VIRUSES IN WASTE, RENOVATED, AND OTHER WATERS

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LITERATURE ABSTRACTS

U.S. ENVIRONMENTAL PROTECTION AGENCY
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Adamczyk, B., Kiehl, W., Adamczyk, G., Wandel, I. (1970). *Epidemiology and Virology of an Aseptic Meningitis Outbreak in Berlin Associated with Echovirus 30.* **DTSCH GESUNDEITSW, 25(11)**:2144-8. German.

One-hundred cases of aseptic meningitis occurred in Berlin in the summer of 1969. Children between 3 and 10 years of age comprised 60% of the cases. Only 7% of the patients were over 30 years of age.

The outbreak began during an unusual heat wave in July and August. Outdoor swimming pools appeared to be the source of infection.

Echovirus 30 was recovered from patients much more frequently than any other virus.

Akin, E. W., Benton, W. H., Hill, W. F., Jr. *Enteric Viruses in Ground and Surface Waters: A Review of Their Occurrence and Survival.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 59-74.

Enteric viruses occur in surface waters throughout the world. These viruses are shed in the feces of infected men and animals and enter water systems by way of soil runoff and sewage, both treated and untreated.

Viruses absorb to soil particles and may be removed before they reach ground water, but both contaminated surface and ground water have been implicated in infectious hepatitis outbreaks. The incidence of endemic virus disease transmitted through surface waters is difficult to determine because of the large percentage of asymptomatic infections which occur with these viruses.

Babov, D. M., Gubenko, L. T., Muromtseva, A. A., Yarotskaya, N. E. (1971). *Enterovirus Circulation in the Environment and Among the Population of Odessa.* **GIG SANIT, 36**:54-7. Russian.

Echoviruses 3, 6, and 7 and coxsackieviruses B3 and B5 circulated throughout the year among the population and in the sewage of Odessa from 1966 to 1968. These serotypes were detected in sewage when they were

recovered from 1.9 to 4.9% of the population. Viruses were recovered from sewage by the gauze pad method.

Bagdasaryan, G. A. (1970). *Viability of Enteroviruses in Waters with Different Degrees of Pollution.* **ZH MICROBIOL, 47(8)**: 96-8. **Translation presently not available.** Russian.

Bagdasaryan, G. A., Abieva, R. M. (1971). *Survival of Enteroviruses and Adenoviruses in Water.* **GIG SANIT, 36**:10-14. Russian.

Survival in water of enteroviruses and adenoviruses was influenced by temperature and the extent of contamination of water by bacteria. Strains of adenovirus 5 survived for the longest periods. In tap water, these strains survived for 63 days at 18 to 20 C, and for longer periods at 4 to 6 C.

Baumann, E. R. (1971). *Lawsuit Involving Source of Hepatitis Outbreak.* **HSMHA HEALTH REP, 86(1)**:19-20.

A lawsuit and its outcome is described in which plaintiffs failed to collect damages for contracting infectious hepatitis, allegedly the result of negligence of a landlord in providing a contaminated well-water supply. A septic tank had been installed only 35 feet from the well, 15 feet closer than permitted by the state plumbing code. The court found that fecal contamination of the well had not been demonstrated, and that unsanitary conditions of the premises and personal contact transmission were the most likely causes of the outbreak.

Berg, G. *An Integrated Approach to the Problem of Viruses In Water.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York,** (1971), 339-64.

Large quantities of viruses of human origin are excreted into sewage, and thus abound in our rivers and streams. Viruses have been detected at water intakes and large numbers apparently enter intakes daily. Since ingestion of a small amount of virus is likely to produce infection rather than disease, the inability of epidemiologists to detect waterborne transmission may be the result of preoccupation with clinical illnesses rather than infection in index cases.

Viruses are removed from sewage effluents and from raw waters by most biological, chemical, and physical treatment procedures, but never completely. Treatment procedures therefore constitute adjunctive removal, complete virus removal being dependent upon terminal disinfection.

No single disinfectant is capable of adequately disinfecting waters of all quality. The chemical quality of effluents and the toxicity to aquatic life of disinfectants and the compounds they form in water are important determinants in the choice of a water disinfectant.

Berg, G. (1971). *Integrated Approach To Problem of Viruses In Water.* **J SAN ENGIN DIV, ASCE, 97:SA6**:867-82.

This paper is a somewhat updated version of the one above. It includes a proposal that the primary standard for microbiological acceptability of renovated and other potable waters should be manifested in disinfectant concentrations and that bacterial and viral determinations, which are usually unavailable until waters are consumed, should serve in a backup status.

Berg, G. *Removal of Viruses from Water and Wastewater.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971). 126-36.

There is not yet available a method that completely recovers all viruses from sewage.

Primary settling, which is used in most communities, removes viruses inefficiently. Biological treatment methods such as activated sludge, stabilization ponds, and trickling filters effect some virus removal but with widely varying results. Chemical-physical treatment may be more uniformly effective in virus removal.

As costs become a little less important, and the quality of our waters a little more important, chemical and physical treatment procedures may find increasing application both in treating raw sewage and secondary effluents especially when total renovation is the goal.

Berg, G., Dahling, D. R., Berman, D. (1971). *Recovery of Small Quantities of Viruses from Clean Waters on Cellulose Nitrate Membrane Filters.* **APPL MICROBIOL, 22(4)**:608-14.

Small amounts of viruses were recovered quantitatively from large volumes of buffered, distilled water by adsorbing the viruses onto cellulose nitrate membrane filters (0.45 μm pore size) and eluting the adsorbed viruses in 3% beef extract under extended sonic treatment. Complete recovery of poliovirus 1, echovirus 7, and coxsackievirus B3 resulted when less than 100 PFU were added to 1-liter quantities of water. Recoveries of reovirus 1 were almost as good. Preliminary studies indicated that good recoveries could be made from 25-gallon quantities of water. The method described was efficient in waters of high quality and may be useful for recovering viruses in renovated, and perhaps in tap waters, but not in waters containing certain organic matter unless that matter is first removed.

Borisov, L. B., Khan-Fimina, V. A., (1970). *Biological Characteristics of the Phages of Enteropathogenic Escherichia coli. Report 4. Biological Properties of Phages Lysing E. Coli 0124 and 026:B6.* **ZH MIKROBIOL EPIDEM IMMUN 47(6)**:34-7. Russian.

The biological properties of five coliphages isolated from sewage are

described. The phages differed in antigenic properties, temperature tolerance, and morphology. On the basis of serology and host range, two phages were classified in *Escherichia coli* group 026 and two in *E. coli* group 0124.

Braga, A., Pagano, A. (1970). *Hygienic and Sanitary Aspects of Sea-Water Pollution.* **IG MOD, 63**:227-48. Italian.

Infective organisms in sewage that pollutes seawater are a hazard to bathers and contaminate shell fish. Infectious hepatitis has resulted from the consumption of raw clams.

Brunner, D. R., Sproul, O. J. (1970). *Virus Inactivation During Phosphate Precipitation.* **J SAN ENGIN DIV, ASCE, 96**:SA2:365-79.

Large quantities of poliovirus 1 were removed during precipitation of phosphate in distilled water and in domestic wastewater effluent by either calcium or aluminum.

In distilled water and in domestic wastewater effluent containing equal molar concentrations of Al^{+++} and $PO_4^{\equiv}$, precipitation with aluminum at pH 5.0 effected 90% poliovirus 1 removal when 24 mg/liter $PO_4^{\equiv}$ were precipitated, and 98% poliovirus 1 removal when 30 mg/liter $PO_4^{\equiv}$ were precipitated.

In distilled water at pH 11, calcium effected 97% virus removal when 37 mg/liter $PO_4^{\equiv}$ were precipitated. In domestic wastewater effluent, calcium treatment effected 94% virus removal when 44 mg/liter $PO_4^{\equiv}$ were precipitated.

Removals of viruses by these two phosphate reduction processes were predictable by a Freundlich isotherm. Poliovirus 1 removals were affected by hydrogen ion concentration in each process. Alum treatment removed more viruses than lime treatment of a comparable wastewater.

Canzonier, W. J. (1971). *Accumulation and Elimination of Coliphage S-13 by the Hard Clam, Mercenaria mercenaria.* **APPL MICROBIOL, 21(6)**:1024-31.

Hard clams *(Mercenaria mercenaria)* exposed to low levels of coliphage S-13 (7 PFU/ml) in running seawater for several days accumulated titers in tissues from two to more than 1,000 times the levels to which they had been exposed. Accumulations of *Escherichia coli* were comparable. Clams polluted with relatively low levels of *E. coli* eliminated most of the bacteria in 24 to 48 hours. The virus, however, persisted for days to weeks even under conditions ideal for clam activity when temperatures were below the inactivation threshold for the virus. Most of the accumulated virus was sequestered in the digestive gland. These sequestered particles were refractory to those mechanisms responsible for elimination of bacteria.

The need for caution in evaluating the efficiency of shellfish depuration processes is thus underscored when only a bacterial criterion is used as a monitoring system.

Chambers, C. W. (1971). *Chlorination for Control of Bacteria and Viruses in Treatment Plant Effluents.* **J WATER POLLUT CONTRL FED, 43(2)**:228-41.

Destruction of bacteria and viruses in treatment plant effluents are reviewed.

Chang, P. W., Liu, O. C., Miller, L. T., Li, S. M. (1971). *Multiplication of Human Enteroviruses in Northern Quahogs.* **PROC SOC EXP BIOL MED, 136(4)**:1380-4.

Proflavine-labeled poliovirus 1, echovirus 1, and coxsackievirus B3 did not multiply in Northern quahogs. Virus isolated from the quahogs after inoculation apparently represented persisting input virus.

Chang, S. L. *Modern Concept of Disinfection.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York** (1971), **339-64:** Also in **J SAN ENGIN DIV, ASCE, 97:SA5**:689-707, 1971.

Concepts of disinfection are founded on the physical chemistry of disinfectants, the cytochemical natures and physical states of microorganisms, the reactions of disinfectants and microorganisms as rate processes, and the quantitative effects of factors such as pH and temperature.

Disinfectants may be grouped as oxidizing agents, heavy metal cations, quaternary ammonium and pyridinium compounds, gaseous agents, and physical agents. The mode of action of each group of agents is different.

The difference in the structure of amoebic cysts, vegetative bacteria, and viruses accounts for the difference in their resistance to disinfectants.

The presence of organisms in aggregates is probably an important cause for aberrations in survival curves.

Cherkinsky, S. N., Lovtsevich, E. L., Ryabchenko, V. A. (1971). *The Sanitary Significance of Escherichia coli in Water Decontamination of Enteroviruses.* **GIG SANIT, 36**:7-10. Russian.

The value of *Escherichia coli* as an indicator for enteroviruses in water undergoing disinfection depends upon the relative amounts of the bacteria and viruses present.

Cliver, D. O. *Viruses in Water and Wastewater: Effects of Some Treatment Methods.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 149-58.

A polycationic primary coagulant did not remove significant quantities of enteroviruses from water and wastewater. Viruses were removed by activated carbon, but a good deal was still present in the effluents from the carbon columns.

Cliver, D. O. (1971). *Transmission of Viruses Through Foods.* **CRIT REV ENVIRON CONTR, 1(1)**:551-79.

Transmission of viruses by shellfish and contaminated processing waters are reviewed as part of a general review on foodborne transmission of viruses.

Cookson, J. T. (1969). *Mechanism of Virus Adsorption on Activated Carbon.* **J AMER WATER WORKS ASSN, 61(1)**:52-6.

Sites on activated carbon that adsorb bacteriophage T4 are probably carboxyl groups or lactones. Adsorption on carbon can be completely blocked by esterifying these groups.

Amino groups on the virus apparently adsorb electrostatically to carboxyl groups on the carbon. The pH range of strong adsorption rules out participation by ionized forms of sulfhydryl, guanidino, and phenolic groups in the electrostatic binding. Ionized imidazolyl groups are probably too few to be significant.

As pH decreases from the optimum of 7, adsorption rates decrease, probably because viral tail fibers on the tail sheath become unable to attach to carbon sites.

At pH levels higher than optimum, when the tail fibers of bacteriophage T4 are extended, the adsorption rates decrease presumedly because negative charges on the virus particles and carbon surfaces increase causing greater repulsive forces between them.

With increasing ionic strength, adsorption increases as like charges on the virus and carbon particles are masked. At the same time, repulsive forces between the viral tail fibers and tail sheath are reduced. With increasing ionic strength, more and more tail fibers adsorb on the tail sheath. Although high ionic strengths cause a maximum collision frequency between viruses and carbon particles, the adsorbing tail fibers become less available. These mechanisms are supported by equilibrium studies at high and low ionic strengths.

Coulanges, P., Mayoux, A., Brygoo, E. R. (1971). *Application of the Soluble Ultrafilter Membrane Technique to the Study of Viruses in Wastewater of Tananarive.* **COMPT REND, 164**:1672-3. French.

At Tananarive, filtration of wastewater through soluble alginate membranes yielded viruses in 43% of 67 samples. Thirty-three enteroviruses and a reovirus were recovered by this method.

Coulon, G., Netter, R. Nejmi, D. (1968). *Research on Viruses in Potable Waters.* **BULL INST NAT SANTE RECH MED, 23(11-12)**:1347-54. French.

Viruses were recovered from one-liter quantities of poliovirus 1-seeded water by direct pressure filtration (ultrafine Gottingen membranes) or by vacuum filtration at 4 C (alginate Gottingen membranes). Adsorption onto

$Al(OH)_3$ followed by filtration through HA Millipore membranes had the advantage of speed and simplicity but lacked sensitivity. Recovery of the virus by adsorption to a Dowex resin and elution in nutrient broth was inefficient.

In 1967 and 1968, viruses were not recovered from drinking water tested by two different methods twice a month at four sites around Paris.

A number of water samples did yield viruses of types used experimentally in the laboratory and were believed to be contaminants.

Culp, R. L. (1971). *Virus and Bacteria Removal in Advanced Wastewater Treatment.* **PUBLIC WORKS, 102(6)**:84-8.

The renovation process at Lake Tahoe is reviewed along with data indicating removal of viruses and bacteria by the process.

De Haas, R. A. (1971). *Distribution of Polioviruses in Surinam.* **ARCH GES VIRUSFORSCH, 33**:72-6.

From the beginning of 1964 to the middle of 1969, polioviruses 1, 2, and 3 circulated continuously among 1- to 5-year-old children. Increased poliovirus circulation correlated with the appearance of clinical poliomyelitis. Trivalent oral vaccination programs, administered when increased levels of poliovirus circulation were observed, only partially reduced circulation of polioviruses, possibly because insufficient numbers of children were vaccinated.

Dolin, R., Blacklow, N. R., DuPont, H., Formal, S., Buscho, R. F., Kasel, J. A., Chames, R. P., Hornick, R., Chanock, R. M. (1971). *Transmission of Acute Infectious Nonbacterial Gastroenteritis to Volunteers by Oral Administration of Stool Filtrates.* **J INFECT DIS, 123(3)**:307-312.

Acute gastroenteritis was induced in two of three volunteers by oral administration of a bacteria-free stool filtrate derived from a patient with naturally occurring acute infectious nonbacterial gastroenteritis. Subsequently, oral administration of a stool filtrate from one of the sick volunteers induced gastroenteritis in seven of nine additional men.

The original rectal swab specimen from the naturally occurring case was passaged three times in human fetal intestinal organ culture: material from the third passage induced gastroenteritis in one of four volunteers.

A spectrum of clinical responses developed ranging from a predominantly diarrheal disease without vomiting to an illness characterized by repeated vomiting without accompanying diarrhea.

Geldreich, E. E., Clarke, N. A. *The Coliform Test: A Criterion for the Viral Safety of Water.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 103-13.

The absence of total coliforms in a treated water is evidence of a bacteriologically safe supply. Whether coliforms are good indicators for rickettsia and viruses has not been determined. The observation that certain enteric viruses are more resistant to chlorine than the indicator bacteria are has raised questions as to whether drinking water that meets the USPHS drinking water standard is free from disease-producing levels of virus. Improved methods for detecting viruses in water, studies on the coliform levels in large volumes of treated water which are coliform-free by conventional tests, and epidemiological studies are needed to confirm that the coliform test reliably indicates the biological safety of water.

Goncharuk, E. I., Grigoryeva, L. V., Bei, T. V., Shulyak, E. V., Korchak, G. I. (1970). *Removal of Enteroviruses and Bacteria from Sewage in a Circulating Oxidizing Channel.* **HYG & SANIT, 35(1)**:36-41.

Sewage in a circulating oxidizing channel was free of seeded coxsackievirus B5 and echovirus 19 in 24 and 48 hours, respectively. Coliphages, present initially in concentrations of 6,000 to 7,000 PFU/ml, were not detected 16 hours after seeding. Pathogenic *Escherichia coli,* present initially in a concentration of 10^8/liter, were detected for 18 days. Coxsackievirus B5 was detected in sludge for three days and echovirus 19 was detected there for five days.

Grigoryeva, L. V., Korchak, G. I., Bey, T. V. (1969). *Survival of Bacteria and Viruses in Sewage Sludges.* **MIKROBIOL ZH, 31(11-12)**:659-64. Russian.

Coxsackievirus B5 survived thermophilic fermentation of sludge for 30 days. Enteropathogenic *Escherichia coli* 0111 survived for 10 days.

Phages survived mesophilic and thermophilic fermentations for four months and nine days, respectively.

Grushko, Y. M. (1971). *Problems of Sanitary Protection of Water Bodies in the Pages of Foreign Journals.* **GIG SANIT, 36**:73-5. Translation presently not available. Russian.

Hill, W. F., Jr., Akin, E. W., Benton, W. H. *Detection of Viruses in Water: A Review of Methods and Application.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69 (1971), 17-46: (Also in WATER RES, 5(11)**:967-95,) 1971.

Mechanisms, procedures, and efficiencies of methods currently under evaluation for effectiveness in detecting small amounts of viruses in large volumes of water are reviewed and evaluated for speed, simplicity, and economy of application.

The most promising methods are the membrane-adsorption technic, adsorption to precipitable salts, iron oxide, and polyelectrolytes, aqueous polymer two-phase separation, and the soluble alginate filter technic. Most of these methods have good-to-excellent virus recovery efficiencies. Other methods such as continous-flow ultracentrifugation, forced-flow electrophoresis and electroosmosis, and hydroextraction are not as useful yet. The most promising methods for detecting small amounts of viruses in clean and finished waters are those that rely on virus adsorption and retention in a flow-through sampling system. For waters that are moderately or grossly turbid, the aqueous polymer two-phase separation may be the better approach.

Hill, W. F., Jr., Akin, E. W., Benton, W. H., Hamblet, F. E. *Viral Disinfection of Estuarine Water by UV.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York (1971), 223-44: Also in** J SAN ENGIN DIV, ASCE, **97:SA5**:601-15, 1971.

Under static conditions in seawater, polioviruses 1, 2, 3, echoviruses 1 and 11, and coxsackievirus A9 were destroyed at about the same rate by ultraviolet light. Coxsackievirus B1 and reovirus 1 were more resistant, perhaps because of clumping of the virions. The applied UV dosage was 116 ergs/mm^2/second.

In a continuous-flow seawater system, poliovirus 1 was destroyed more rapidly by a Kelly-Purdy UV unit than in the static system, apparently because of the higher UV dosage applied in the continuous-flow system.

Johnson, J. D., Overby, R. *Bromine and Bromamine. Disinfection Chemistry.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York (1971),** 37-60.

A pH versus bromine-ammonia mole ratio distribution diagram for bromine and the bromamines is presented for 10^{-4} M aqueous bromine solutions. Ultraviolet absorption spectra were used to identify the principal bromamine species initially formed, and also to follow the apparent second and third order decomposition of dibromamine and tribromamine.

In the neutral pH range, tribromamine formed in solutions with mole ratios of ammonia to bromine less than 2:3; dibromamine occurred at ratios greater than 2:3. At ammonia to bromine mole ratios of 2:3 in neutral solution, a breakpoint reaction occurred between di- and tribromamine. Below pH 8 tribromamine was stable. At ratios of ammonia to bromine of 1:3, pure tribromamine formed and decomposed to nitrogen and free bromine. At pH values less than 8, the rate of decomposition was slow in the presence of excess bromine.

Known variations of sporicidal and virucidal efficiencies as a function of pH, time, and ammonia to bromine ratios correlated with changes in the chemical species in solution.

Kinman, R. N., Black, A. P., Thomas, W. C., Jr. *Status of Water Disinfection with Iodine.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York** (1971), 11-35.

The qualities and characteristics of iodine as a water disinfectant are reviewed.

No major difficulties were encountered with iodine during six years and eight months of iodination of two public water supplies of 25,000 and 100,000 gpd capacities. Iodine had no detrimental effect on general health or thyroid function and was an effective water disinfectant.

Iodine ($1.30/pound) cannot compete economically with gaseous chlorine ($0.05/pound) in large water treatment plants at this time. However, in disinfection applications where hypochlorites are used ($0.70/pound available chlorine) iodine can compete with chlorine and may be the cheaper of the two disinfectants depending upon the conditions of use.

Klein, E., Smith, J. K., Morton, F., and Sweet, B. H. (1971). *Concentration of Virus from Water by Osmotic Ultrafiltration II. Mass Transport Aspects.* **WATER RES, 5(11):**1067-77.

Mathematical analyses of the physical chemistry aspects of the osmotic ultrafiltration method for concentrating viruses suspended in water were utilized for determining optimum experimental conditions. Laboratory studies showed that the rapidity of concentration depended upon the starting volume of osmotic and virus solutions, the concentration of the osmotic solution, the type membrane employed, and the membrane area.

Graphic illustration of the interaction of these parameters and the derivation of mass transport formulae indicated agreement between experimental and computer predicted results.

Knocke, K.-W., Pittler, H., Höpken, W. (1967). *Demonstration of Reovirus in Sewage.* **ZBL BAKT ORIG, 203:**417-21. German.

Sewage samples, taken from seven towns of Lower Saxony from 1963 to 1965, began to yield large numbers of reoviruses in 1964. In 1965, 130 strains of reovirus were recovered from 382 samples of sewage.

By hemagglutination inhibition tests, 51 isolates were identified as reovirus 1 and 66 as reovirus 2.

During 1965, 13 reoviruses were recovered from 2,500 specimens taken from 1,115 patients.

Konowalchuk, J., Speirs, J. I., (1971). *A Method for Recovering Enterovirus from Infected Samples by Adsorption onto Shaken Suspended Cells.* **CAN J MICROBIOL, 17:**1279-82.

Coxsackievirus B5 in a 5-ml liquid sample was completely recovered on a single HEP-2 culture in a single 60 x 15 mm culture dish. Adsorption

was accomplished by constant agitation of the sample with suspended cells followed by a stationary period to allow monolayer formation for plaque development. Comparative studies indicated that the conventional method of adsorption onto stationary monolayers would require 50 times as many dishes and cells for an equal efficiency. The new method may be useful for recovery of small numbers of viruses from food or water providing these are nontoxic to cells and contain no bacteria.

Kott, Y. *Chlorination Dynamics in Wastewater Effluents.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York, (1971),** 585-608.

Eight mg/liter chlorine decreased the coliform level of wastewater effluents to less than 100/100 ml. Fourteen mg/liter did not give better results.

Eight mg/liter chlorine rapidly destroyed *Endamoeba histolytica* cysts in a temperature dependent reaction.

No algae kill was observed in oxidation pond effluents treated with 8 mg/liter of chlorine for two hours.

Kruse, C. W., Hsu, Y. C., Griffiths, A. C., Stringer, R. *Halogen Action on Bacteria, Viruses, and Protozoa.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York, (1971),** 113-36.

Chlorine, iodine, or bromine, added to water at a low pH, at a dosage insuring a free residual, would be a universal disinfectant. Less iodine than chlorine or bromine would be needed to provide a free residual.

The cysticidal properties of free iodine, bromine, and chlorine in water of low pH is about the same on a mg/liter basis. Chlorine and, to a lesser extent, bromine fail as cysticides in water containing nitrogenous substances, although some amines are fair disinfectants.

The virucidal properties of free halogens are similar. Since neither infective RNA nor DNA is destroyed by iodine, the optimum pH for viral iodination is greater than 6. Free bromine and chlorine are more virucidal at lower pH levels.

On a weight basis, iodine kills more viruses in a wide range of natural waters than either chlorine or bromine because amines are not formed with iodine.

Kruse, C. W., Olivieri, V. P., Kawata, K. *The Enhancement of Viral Inactivation of Halogens.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 197-209.

Free halogens are virucidal in the pH range of natural waters. To disinfect water supplies, chlorine should be applied beyond the breakpoint to

inactivate viruses. Longer contact time gives better disinfection; thus, prechlorination is frequently a desirable water treatment practice. Flash mixing is of great value when combined residuals are used because free chlorine does exist for a short time after mixing. Disinfection can be accomplished even in this short time.

Lautier, F., Wilenski, A., Lavillaureix, J. (1971). *A Method for Demonstrating Viruses in Polluted Waters.* **PATH MICROBIOL, 37**:99-104. French.

One-hundred ml of filtered sewage was mixed with $Al(OH)_3$, and the precipitate was trapped on a 0.45 μm membrane filter. Viruses were eluted with culture medium containing protein. Viruses were recovered from most of 19 sewage samples tested. The method was superior to a resin method tested concurrently.

Layton, R. F., Kinman, R. N. *New Analytical Method For Ozone.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York,** (1971), 285-305.

A colorimetric method for detecting ozone in air and water is described. The method is based on the oxidation of leuco crystal violet via a hydride transfer mechanism.

Leclerc, H. (1971). *Pathogens in Residual Waters: Evolution in the Course of Purification Treatments.* **TSM – L'EAU, 66(11)**:389-400. French.

Viruses were rarely recovered from raw sewage, and could not be recovered from experimentally seeded sludge treated with lime and iron perchloride and vacuum filtered. Viruses were recovered from seeded sludge flocced with an organic polyelectrolyte and pressure filtered. Results of studies on the removal of other microorganisms by treatment processes are presented.

Leogrande, G., Iandolo, E. (1969). *Effect of Seawater on Survival of Virulent and Attenuated Polioviruses.* **IG MOD, 62**: 705-14. Italian.

Survival of six poliovirus strains (three virulent and three attenuated) in seawater, autoclaved (120 C) seawater, and in Hanks' balanced salt solution were studied. In ten experiments, highly variable results were obtained, but test conditions were highly variable because of the physical, chemical, and microbiological (bacterial and protozoan) variations in the seawater. However, viruses were inactivated in seawater very slowly, at a rate apparently not much different than in Hanks'.

The authors concluded that seawater has no unusual virus-inactivating capacity.

Liu, O. C. *Viral Pollution and Depuration of Shellfish.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York** (1971), 397-428.

Viral pollution and depuration of shellfish are reviewed.

In the last 15 years, nine outbreaks of infectious hepatitis have been associated with various species of shellfish. Recently, sporadic cases of hepatitis have been associated with raw and inadequately cooked shellfish.

Field investigations over the northeastern United States showed a variety of human enteric viruses in American oysters and in their growing waters.

Viruses localize in the digestive diverticula of shellfish. The process of contamination is dynamic. The viruses are retained in the diverticula when water temperatures are below a certain level. Thus, the shellfish serve as a reservoir for virus dissemination.

Shellfish can self-cleanse themselves when subjected to optimal hydrographical conditions.

Liu, O. C., Brashear, D. A., Seraichekas, H. R., Barnick, J. A., Metcalf, T. G. (1971). *Virus in Water. I. A Preliminary Study on a Flow-Through Gauze Sampler for Recovering Virus from Waters.* **APPL MICROBIOL 21(3)**:405-10.

The efficiency of a flow-through gauze sampler for recovering viruses from both fresh water and seawater was evaluated. An attenuated strain of poliovirus 1 was seeded into water in the preliminary laboratory studies.

The amounts of poliovirus 1 adsorbed by the gauze pads from tap water were very small, about 2% of the total number of virus particles flowing through the sampler. Virus recoveries from seawater ranged from 15 to 19%. Addition of NaCl to tap water increased virus recovery to 47%.

Viral elution from the pads was greatest in pH 8 to 9 buffer containing serum. Repeated elutions from the pads increased viral recovery. The first eluate contained approximately 50% of the adsorbed virus.

Liu, O. C., Seraichekas, H. R., Akin, E. W., Brashear, D. A., Katz, E. L., Hill, W. J., Jr. *Relative-Resistance of Twenty Human Enteric Viruses to Free Chlorine in Potomac Water.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin 69** (1971), 171-95.

A wide range of resistance was observed among polioviruses 1, 2, and 3, five coxsackieviruses, six echoviruses, three adenoviruses, and three reoviruses subjected to chlorination in partially treated Potomac River water.

A reovirus that required 2.7 minutes for 99.99% devitalization by 0.5 mg/liter of free chlorine was the least resistant virus tested, and a poliovirus that required 40 minutes for 99.99% devitalization was the most resistant. These findings are in general agreement with those reported in the literature when comparable information is available.

Naturally occurring viruses may be much more resistant to chlorination than laboratory strains.

Malaviya, A. N., Sama, S. K., Ramachandran, K., Gandhi, P. C., Tandon, B. N. (1971). *Australia/SH Antigen and Immunoglobulins in an Epidemic of Viral Hepatitis.* **AM J TROP MED HYG, 20(3)**:502-5.

In a waterborne epidemic of viral hepatitis, none of 97 persons with hepatitis showed evidence of infection with Australia antigen. In 26 persons randomly selected from those with hepatitis, IgG and IgM levels were significantly elevated.

Manwaring, J. F., Chaudhuri, M., Engelbrecht, R. S. (1971). *Removal of Viruses by Coagulation and Flocculation.* **J AMER WATER WORKS ASSN, 63(5)**:298-300.

In laboratory studies, coagulation of coliphage MS2 in water with $FeCl_3$ was as effective as coagulation with $Al_2(SO_4)_3$. The optimum concentration of $FeCl_3$ was 50 to 60 mg/liter. Calcium and magnesium concentrations up to 50 mg/liter each did not affect the efficiency of coagulation. Virus and turbidity removal paralleled each other. Removal efficiency increased as the pH decreased over a range from 8 to 5, and reached a maximum of 99.5%.

The addition to the water of 20% wastewater reduced the efficiency of virus removal to less than 70%. Wastewater may have interfered more with virus removal from $FeCl_3$-coagulated water than with virus removal from water coagulated with $Al_2(SO_4)_3$.

Virus was recovered from the settled ferric-sludge indicating that sludge disposal must be undertaken with care.

Mehta, N. R., Acharya, P. T. (1969). *Study of an Outbreak of Infective Hepatitis in the Hospital Staff Quarters, Baroda. I. Epidemiological Aspects.* **IND J MED RES, 57(8)**:1437-48.

A waterborne outbreak of infectious hepatitis limited to young adult males occurred in families of the staff of a hospital and medical college in Baroda in February, March, and April, 1966. Forty-two cases were reported.

Superchlorination of water and administration of gamma globulin were instituted to control the outbreak.

Melnick, J. L. *Detection of Virus Spread by the Water Route.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 114-24.

Viruses occur in water, and waterborne outbreaks of viral diseases have been well-documented. If a virus infection has a short and uniform incubation period, and produces a characteristic, easily recognizable disease, carriage of the virus by water routes can be traced with a fair degree of accuracy.

In contrast to diseases whose spread can be traced in this fashion, the characteristics of many viral diseases are such that their transmission by water

is very difficult to recognize. Viruses whose spread is difficult to trace include those which produce clinically observable illness in only a small fraction of the persons who become infected, those viruses which produce diseases with widely variable incubation periods, and those viruses which are readily spread by direct human contact.

Even though water transmission is often difficult to trace, the presence of viruses in sewage effluent, in streams, and in other waters cannot be viewed with equanimity. New methods capable of detecting viruses in large fluid volumes are available, and the time may have arrived for setting standards of permissible virus content of waters. A maximum is proposed of one detectable infectious virus unit/10 gallons of water intended for swimming and bathing purposes, and of no more than one infectious virus unit/100 gallons of drinking water.

Metcalf, T. G. *Biologic Parameters in Water Transmission of Viruses.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 1-16.

The properties of animal viruses important to man and transmitted by water are discussed. The salient features of these viruses which set them apart from bacteria and which must be understood to understand the problems of viruses in water are described.

Mitchell, R. (1971). *Destruction of Bacteria and Viruses in Seawater.* **J SAN ENGR DIV, ASCE, 97**:SA4:425-32.

The rate of inactivation of enteric bacteria in seawater was proportional to the quantity of marine microflora present. Continued disposal of enteric microorganisms into the sea results in the development of a specific antagonistic microflora.

Three groups of microorganisms have been associated with the destruction of coliforms in the sea. They are bacteria which enzymatically lyse the cell walls of enteric bacteria, the obligately parasitic Bdellovibrio, and a group of amebae that attack and consume bacterial cells. The amebae appear to be the most effective of the three groups.

Viruses in seawater apparently are destroyed by native marine microflora in the same way enteric bacteria are destroyed, but the antiviral microorganisms have not been identified. A chemical component of the seawater, probably a heavy metal, is also involved in the destruction of viruses. Shellfish-associated infectious hepatitis indicates, however, that viruses in the sea may survive inactivation. Viruses are protected from inactivation in the sea for long periods by adsorption to living and dead bacterial cells and to cell debris.

Moro, S. (1970). *Technics for the Virological Analyses of Water and Sewage.* **G BATTERIOL VIROL IMMUN, 63(9-10)**:467-84. Italian.

Some methods for detecting viruses in water are reviewed.

Morris, J. C. *Disinfectant Chemistry and Biocidal Activities.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York** (1971), 609-33.

To understand the kinetics of disinfecting action, the germicidal process must be viewed as a mutual interaction between each specific molecular form of the chemical agent and the microbes (considered as biochemical units). For the chemical agent, the positions of chemical equilibria and the germicidal potency of each of the active species must be known. For the organism, the physical and chemical nature of its areas of interaction with the chemical agent, and its susceptibility changes in different solutions must be known.

Morse, L. J., Bryan, J. A., Chang, L. W., Hurley, J. P., Murphy, J. F., O'Brien, T. F. (1970). *Holy Cross Football Team Hepatitis Outbreak.* **ANTIMICROB AGENTS CHEMOTHER, 10**:30-2.

An outbreak of infectious hepatitis occurred at Holy Cross College among players and coaches of the football team during September and October, 1969. Ninety of the 97 persons exposed were infected. Thirty-two experienced icteric disease, 22 were anicteric but symptomatic, and 36 asymptomatic players experienced elevated serum glutamic pyruvic transaminase values (>100 units).

The source of infection appeared to be a water supply contaminated by back siphonage into an open, flooded, below-ground irrigation faucet when a fire department placed heavy demand on the supply several miles away. The faucet area had been flooded and contaminated by playing children who had just recovered from infectious hepatitis.

Nestor, I. (1970). *Methods for Isolation of Viruses from Water.* **STUD CERCET INFRAMICROBIOL, 21(4)**:345-57. **Translation presently not available.** Rumanian.

Nestor, I., Costin, L. (1971). *The Removal of Coxsackievirus from Water by Sand Obtained from the Rapid Sand Filters of Water Plants.* **HYG EPIDEM MICROBIOL IMMUN, 15:** 129-36.

Fresh dry sand removed viruses much less efficiently than wet sand. Both experimentally and in field studies, sand from functioning filters more effectively removed viruses than other sands.

Nesvold, H. P. (1970). *Infectious Hepatitis, Hygienic Problems Related to an Epidemic in a Hamlet in Trysil.* **TIDS NOR LAEGEFOREN, 90(10)**: 1882-8. **Translation presently not available.** Norwegian.

Nitzkin, J. L., Henry, M. H. (1971). *Infectious Hepatitis in Logan County, Kentucky, A Probable Common Source Outbreak.* **J KY MED ASSOC, 69(5)**:349-53.

Ninety cases of viral hepatitis were reported in a six-county area of Western Kentucky during September, October, and November, 1967. Seventy-six of the 90 patients were residents of Logan County, and 64 were between 15 and 24 years of age. Soft drinks prepared from unchlorinated well water at a public eating place in Logan County appeared to be the common source of 74 cases. Five secondary cases occurred.

Nupen, E. M. (1970). *The Isolation of Viruses from Sewage and Treated Sewage Effluents.* **WATER POLLUT CONTRL (So. Africa), 69:**430-4.

The occurrence of viruses in sewage and effluents, their removal by treatment processes and disinfection, and methods for concentrating and detecting them are reviewed.

Olifson, L. E., Baltenko, E. N., Bukharin, O. V., Pozhar, V. N., Turovets, G. L. (1970). *Utilization of Industrial and Agricultural Wastewaters.* **GIG SANIT, 35(12):**92-4. **Translation presently not available.** Russian.

Olivieri, V. P., Donovan, T. K., Kawata, K. *Inactivation of Virus in Sewage.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York (1971), 365-84: Also in J SAN ENGIN DIV, ASCE, 97:SA5:**661-73, 1971.

Data are presented that strongly support the hypothesis that free chlorine is required for significant inactivation of viruses in sewage. The occurrence of short-lived virucidal intermediates and a long-lived chlorine-virus complex does not appear significant. The short-lived presence in sewage of free chlorine, as determined by a modification of the Black and Whittle procedure, appears likely when coupled with the results of dynamic tests.

Pálfi, A. B., Simon, M., Schulek, E. (1970). *Virological Examination of Urban Sewage from Budapest. II. Virus Isolations.* **EGESZSEGTUDOMANY, 14:** 127-32. Hungarian.

In the six-week periods following vaccination programs with monovalent live poliovirus vaccines, polioviruses were continuously recovered.

In August and September, coxsackieviruses and echoviruses, primarily coxsackievirus B4 and echovirus 7, were recovered. Reoviruses were recovered in the later period of the study.

Trickling-filter and activated-sludge plants did not effectively reduce virus concentrations.

Pittler, H., Höpken, W., Knocke, K.-W. (1967). *Enteroviruses and Adenoviruses in Sewage: Demonstration and Epidemiological Study 1963-1965.* **Z BAKT ORIG, 204:**33-48. German.

From 1963 to 1965, viruses were detected in 55% of 381 sewage samples collected from ten towns of Lower Saxony. Samples were concentrated at first by ultracentrifugation and later by precipitation with polyphosphoric acid.

Polioviruses, coxsackieviruses, echoviruses and adenoviruses were found. Most of the enteroviruses recovered from patients during this period were also found in sewage. There were no viruses in the sewage that were not also recovered from patients at about the same time. Most viruses were recovered during the summer and autumn.

Primavesi, C. A. (1969). *Modern Problems of Water Management and Water Distribution. I.* **GELSENKIRCHEN, 4:**195-213. German.

The occurrence and survival of viruses in sewage and river waters are reviewed.

Primavesi, C. A. (1971). *Virology and Its Importance for Water Hygiene.* **OEFF GESUNDHEITSWES, 33(6):**330-6. German.

The occurrence of viruses in sewage and sludge are reviewed.

Sewage containing fecal matter nearly always contains enteroviruses. Coxsackieviruses and echoviruses occur in sewage during the summer and autumn months. Polioviruses occur in sewage following vaccination programs.

The epidemiology of enterovirus infections in the community is reflected in the sewage. Enteroviruses are found in the influents and effluents of sewage treatment plants. Treatment processes do not substantially reduce the virus content of sewage. Enteroviruses are present also in sewage-containing canals. These canals contain viruses in the winter, summer, and autumn.

Enteroviruses are also present in treatment sludges even after months of storage. This is important in the agricultural utilization of sludges.

Reddick, R. A., Aycock, E. K., (1971). *Water – A Vehicle of Disease Dissemination.* **J SC MED ASSOC, 67(2):**56-60.

Viral diseases transmitted through contaminated water are reviewed along with bacterial and protozoan diseases transmitted by this route.

Ringertz, O. (1971). *Some aspects of the Epidemiology of Hepatitis in Sweden.* **POSTGRAD MED J, 47(7):**465-72.

An outbreak of infectious hepatitis associated with the consumption of oysters occurred in 1955.

Subsequently, an increasing incidence of hepatitis was noted among cross country runners who apparently crossinfected each other directly and indirectly.

Since 1964, hepatitis associated with haemodialysis and with narcotic addiction has become common.

The changes in the epidemiological pattern of infectious hepatitis during the last 20 years are discussed.

Rubenstein, S. H., Orbach, H. G., Shuber, N., King, E., Zackler, J. (1971). *Freeze Concentration of Viral Agents from Large Volumes of Water.* J **AMER WATER WORKS ASSN, 63(5)**:301-2.

Poliovirus 1 and Newcastle disease virus were freeze-concentrated from five-liter quantities of distilled water in a Virtis Freeze Concentrator. The process took eleven hours. Seventy to 125 ml of water remained unfrozen at the end of the process. One-hundred fold concentration of both viruses was noted when high concentrations of viruses had been added to the test waters. The efficiency of virus recovery was not reported.

Scarpino, P. V. Bacterial and Viral Analysis of Water and Wastewater. In *"Water and Water Pollution Handbook," Chapter 13, edited by L. Ciaccio.* **Marcel-Dekker, New York, New York, (1971)**, 639-761.

This chapter includes a comprehensive literature review on viruses in the water environment. Although its major emphasis is on methodology, the review covers occurrence, importance, detection, and quantitation of viruses in waste and other waters.

The major segment of the chapter deals with bacteria, primarily those of sanitary significance, in the water environment and analyses related to them.

Schäfer, E. (1971). *Quantitative Recovery of Poliovirus 2 in Surface Waters.* **GAS WATER ASSN/SEWAGE, 112(2)**:109-13. German.

Ultrafiltration through lanthanium-aluminum-alginate filters, adsorption to 0.45 μm cellulose nitrate filters (after prior filtration through an ion exchange resin), two-phase separation, and $FeCl_3$ floculation were compared for their efficiencies in recovering poliovirus 2 from seeded surface waters.

In numerous experiments, all of the methods had efficiencies that averaged about 60 to 70% except the membrane filter procedure which recovered less than 30% of the virus. Combining $FeCl_3$ floculation with two-phase separation yielded less than 30% of the virus, but reduced the final volume to a few ml.

Schneweis, K. E., Stifter, G. (1971). *Recovery on Membrane Filters of Enteroviruses in Water.* **ZBL BAKT ORIG, 216:** *128-39. German.*

A poliovirus, seeded into one-liter quantities of phosphate-buffered tap water (pH 7.4), adsorbed onto collodion membranes with an average pore diameter of 200 nm and was eluted by passing three ml of tissue culture medium containing 2% calf serum and 1% gelatin through the membranes.

Eighty-four percent of the virus was recovered. One and three-tenths infectious units of poliovirus was detected in 900 ml of the water.

The method was faster, simpler, and as efficient as the alginate filter technic. Bacteria were retained on the filter, and the eluted material produced no toxicity to tissue cultures. Extensive studies with coliphage T3 also yielded good results.

With sewage, 300 ml quantities of gauze pad elutes were centrifuged at 8,000 to 10,000 rpm for one hour, filtered successively through filterpaper (Schleicher and Schull 595-1/2), through collodion membranes with approximate pore diameters of 3,000 (with adsorbing pad), 1200, 800, 450 and 200 nm, and through a Dowex column. Magnesium chloride was then added and the viruses were adsorbed onto and eluted from a collodion membrane as described for tap water. Virus recoveries were lower than from tap water, but the technic was simpler and apparently more sensitive than the alginate filter method. Enteroviruses were detected in 41 of 43 samples tested.

Scutt, J. E. (1971). *Virus Retention by Membrane Filters.* **WATER RES, 5(5):** 183-5.

Twenty ml amounts of phosphate-buffered saline containing about 338 PFU/ml reovirus or 216 PFU/ml poliovirus 1 were filtered through 0.45 μm cellulose nitrate membranes at pressures ranging from about 0.023 to 3.54 mm S^{-1}.

Retention of poliovirus 1 by filters decreased with increasing filtration rates. Reovirus 1 was completely retained by these membranes at all rates examined. The poliovirus results suggest that membrane filtration may be an unsatisfactory method for concentrating viruses from large volumes of water.

Shane, M. S. (1971). *Distribution of Blue-Green Algal Viruses in Various Types of Natural Waters.* **WATER RES, 5(9):**711-16.

LPP blue-green algal viruses were recovered from rivers, streams, lakes, farm and residential ponds, oxidation lagoons and industrial storage waters. These viruses were widely distributed in nature and stable throughout the year in three oxidation ponds examined in the Delaware-Maryland area.

Shuval, H. I., Thompson, A., Fattal, B., Cymbalista, S., Wiener, Y. *Natural Virus Inactivation Processes in Sea Water.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE New York, New York (1971), 429-52: Also in J SAN ENGIN DIV, ASCE, 97:** SA5:587-600, 1971.

Enteroviruses were more resistant to inactivation in the marine environment than coliform organisms which have been the classical pollution indicator. Enteroviruses were often detected in a sewage-polluted coastal area and opposite a bathing beach where coliform counts were low.

Seawater samples from sewage polluted areas of the Mediterranean and Red Seas had higher marine antiviral activity (MAVA) than samples of unpolluted seawater.

Heat and ether treated samples lost their antiviral activity, as did samples passed through membrane filters. All antiviral seawater samples contained viable marine bacteria with an average density of 10^3/ml.

Active antiviral factors could not be demonstrated in seawater in the absence of marine bacteria. Whether the antiviral activity requires the presence of the bacteria or is associated with an agent produced by the bacteria has not been determined.

An effect similar to MAVA was detected in eight pure cultures of marine bacteria. The morphological and biochemical characteristics of a number of these organisms differed widely. On multiple sub-cultivation their antiviral activity was lost. MAVA has been observed in the Atlantic Ocean, North Sea, Baltic Sea, Mediterranean Sea and Red Sea.

Simon, M., Pálfi, A. B. (1970). *Virological Examination of Urban Sewage from Budapest. I. Concentration of Virus by Adsorption to Calcium Phosphate.* **EGESZSEGTUDOMANY 14:** 13-18. Hungarian.

Viruses in sewage were adsorbed onto $CaHPO_4$. A purified suspension for inoculation was prepared by subjecting the adsorbed virus first to phosphate buffer of high molarity and then to buffer of low molarity.

Sobsey, M. D., Cooper, R. C. *Laboratory Studies on the Survival of Poliovirus in Algal-Bacterial Wastewater Treatment Systems.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 137-47.

In laboratory studies, considerable antipoliovirus 1 activity was observed in stabilization pond water and in algae-bacteria cultures. Bacterial cultures alone showed less virus-inactivating capacity, and a pure culture of the alga *Scenedesmus quadricauda* had none. Antiviral activity appeared to be associated with either biological activity or heat labile factors, but the specific causes were not identified.

Sollo, F. W., Jr., McGurk, F. F., and Larson, T. E. *Status of Methods for Halogen Determination (Br-Cl).* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York** (1971), 245-67.

Analytical technics for determining halogens and some of their compounds are reviewed and compared.

Sorber, C. A., Sagik, B. P., Malina, J. F., Jr. (1971). *Monitoring of Low-Level Virus in Natural Waters.* **APPL MICROBIOL, 22(3):**334-8.

The effectiveness of the insoluble polyelectrolyte technic (PE 60) for concentrating coliphage T2 was a constant 20% over a range of virus levels from 10^3 to 10^4 PFU/ml. The efficiency of the method was dependent upon pH during the concentration phase.

Sproul, O. J. *Recent Research Results on Virus Inactivation by Water Treatment Processes.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink, Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 159-69.

Research data collected within the past five years on virus inactivation by water softening and alkaline pH conditions, coagulation, filtration, and adsorption are reviewed. Research efforts presently under way are also reviewed.

Sproul, O. J., Thorup, R. T., Wentworth, D. F., Atwell, J. S. *Salt and Virus Inactivation by Chlorine and High pH.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York** (1971), 385-96.

Increased divalent cation concentration increased the rate of inactivation of T2 coliphage by chlorination.

The pH required to produce significant inactivation of poliovirus 1 was higher than that previously reported. No inactivation occurred after 90 minutes at pH 10.5 produced with NaOH and $Ca(OH)_2$, or at 11.5 produced with KOH.

Sullivan, R., Fassolitis, A. C., Larkin, E. P., Read, R. B., Jr., Peeler, J. T. (1971). *Inactivation of Thirty Viruses by Gamma Radiation.* **APPL MICROBIOL, 22(1):**61-5.

The weighted decimal reduction values (D values) of 30 viruses suspended in Eagle's minimum essential medium ranged from 0.39 to 0.53 Mrads. Only one-third of this radiation dose was required to achieve equal inactivation rates in distilled water. The destruction rate curves were those of a first-order reaction.

Sweet, B. H., Klein, E., Ellender, R., Morton, F. C., Smith, J. K. *Concentration of Viruses by Osmotic Ultrafiltration: A Preliminary Report on the Development of a Model System.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 51-8.

The basic physical features of an osmotic ultrafiltration unit and the equipment and solutions employed in experimental studies to concentrate

poliovirus 1 suspended in distilled water are described. The mainstays of the system are the asymmetric cellulose acetate membranes which separate the osmotic and virus compartments.

The system reduced 20 liters of sterile water to 50 ml in 5-1/4 hours. Dehydration of virus-inoculated water allowed 100% recovery of virus.

Sweet, B. H., McHale, J. S., Hardy, K. J., Morton, F., Smith, J. K. and Klein, E. (1971). *Concentration of Virus from Water by Osmotic Ultrafiltration-I. Biological Aspects.* **WATER RES, 5(10):**823-9.

Distilled water seeded with poliovirus 1 was dehydrated by osmotic ultrafiltration in a two compartment system utilizing distilled water as the virus suspending medium and saturated magnesium sulfate, sucrose, or both solutions as the osmotic driving force. The compartments were separated by asymmetric cellulose acetate, reverse osmosis-type membranes.

A minimum virus inoculum of 1.3 PFU/ml could be detected in a 4-liter starting volume. Virus recoveries of 90% or greater were achieved.

Telniceanu, A. (1971). *Epidemiologic Relationships in Viral Hepatitis. Housing Conditions and Water Transmission.* **STUD CERCET INFRA MICROBIOL, 22:**113-22. Rumanian.

The relationships between living conditions (housing, district, drinking water supplies) and the epidemiologic character of hepatitis morbidity were evaluated in four areas of Bucharest during an epidemic in 1969 and 1970.

Telniceanu, A. (1971). *The Epidemic Evolution of Infectious Hepatitis Under Conditions of Intermittent Water Transmission in Urban Areas.* **STUD CERCET INFRA MICROBIOL, 22:**123-33. Rumanian.

The relationship between infectious hepatitis incidence and chlorination of drinking water was investigated. Forty-nine periods, where chlorine was absent, were correlated with infectious hepatitis occurring 31 to 42 days later.

Vajdic, A. H. (1970). *The Isolation of Virus (Bacteriophage) from Water and Wastewater by the Millipore Filter Method.* **WATER MANAGEMENT IN ONTARIO (Ontario Water Resources Commission), 37:**1-22.

A phage of *Escherichia coli* B, in quantities from two to more than 500 MPN, was seeded into volumes of water up to 20 liters and recovered by adsorption onto 0.45 μm cellulose nitrate membrane filters and eluted with 3% beef extract. Recovery efficiencies ranged from 0 to 100%. Reovirus recoveries were greatest from distilled water containing calcium. Lesser recovery efficiencies were experienced with dechlorinated tap water, well water, and surface water. The phage were also recovered from sewage with this method.

Vaněčková, N., Koza, J., Mikešová, V. (1971). *Systematic Follow-up Study of the Circulation of Polioviruses and Other Enteroviruses in Wastewater.* **CS EPIDEM, 20(1):** 18-26. Czechoslovakian.

From November 1962 to October 1966, in ten different regions, 96 viruses were recovered from 229 sewage samples including 44 polioviruses, 20 echoviruses, 8 coxsackieviruses, and 24 untypable viruses. Wild-type poliovirus strains were also recovered from wastewater in two regions.

Verlinde, J. D., Wilterdink, J. B. (1970). *Neurovirulence of Polioviruses.* **ANTONIE VAN LEEUWENHOEK 36:** 587.

From 1964 to 1968, polioviruses were recovered from stools of healthy children in day nurseries and from samples taken from sewage treatment plants.

Five strains each of polioviruses 1, 2, and 3, recovered during the five years of the study, were selected at random and examined for neurovirulence by intraspinal inoculation of cynomolgus monkeys. The degree of neurovirulence was measured by the amount of virus that produced paralysis or characteristic histological lesions.

The neurovirulence of the strains examined ranged from highly neurovirulent to highly attenuated. Most strains were intermediate.

Verlinde, J. D., Wilterdink, J. B. (1970). *Neurovirulence of Polioviruses Recovered from Sewage and Stools of Healthy Children. II. Neurovirulence of Strains of Types 1 and 3.* **ARCH GES VIRUSFORSCH, 32:** 311-17.

The monkey neurovirulence of five strains of poliovirus 1 and five strains of poliovirus 3, recovered from stools of healthy children in day nurseries and from sewage samples taken over a five-year period (1964-1968), was examined. Neurovirulence ranged between the extremes of highly neurovirulent and completely attenuated. The majority of strains possessed an intermediate neurovirulence.

Wallis, C. *Progress in the Development of an Apparatus for Concentration of Viruses from Large Volumes of Water.* **In "Virus and Water Quality: Occurrence and Control," edited by V. Snoeyink. Proceedings of the Thirteenth Water Quality Conference, February 1971. University of Illinois Bulletin, 69** (1971), 47-50.

Poliovirus 1 added to tap water was efficiently recovered by the following procedure. The water was passed through clarifying filters with porosities of 10μm, 5μm, 3μm, and 1μm to remove particulate matter, and then through a 1μm cotton textile filter to electrostatically remove ferric compounds. The water was then passed through a special amberlite resin to remove other insoluble salts and fine silts not removed by the textile filter, and the clean water containing the virus was driven through a virus adsorbent, either a cellulose nitrate membrane or the insoluble polyelectrolyte PE 60. $MgCl_2$

was added to enhance the adsorption of virus on cellulose nitrate membranes when these were used, and CO_2 was added to concentrate the virus on the polyelectrolyte when this was used. Water could be processed at the rate of 300 gph. Virus recovery efficiencies ranged from 61 to 84%.

Wallis, C., Melnick, J. L., Fields, J. E. (1970). *Detection of Viruses in Large Volume of Natural Waters by Concentration on Insoluble Polyelectrolytes.* **WATER RES, 4(12):**787-96.

Poliovirus 1, added to large volumes of tap water, could be recovered by adsorbing it onto thin layers of an insoluble polyelectrolyte (a cross linked copolymer of isobutylene maleic anhydride), and subsequently concentrating the virus into small volumes of elutant for assay. Virus contained in 25, 50, 75 and 100 gallons of water was recovered with efficiencies ranging from 60 to 80%. Poliovirus 1, added to a 17,000 gallon swimming pool, was recovered with an efficiency of about 40% by passing 300 gallons of the pool water through a thin 3 mm polyelectrolyte layer 293 mm in diameter, and subsequently eluting the virus from the layer.

Wallis, C., Melnick, J. L., Fields, J. E. (1971). *Concentration and Purification of Viruses by Adsorption to and Elution from Insoluble Polyelectrolytes.* **APPL MICROBIOL, 21(4):**703-709.

Acid-resistant, nonenveloped viruses of the enterovirus, reovirus, and adenovirus groups concentrated on PE 60, an insoluble cross-linked polyelectrolyte based on isobutylene maleic anhydride. NaOH hydrolysis of PE 60 increased its capacity to adsorb viruses. Maximal virus adsorption occurred at pH levels between pH 3.0 and 4.5, and the adsorbed viruses were readily eluted at pH 8 to 9.

Volumes of cell culture fluids up to one liter, containing 10^8 PFU of virus/ml, were tested. Virus recoveries exceeded 60%.

Whittle, G. P. (1970). *Recent Advances in Determining Free Chlorine.* **In Proceedings of the National Specialty Conference on Disinfection, July 1970. ASCE, New York, New York** (1971), 269-283.

The leuco-crystal violet (LCV) method apparently measures completely unbound, free chlorine present at any instant in time. This specificity apparently stems from inhibition of hydrolysis of N-chlor compounds brought about by mercuric chloride, a reagent in the LCV method.

Application of the LCV method and other methods to solutions of chlorine and cyanurate failed to show significant concentrations of combined chlorine. An explanation of the stabilization and reduced biocidal activity of solutions of chlorine and cyanurate based on ultraviolet energy absorption by the cyanurate molecule was tendered.

Zdražilek, J., Záček, K., Chvapil, J., Mikešová, V., Pokorná, L., Tomanová, V., Trauč, J., Vrábková, J. (1971). *Virological Surveys for Enteroviruses in*

Wastewater. I. Incidence of Polioviruses in Prague at the End of 1968 and in 1969. **CS EPIDEMIOL MICROBIOL IMMUN, 20(3)**:67-72. Czechoslovakian.

In 1968 and 1969, 180 gauze pad samples were collected from 10 points in the main Prague sewers. Polioviruses were recovered from 21 samples, other enteroviruses from 71 samples, and mixtures of polioviruses and other enteroviruses from two samples. No enteroviruses were recovered from 86 samples.

With the exception of one strain of poliovirus 3, recovered from sewage in February 1968, polioviruses were recovered from samples collected only from April to July, a period following mass vaccination of newborn children with live poliovirus vaccine.

Polioviruses apparently did not circulate in the population during the winter months, the period during which they occurred in greatest numbers before introduction of vaccination.