GIG SANIT, 37(2)**:94–5. Russian.

This paper was listed in the 1972 edition of these abstracts. A translation was not then available.

From 8 to 20% fewer viruses were recovered by the gauze pad method from several hundred sewage samples when bacteria and fungi were controlled with ether than when they were controlled with penicillin and streptomycin.

In Orel, Russia from 1968 through 1970, along with the polioviruses, echoviruses 6 and 7 were the viruses recovered from sewage most frequently, especially during the first two years. Echoviruses 11, 12, 13, 19, and 29, and coxsackieviruses B1, B3, and B5 were also recovered during this study.

Mazur, B., Paciorkiewicz, W. (1974). *The Role of Vegetables in Dissemination of Enteroviruses. I. The Presence of Poliovirus in Overground Parts of Plants Cultivated on Soil Containing the Virus.* **ACTA MICROBIOL POL (A), 6(23)**:144. Polish.

In 123 experiments with 13 plant species cultivated on soil to which a poliovirus had been added, the virus was detected in overground green parts of the plants seven times (5.7%), in ground parts 50 times (40.7%), and in upper parts of the roots, which passed from the ground through an air layer to the vessel with virus-laden water, 108 times (87.9%).

Ten percent of the soil samples taken close to the virus-bearing water source yielded viruses.

McDermott, J. H. (1974). *Virus Problems and Their Relation to Water Supplies.* **J AMER WATER WORKS ASSN, 66(12)**:693–8.

The inadequacy of methods for sampling, detecting, enumerating, and identifying viruses in water samples is a most important gap in current technology. Once this gap is filled, the epidemiologist will be able to assess the threat posed by viruses in water, and process engineers will be able to improve the performance of unit processes, singularly, and in alternative treatment trains.

Mendzhul, M. I., Lysenko, T. G., Bobrovnik, S. A., Spivak, N. Y. (1973). *Detection of the A-1 Virus of Blue Green Alga* Anabaena variabilis *in the Kremenchug Reservoir.* **MIKROBIOL ZH, 35(6)**:747–51. Ukranian.

Cyanophage A-1 was recovered from the Kremenchug reservoir. This phage had a hexagonal head with a diameter of 55 to 60 nm and a short appendage 20 nm long attached to one of its capsomeres. The appendage did not contain a base plate or fibers.

Of the 51 green and blue-green alga tested, the cyanophage lysed only the filamentous blue-green algae *Anabaena variabilis* 458. The latent period for the virus was four hours; the yield per cell was approximately 70 virions. The virus was inactivated at 58 C in one hour and was stable over a pH range of 4 to 12. Cyanophage A-1 is not related serologically to the LPP-1 virus.

Mendzhul, M. I., Zhigir, V. V., Bobrovnik, S. A., Lysenko, T. G. (1974). *Identification of LPP-1 Viruses Recovered from Dnieper Reservoirs.* **MICROBIOL ZH, 36(1)**:47–53. Ukrainian.

Four strains of LPP-1 virus recovered from Dnieper reservoirs differed from each other in morphology, rate of inactivation with specific antiserum, rate of virion adsorption onto host-cells, sensitivity to sodium citrate, pH-stability, and rate of temperature inactivation.

Metcalf, T. G., Wallis, C., Melnick, J. L. (1974). *Environmental Factors Influencing Isolation of Enteroviruses from Polluted Surface Waters.* **APPL MICROBIOL, 27(5)**:920–6.

The recovery of viruses from saline waters with the Wallis and Melnick virus concentrator was influenced by the qualities of the waters tested.

The addition of salts to ocean waters increased adsorption of viruses to adsorbing filters despite the saline nature of such waters. $AlCl_3$ was superior to $MgCl_2$ for this purpose.

Textile filters made of orlon, polypropylene, and polyester were poor virus adsorbents and thus, useful clarifying filters. Fiberglass and cellulose ester

filters were good virus adsorbents. Viscose, cotton, and dynel were not sufficiently adsorbent or non-adsorbent to be useful for either purpose.

Viruses were adsorbed to filters at pH 3.5 and eluted in glycine buffer at pH 11.5. These pH levels were not destructive to poliovirus 1 after 10 minutes of exposure, but losses of 5 and 10% of the virus occurred after 20 minutes and 30 minutes of exposure, respectively.

Treatment of eluted virus suspensions with a cationic resin (C-249, Na^+ charged, Ionic Corp.) removed substances that interfered with virus adsorption to membranes and increased the recoveries of viruses during a reconcentration process designed to reduce the final volume of the virus concentrates.

Metcalf, T. G., Wallis, C., Melnick, J. L. *Virus Enumeration and Public Health Assessments in Polluted Surface Water Contributing to Transmission of Virus in Nature.* **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), 57–70.

Nine potentially pathogenic enteroviruses were recovered from the effluents of two Houston waste treatment plants. The total daily discharge of viruses from these plants was about 1.7×10^9 PFU.

Poliovirus 1 with d^+t^+ virulence markers were recovered from oysters lying in Galveston Bay waters polluted by Houston Ship Channel discharges. The shellfish waters were of acceptable sanitary quality according to fecal coliform indices.

The possibility of virus transmission via waterborne particulate matter was suggested by the recovery of 19 strains of five different enteroviruses from a total of 13 mud samples collected from the bottom of the ship channel.

Mix, T. W. *The Physical Chemistry of Membrane-Virus Interaction.* **In "Developments in Industrial Microbiology," Vol. 15. In the Symposium: Detection of Viruses in Waste and Other Waters, August 1973, Convenor G. Berg. Proceedings of the Thirtieth General Meeting of the Society for Industrial Microbiology. American Institute of Biological Sciences, Washington, D. C.** (1974), 136–42.

The structure and properties of different types of membranes are reviewed, as is the management of flow in the utilization of the membranes. The surface adsorption characteristics of membranes are analyzed in relation to their use for concentrating viruses.

This paper represents a major effort to identify the characteristics of membrane and virus surfaces that are critical in the adsorption and elution processes.

Moore, B. (1974). *Scientific Services in the Water Industry: Public Health Aspects.* **WATER TREAT & EXAM, 23(3):** 269–74.

In a broad discussion of waterborne disease transmission, argument is made that the presence of viruses (with the possible exception of hepatitis A virus) in a raw water source does not necessarily constitute a threat to the public health.

Moore, B. E. D., Funderburg, L., Sagik, B. P., Malina, J. F., Jr. *Application of Viral Concentration Techniques to Field Sampling.* **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), 3–15.

Enteroviruses adsorbed rapidly to the mixed liquor, suspended solids in sewage. Large numbers of viruses were recovered from the sludge, indicating slow inactivation after initial adsorption. Under normal operating conditions where the designed plant capacity was not exceeded, the contact-stabilization process removed 91 to 97% of the viruses present in raw wastewaters.

Poliovirus 1 was concentrated from waters by the bentonite, PE60, and Lyphogel methods. Bentonite (with 0.01M Ca^{++}) was most effective in deionized water (77% recovery); Lyphogel was least effective. In wastewater, similar results were obtained, the bentonite method recovering 48% of the virus.

Lyphogel, with an elution procedure involving the release of viruses from solids by dounce homogenization, was most effective for recovering seeded poliovirus from mixed liquor, suspended solids in sewage (27% recovery).

Nikiforov, V. N., Paltseva, T. F., Skavinskiy, Y. V., Gulman, L. A., Shilenok, I. G., Starosotskaya, T. Y. (1974). *A Waterborne Outbreak of Infectious Hepatitis.* **SOV MED, 37(9):**101–5. Russian.

A waterborne outbreak of hepatitis A occurred in two schools during March and April 1972 after the schools' water supplies were contaminated with sewage from a broken sewer line. An outbreak of gastrointestinal illness of unknown etiology preceeded the hepatitis outbreak in one of the schools.

The highest incidence of illness occurred among students in the lower grades. The incidence was lowest in teachers (adults).

The incidence of disease abated quickly after the broken sewer line was repaired, the water supplies to the schools were shut off, and a general gamma globulin prophylaxis program was instituted.

Nikolayevskaya, Z. S., Ayzen, M. S. (1974). *Increasing the Effectiveness of the Direct Detection of Viruses in Open Reservoirs by Ultrafiltration through Soluble Ultrafilters.* **GIG SANIT, 39(4):** 68–70. Russian.

Poliovirus 1 was recovered consistently, by ultrafiltration through alginate membranes, from 1-liter quantities of sewage effluent and from 3-liter

quantities of reservoir water after those waters were seeded at levels of 0.1 TCD_{50}/ml. In two of three tests, the virus was recovered after it had been seeded at a level of 0.01 TCD_{50}/ml.

The gauze pad technic was much less sensitive in similar tests.

Nupen, E. M., Bateman, B. W., McKenny, N. C. *The Reduction of Virus by the Various Unit Processes Used in the Reclamation of Sewage to Potable Waters.* **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), 107–14.

Large reductions in seeded poliovirus 2 (P 712) concentrations were achieved with unit processes used to reclaim municipal wastewaters.

Treatment with excess lime reduced the concentration of seeded virus by 4 to 5 logs. Stabilization followed by secondary settling after the addition of powdered carbon, ferric chloride, and a polyelectrolyte reduced the virus concentration by 5 logs. Subsequent chlorination reduced the virus concentration by at least 7 logs.

A combination of these process units should achieve a reduction in virus concentration of at least 16 logs and should produce a final water safe for potable use.

Opacic, S., Markic, D. (1974). *Epidemic of Virus Hepatitis at Vrhnika in 1971–1972. I. Epidemiological Analysis.* **ZDRAV VESTN, 43(1)**:15–7. Yugoslavian.

A waterborne epidemic of hepatitis A began in November 1971 and lasted until the end of February 1972 in Vrhnika, Yugoslavia. Ten percent of the community, supplied with drinking water from the aqueduct of Vrhnika, suffered icteric disease. Among those who did not use aqueduct water, including army personnel, the attack rate was only 1.2%.

Palfi, A. (1974). *Effectiveness of Virus-Inactivation of Different Methods of Effluent Treatment.* **Z BAKT ORIG A, 227(1–4)**:389–91. **Translation presently not available.** German.

Paver, W. K., Ashley, C. R., Caul, E. O., Clarke, S. K. R. (1973). *A Small Virus in Human Faeces.* **LANCET, 1(7797)**:237–40.

Clumps of spherical virus-like particles, 22 nm in diameter, some empty, were seen in the feces of two people with gastroenteritis and three people without gastroenteritis. The clumps were seen after the fecal extracts had been incubated with human serum.

It is suggested that these particles may be a new human parvovirus.

Pavoni, J. L., Tittlebaum, M. E. *Virus Inactivation in Secondary Wastewater Treatment Plant Effluent Using Ozone.* **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), 180–97.

Coliphage f2, seeded into sewage effluent, was inactivated within five minutes by an applied ozone dose of about 15 mg/liter (residual ozone – 0.015 mg/liter). The coliphage was inactivated more rapidly than *Escherichia coli.*

In distilled water, 10^9 f2 coliphage and more than 10^6 *E. coli* were inactivated in 15 seconds by 15 mg/liter of applied ozone.

Peterson, M. L. (1974). *Soiled Disposable Diapers: A Potential Source of Viruses.* **AMER J PUBLIC HEALTH, 64(9)**:912–14.

Viruses were recovered from 9 of 84 fecally-contaminated disposable diapers separated out of municipal solid wastes. Seven of the diapers contained poliovirus 3 and two contained echovirus 2. Virus densities ranged from 16 to 1,920 PFU/gm of feces.

T and d marker tests suggested that some of the polioviruses may have been neurovirulent.

Petrilli, F. L., Crovari, P., De Flora, S., Vannucci, A. (1974). *The Virological Monitoring of Water. I. Drinking Water.* **BOLL IST SIEROTER MILAN, 53(3)**:434–42.

Enteroviruses were recovered from spring water that contained 35 *Escherichia coli* and 14 fecal streptococci/100 ml of water, and from the same water after chlorination when neither coliforms nor fecal streptococci were recovered.

In an experimental treatment plant, viruses were recovered from heavily polluted prechlorinated (3 ppm ClO_2, 45 minutes; 10 ppm Cl_2 gas, 10 minutes) raw water that contained 2,220 total coliforms, 220 *E. coli*, and 250 fecal streptococci/100 ml of water, and from the same waters after coagulation with ferric chloride, sedimentation, filtration through activated carbon or sand, and terminal chlorination (2 ppm ClO_2, 10 minutes; 0.2 ppm free residual chlorine) when coliforms and fecal streptococci could no longer be recovered from 500-ml volumes of the water.

Viruses were recovered by the insoluble polyelectrolyte (PE60) technic. Bacteriological tests were done by Standard Methods.

Rabyshko, E. V. (1974). *The Recovery of Enteroviruses from Environmental Waters.* **GIG SANIT, 39(4)**:105–6. Russian.

Viruses were recovered from 9 of 64 7- to 10-liter samples of tap water by filtration of the water through an anion exchange resin (Anionite EDE-10P).

Four strains of coxsackievirus B3, two other type B coxsackieviruses, three echoviruses, two polioviruses, and one strain of coxsackievirus A9 were recovered. In six instances, viruses recovered from tap water in the distribution system were of the same type as those recovered concurrently from Volga River water collected near the intake of the plant that treated the water. The water treatment plant and its chlorinators functioned normally during the periods when viruses were recovered.

From 1968 to 1971, viruses were recovered by the gauze pad method from 41% of municipal sewage samples that contained industrial wastes. Of the viruses recovered, 146 were echoviruses, 37 were coxsackievirus B, 27 were polioviruses, 13 were coxsackievirus A9, and 6 were untyped. Most of the viruses were recovered in 1970. Echoviruses 11, 16, and 19 and coxsackievirus B3 were the most common types recovered in this sewage study.

Enteroviruses were recovered from 15% of the Volga River water samples (5-liter) studied during this same period. Fifty-nine strains of viruses were recovered. Coxsackievirus B3 and poliovirus 1 were the predominant types recovered from river water.

Radsel-Medvescek, A., Marolt-Gomiscek, M. Bufon-Luznik, T. (1974). *An Outbreak of Infectious Hepatitis in Vrhnika. II. Evaluation of Clinical Data.* **ZDRAV VESTN, 43(1)**:19–21. Yugoslavian.

A waterborne epidemic of hepatitis A broke out in Vrhnika, Yugoslavia in November 1971. The course of the disease was mild and there were no fatalities. Of 767 individuals affected, 308 were hospitalized. The clinical and laboratory data relating to some of these individuals are presented.

Rosen, H. M., Lowther, F. E., Clark, R. G. (1974). *Get Ready for Ozone.* **WATER & WASTES ENGIN, 11(7)**:25–31.

In a discussion on ozone disinfection that covers equipment design, cost, and various disinfection data, some data on bacterial virus inactivation by ozone, presented in greater detail elsewhere (See Wolf, H. W., *et al., Virus Inactivation During Tertiary Treatment* in this edition of these abstracts.) are included.

Rowland, A. J. (1972). *The Epidemiology of Infectious Hepatitis.* **PUBLIC HEALTH, LOND, 87(1–2)**:25–32.

Water transmission and shellfish transmission are discussed briefly within the framework of a general dissertation on the epidemiology of hepatitis A.

Ruschi, A., Spaziante, G. (1972). *Occurrence and Significance of Adenoviruses in Various Materials.* **BOLL IST SIEROTER MILAN, 51(4)**:249–56. Italian.

In a 10-year period (1962–1971), adenoviruses were recovered, by homogenization of tissues with Freon 113, from 31% of the tonsils studied. Only 6% of the tonsils yielded viruses with the explant technic.

Adenoviruses were recovered also from 2% of the fecal samples studied, but never from drain or surface waters, or from mussels.

Sadovski, A., Fattal, B., Katzenelson, E. *Evaluation of Methods for a Quantitative Estimation of Microbial Contamination of Sewage Irrigated Vegetables.* **In Proceedings of the Fifth Scientific Conference of the Israel Ecological Society, Tel-Aviv, May 1974.**

When cucumbers or eggplants were contaminated with sewage effluents seeded with 10^3 PFU of attenuated poliovirus 1/ml, 95% of the viruses were recovered by two washings (under agitation) with phosphate-buffered saline at slightly alkaline pH levels. Almost 99% of the viruses were recovered with four washings.

To attain similar recoveries of fecal and total coliforms one more washing was required.

The multiple tube fermentation technic yielded higher total coliform counts than the membrane filter (MF) method did. Large numbers of non-coliform organisms were present in the samples.

Sattar, S. A., Ramia, S., Westwood, J. C. N. (1974). *Removal and Inactivation of Poliovirus During Lime (Calcium Hydroxide) Treatment of Sewage.* **IRCS (Res. on: Biomed. Technol.; Microbiol., Parasitol. and Infect. Dis.; Social and Occupat. Med.), 2**:1635.

Lime, in an amount sufficient to achieve a pH of 11.5, reduced the concentration of seeded poliovirus 1 (LSc) in domestic sewage by 99.99 to 99.999%.

Significant numbers of viruses were recovered from the sludge by elution with 10% fetal calf serum at pH 7.2.

Viruses were not recovered from the lime-treated effluent.

Sattar, S. A., Westwood, J. C. N. (1974). *Talc-celite Layers in the Recovery of Poliovirus from Experimentally-contaminated Samples of Surface and Waste Waters.* **IRCS (Res. on: Biomed. Technol.; Microbiol., Parasitol. and Infect. Dis.), 2**:1432.

In parallel studies, poliovirus 1 (LSc) seeded into sewage or canal water was adsorbed to either talc-Celite or to the polyelectrolyte PE60 and eluted with 10% fetal calf serum in saline (pH 7.2).

About 78% of the virus seeded into canal water was recovered on the talc-Celite and about 82% was recovered on PE60. About 68% of the virus seeded into sewage was recovered on talc-Celite, and about 76% was recovered on PE60.

Scarpino, P. V., Lucas, M., Dahling, D. R., Berg, G., Chang, S. L. *Effectiveness of Hypochlorous Acid and Hypochlorite Ion in Destruction of Viruses and Bacteria.* **In "Chemistry of Water Supply, Treatment, and Distribution," Chapter 15, edited by A. J. Rubin. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan** (1974), 359–68.

In kinetic studies at 5 C, poliovirus 1 and coxsackievirus A9 were 13 times more resistant to HOCl than coliphages f2 and MS2, about 40 times more resistant than *Escherichia coli*, and about 135 times more resistant than coliphage T5. The slopes of concentration-time van't Hoff plots for these organisms approximated one, but the slope for coliphage T2 was only 0.3 making such comparisons for this phage with the other organisms difficult.

E. coli was more resistant to chlorine than any of the viruses at high pH levels where OCl^- is supposed to predominate. *E. coli* was 1.4 times more resistant than coxsackievirus A9, about twice as resistant as poliovirus 1, about 8 times as resistant as coliphage T5 and about 10 times as resistant as coliphage f2. The slopes of concentration-time van't Hoff plots for the inactivation reactions were about one for all of the organisms studied except for coliphage MS2.

The relatively rapid destruction of viruses at high pH levels by chlorine is anomalous, in contradiction to previously published data, and is not presently explainable.

The usefulness of coliforms as indicators of viruses in chlorinated waters, however, is doubtful in any event.

Schaub, S. A., Sorber, C. A., Taylor, G. W. *The Association of Enteric Viruses with Natural Turbidity in the Aquatic Environment.* **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), 71–83.

Enteroviruses adsorbed rapidly to bentonite clay and to natural suspended solids in deionized distilled water, wastewater, and natural water. The quantity of adsorption increased with greater concentrations of solids and increased even more in the presence of bivalent metal cations (10^{-2} to 10^{-3} M). The virus-solids association was stable over prolonged periods.

Waters in which adsorption to solids was poor eluted virions from solids in highly adsorptive waters.

Virions adsorbed to clay infected animals by the intracerebral and oral routes. The dose response was comparable to that obtained with unadsorbed virions.

Shirobokov, V. P. (1974). *Concentration and Purification of Enteroviruses with Bentonite.* **VOPR VIRUSOL, 2**:228–33. Russian.

A convenient and effective method was developed for the concentration of coxsackieviruses B1 and B6 with bentonite. The method consisted of adsorbing the viruses onto the bentonite at acid pH and then eluting them from the adsorbent in alkaline solutions of low ionic strength.

Singh, P. K. (1974). *Isolation and Characterization of a New Virus Infecting the Blue-Green Alga* Plectonema boryanum. ***VIROLOGY, 58(4)**:586–8.*

The first isolation of a long, contractile-tailed virus that infects *Plectonema boryanum* is reported. The virus has the shortest latent period of the known blue-green algae viruses.

Sklarow, S. S., Colwell, R. R., Chapman, G. B., Zane, S. F. (1973). *Characteristics of a* Vibrio parahaemolyticus *Bacteriophage Isolated from Atlantic Coast Sediment.* **CAN J MICROBIOL, 19(12)**:1519–20.

A DNA-containing bacteriophage morphologically similar to the T phages and specific for *Vibrio parahaemolyticus*, was recovered from sediments collected along the Atlantic coast.

Sobsey, M. D., Wallis, C., Melnick, J. L. (1974). *Chemical Disinfection of Holding-Tank Sewage.* **APPL MICROBIOL, 28(5)**:861–6.

The virucidal effectiveness and bactericidal effectiveness of formaldehyde, benzalkonium chloride, cetylpyridinium chloride, and methylene blue in holding tank sewage were much greater at pH 10.5 than at pH 8.0.

With formaldehyde or benzalkonium chloride concentrations of 100 mg/liter or more at a pH of 10.5, effective disinfection was achieved over 10-day holding periods even when fresh sewage was added daily. Calcium hypochlorite, zinc sulfate, and phenol were relatively ineffective disinfectants for holding-tank sewage.

Sobsey, M. D., Wallis, C., Melnick, J. L. (1974). *Development of Methods for Detecting Viruses in Solid Waste Landfill Leachates.* **APPL MICROBIOL, 28(2)**:232–8.

A poliovirus added to a solid waste landfill leachate apparently adsorbed to leachate particulates and was not readily detectable. Recovery of masked viruses was achieved by adding sodium (tetra)ethylenediaminetetraacetate (versene) to the leachate (final concentration 0.1 M) clarifying the leachate by filtration at pH 8.0, removing interfering anionic materials (which prevented

virus adsorption to epoxy-fiber glass filters) by adsorption on an anion-exchange resin, and concentrating the viruses by adjusting the leachate to pH 3.5, adding $AlCl_3$ to a final 0.005 M concentration, and adsorbing the viruses to an epoxy-fiber glass virus adsorbent.

The adsorbed viruses were recovered in a small volume of elutant. Concentrating clarified leachates 100-fold resulted in an average virus recovery efficiency of 37%.

Sorber, C. A., Schaub, S. A., Bausum, H. T. *An Assessment of a Potential Virus Hazard Associated with Spray Irrigation of Domestic Wastewaters.* **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), 241–52.

Through dispersion modeling, concentrations of viruses downwind of a spray irrigation site were predicted as a function of virus concentration at the source, effectiveness of wastewater treatment, effects of aerosolization, and various meteorological conditions.

The argument is made that it is impractical to rely upon buffer zones or upon optimum meteorological conditions for minimizing the quantities of airborne viruses downwind of spray irrigation sites. Under most operating conditions, removal of viruses by treatment of effluents appears to be the most effective means for preventing dispersion of viruses downwind of such sites.

Sweet, B. H., Ellender, R. D., Leong, J. K. L. (1974). *Recovery and Removal of Viruses from Water-Utilizing Membrane Techniques.* **In "Developments in Industrial Microbiology," Vol. 15. In the Symposium: Detection of Viruses in Waste and Other Waters, August 1973, Convener, G. Berg. Proceedings of the Thirtieth General Meeting of the Society for Industrial Microbiology. American Institute of Biological Sciences, Washington, D. C.** (1974), 143–59.

There are two basic concepts and technics of membrane filtration that apply to concentration, detection, and removal of viruses from waters of different sources.

The membrane-adsorption-elution technic depends on adsorption of viruses to a matrix of insoluble cellulosic filters under controlled conditions of cations and pH and subsequent elution of the viruses into a small volume of fluid for assay. This method has been developed to the point where viruses in 300 gallons of water can be concentrated into 10 to 20 ml with the reported recovery of one infectious viral unit originally present in 3 to 5 gallons of water.

The ultra or hyperfiltration technic depends on the use of a new generation of thin-skinned (anisotropic) membranes of specific pore sizes and molecular weight cutoffs that exhibit rapid water transport properties. In contrast to the membrane adsorption-elution method, the ultrafiltration technic

depends on viral concentration by rapid dehydration across the membrane with the viruses retained in suspension in small volumes of the remaining fluid. Adsorption is prevented by rapid horizontal flow rates and laminar-flow channelized arrangements with the apparatus used.

No one method is ideal presently for water sources of all qualities or for all viruses. Inherent problems of viral instability, aggregation, adsorption to suspended matter in water, and problems in virus assay still await solution.

Taylor, D. G., Johnson, J. D. *Kinetics of Viral Inactivation by Bromine.* **In "Chemistry of Water Supply, Treatment, and Distribution," Chapter 16, edited by A. J. Rubin. Ann Arbor Science Publishers Inc., Ann Arbor, Michigan.** (1974), 369–408.

Five logs of viral inactivation (99.999%) were achieved in 1.2 minutes at pH 4.5 and 0 C with 0.4 mg/liter (2.6 μM) HOBr. Molecular bromine at a concentration of 0.8 M was about six times more effective than HOBr as a virucide.

HOBr was more effective than NBr_3.

Taylor, F. B. (1974). *Viruses—What is Their Significance in Water Supplies?* **J AMER WATER WORKS ASSN, 66(5)**:306–11.

The importance of viruses in potable waters is reviewed and discussed.

Tripatzis, I., Yano, M. (1974). *Standardization of the Sepharose Radioimmunoassay to Identify Hepatitis B Antigen in Major Volumes of Water.* **ZBL BAKT HYG, 227(1–4)**:383–8. **Translation presently not available.** Russian.

Tschider, S. R., Berryhill, D. L., Schipper, I. A. (1974). *Membrane Concentration of Infectious Bovine Rhinotracheitis Virus from Water.* **APPL MICROBIOL, 28(6)**:1030–2.

Infectious bovine rhinotracheitis virus (a herpesvirus) was recovered from seeded 1-liter quantities of distilled water, to which $MgCl_2$ had been added, by adsorption of the virus onto cellulose nitrate membrane filters (0.45 μm pore size). The herpesvirus was eluted from the membranes with 10-ml amounts of fetal calf serum under sonication. The average recovery was 70%.

Tsvetkova, S. A., Sobko, A. I. (1972). *Detection of Foot-and-Mouth Disease Virus in Animal Slaughter Products.* **VETERINARIIA, 1(4)**:35–6. Russian.

This paper was listed in the 1973 edition of these abstracts. A translation was not then available.

Foot-and-mouth disease virus was recovered from the organs of infected cattle by treating infected tissues with Freon 113 and extracting the virus from the Freon 113 with polyethylene glycol (MW 20,000).

About ten times as many viruses were recovered with this concentration procedure than without it. In several instances, viruses were recovered from concentrates when they were not recovered from untreated tissues.

Varma, M. M., Christian, B. A., McKinstry, D. W. (1974). *Inactivation of Sabin Oral Poliomyelitis Type 1 Virus.* **J WATER POLLUT CONTR FED, 46(5)**:987–92.

Inactivation of poliovirus 1 (LSc) in sewage at pH 5.2 at 20 C was achieved with 22 mg/liter of chlorine in five minutes, 19 mg/liter in 15 minutes, 19 mg/liter in 30 minutes, 17 mg/liter in 45 minutes, and 14 mg/liter in 60 minutes.

Walter, R., Rudiger, S. (1974). *The Significance of Recovering Viruses from Surface Waters in Terms of Municipal Hygiene.* **Z GESAMTE HYG, 20(10)**:691–9. German.

The virological quality of five river sections was explored over a four-year period. Viruses were recovered from 134 of 513 water samples taken. The spectrum of viruses recovered from river water was similar to the spectrum recovered from patients during the same period.

Virus concentrations in 30% of the samples tested exceeded the limit recommended as a potable-water standard by WHO. Since surface waters are utilized increasingly as sources of potable waters, removal by water treatment processes of at least 99.9% of the viruses present is essential.

In laboratory studies, slow sand filtration removed 99.95% of the viruses in river water, but contact filtration (alum-polymer coagulation followed by rapid sand filtration) and filtration through river bank soil removed only 99%.

Walter-Offenhauer, R., Horn, K. (1974). *A Sanitary Virological Study of Surface Waters.* **GIG SANIT, 0(9)**:72–4. Russian.

Viruses were recovered from 67 of 247 water samples taken during the swimming season from five bathing area sites, either lakes or flowing waters. The viruses were flocced from 5-liter samples with a polyelectrolyte and alum at pH 5.4 to 5.8 and recovered by dissolution of the centrifuged flocs at pH 8. The virus concentrations were at least one infective unit/300 ml of water. Two of the bodies of water received no sewage directly but were subjected to sewage overflow during heavy rains.

Recoveries of viruses did not correlate with coliform concentrations.

The spectrum of viruses recovered from patients suffering from viral diseases in the region did not correlate with the spectrum of viruses recovered

from the waters, but only major group correlations were attempted. In the summer of 1969, an outbreak of an echovirus meningitis was associated with swimming in some of the bathing areas.

Weismann, K. (1973). *An Epidemic of* Molluscum contagiosum *Originating in an Outdoor Public Swimming Pool. Analysis of 125 Consecutive Cases.* **UGESKR LAEGER, 135(40)**: 2151–6. Danish.

Half of a group of 77 boys and 48 girls (average age 11.4 years) with *Molluscum contagiosum*, acquired during the period from February 1968 to September 1970 had visited outdoor swimming pools. Seventy-five percent had visited one pool in Rodovre, Denmark.

The patients presented a typical clinical picture with massive infection on the buttocks, *crena ani*, perineum and thighs. The distribution suggested indirect contact infection from the edge of the pool, from the seats around the pool, or from the wooden benches in the sauna on which the patients sat naked.

Patients who did not visit the outdoor swimming pool were younger than those who did. These younger patients may have been infected in their homes or in public facilities.

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.

In St. Petersburg, Florida, enteroviruses were recovered throughout 1972 from the chlorinated effluents of an activated sludge sewage treatment plant.

Following spray irrigation with these effluents, viruses were recovered from the sprayed site at 5-ft depths on four occasions during the first year of the study.

In the following year, after heavy rains in July, August, and September, viruses were recovered from the waters of 10-ft deep monitoring wells on four occasions, the third yielding a burst of poliovirus 1 (78 PFU/50 gallons). Other samples contained echovirus 7 and coxsackievirus B4. A similar burst of poliovirus 1 occurred in a 20-ft well one week later (67 PFU/100 gallons in a morning sample, 14 PFU/100 gallons in the afternoon, and 0 PFU/100 gallons the following morning).

The significant differences in pH and buffering capacities of the 5-, 10-, and 20-ft deep well waters argue against a loss of well integrity. Rather, the bursts of poliovirus 1 into the 10– and 20-ft wells may indicate that this virus is more stable than other viruses in the terrestrial environment, or that this virus is selectively desorbed under certain conditions.

White, G. C. (1974). *Disinfection: Present and Future.* **J AMER WATER WORKS ASSN, 66(12)**689–90.

Growing concern with waterborne viruses and the need to make all potable waters safe to drink requires that disinfection must destroy viruses as well as bacterial pathogens. Serious doubts of the validity of the coliform index as an indicator of disinfection have been raised because coliform organisms are easier to destroy than viruses.

We must differentiate quantitatively and qualitatively between free chlorine residuals and combined residuals. Moreover, all free chlorine residuals must be reported quantitatively as undissociated HOCl. Present monitoring and recording equipment measures the sum of the dissociated and undissociated HOCl. The water industry needs instrumentation capable of measuring only the undissociated HOCl.

Thinking habits about the entire disinfection process must be altered if water utility operators are to keep pace with the continuing need to produce drinking water that is free of objectionable tastes and odors and meet the challenge presented by the clamor for water reuse.

Wolf, H. W., Safferman, R. S., Mixson, R. A., Stringer, C. E. *Virus Inactivation During Tertiary Treatment.* **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), 145–57. Also in **J AMER WATER WORKS ASSN, 66(9)**:526–31, 1974.

This paper was published jointly by agreement of the editors concerned.

Poliovirus 1 and coliphage f2 in secondary effluents were removed or inactivated in a solids contact module (Infilco Densator).

More than 99% of both poliovirus 1 and bacteriophage f2 were removed by alum added to produce an aluminum:phosphorus (Al:P) weight ratio of 7:1. At a lower alum dose, a marked decrease in virus removal occurred. At an Al:P ratio of 0.44:1, only 46% of the coliphage and 63% of the poliovirus were removed by the coagulation-sedimentation process.

High lime treatment (pH 11 to 11.9) removed or inactivated more viruses than the alum treatment did. Both viruses were recovered from alum sludges, but neither was recovered from lime sludges.

York, D. W., Drewry, W. A. (1974). *Virus Removal by Chemical Coagulation.* **J AMER WATER WORKS ASSN, 66(12)**:711–16.

Aluminum sulfate and ferric chloride removed more than 99% of coliphage f2 and more than 90% of the turbidity in coagulated lake water. Alum was most effective over a range of 20 to 25 mg/liter; ferric chloride was most effective at a level of 50 mg/liter.

Two mg/liter of either the cationic polyelectrolyte Drewfloc 21 or CatFloc significantly reduced turbidity and formed a good floc. But the Drewfloc 21 removed only 76% of the phage, and the CatFloc removed more than 99% of the phage.

Cationic, nonionic, and anionic polyelectrolytes improved floc formation by alum, but did not increase the extent of phage removal by alum.

Zachary, A. (1974). *Isolation of Bacteriophages of the Marine Bacterium* Beneckea natriegens *from Coastal Salt Marshes.* **APPL MICROBIOL, 27(5)**:980–2.

Bacteriophages of the marine bacterium *Beneckea natriegens* were recovered from coastal marshes. They occurred only in brackish and marine waters where they were widely distributed. The phages were morphologically diverse.

Zdrazilek, J. (1974). *Sensitivity of Human Diploid Embryonic Lung Cells for Isolation of Echo Viruses from Sewage.* **J HYG, EPIDEMIOL, MICROBIOL & IMMUNOL, 18(1)**:2–8.

A strain of human embryonic diploid lung cells (HDLC) and a strain of secondary monkey (*Cercopithecus aethiops*) kidney cells (MKC) were used in parallel studies to detect viruses in Prague, Czechoslovakia sewage.

Thirty-six polioviruses of all three types and 47 echoviruses (types 3, 4, 6, 7, 11, 12, 14 and 19) were recovered between January 1969 and April 1970. Two-thirds (24) of the polioviruses were recovered in MKC only, 31 echoviruses were recovered in HDLC only, and 12 other viruses were recovered in both types of cells.

Most of the echovirus strains produced titers ten times higher in the strain of cells in which they were recovered than in the others.

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16. ABSTRACT

The volume comprises the abstracts of the published papers and books on viruses in waste, renovated, and other waters for 1974.

17. KEY WORDS AND DOCUMENT ANALYSIS

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