Over 114 different human enteric viruses have been isolated to date and have been implicated in a range of human disease. The group contains the polio and hepatitis A viruses, together with rotavirus (a major cause of infant diarrhoea in developing countries) and norwalk virus which is frequently implicated in outbreaks of idiopathic vomiting and diarrhoea. Both hepatitis A and norwalk viruses still cause problems in Europe.

The factors influencing the numbers and types of viruses in sewage were considered. They were shown to depend partly on the composition of the community from which the sewage derived with special regard to the age, level of health, economic status and general hygiene. It also is related to the composition of sewage, with water from industrical sources having a low virus content.

The treatment of sewage was examined. This process is important because it is the point at which the majority of viruses are released into the environment. Once dispersed a variety of routes exist by which they can return to the community and establish a cycle of infection. These include the contamination of drinking water, crops, shellfish and waters used for recreation. The treatment processes were shown to be capable of producing a range of products both liquid and solid with varying levels of virus contamination. In general viruses tend to associate with the solids and are therefore predominantly found in the sludges. All the treatment processes tended to reduce the numbers of viruses but, with very few exceptions, none removed them entirely. The importance of designing treatment systems with desirable pathogen control characteristics – plug flow rather than fully mixed, for example – was emphasized.

Data were presented on the concentrations of viruses found in a range of sludges and effluents; these were mainly a reflection upon the degree of treatment to which the material had been subjected. The results of a year long study at a treatment works near London were illustrated. These works, processing mainly domestic sewage by the activated sludge method, reduced virus numbers by approximately 99% which was considered to be good by comparison with other published results.

The types and concentration of viruses found in the River Thames over a period of several years were also shown. These viruses which are largely attributable to contamination by treated sewage effluents present a problem when the water is processed to produce drinking water. These findings were interpreted in terms of the epidemic state of the community, the influence of polio vaccination programmes, the ability of the viruses to survive in the environment and the limitations of viral analysis methodology. Successive waves of infection in the community were reflected in the virus content of the river. Amongst the various factors affecting survival temperature was found to be the most important with viruses being adversely affected by high temperatures.

The influence of temperature and time on survival were shown to be significant in a wide variety of treatment processes ranging from sludge digestion, pasteurization and composting to long term storage of lagooning. This theme was expanded to embrace the many other pathogens which may occur in sewage including such resistant organisms as ascaris and taenia.

The presentation concluded with the suggestion that sewage should be regarded as a resource rather than a nuisance. Dried sewage sludge, for instance, contains some 20% fat and 50% protein plus significant quantities of fertilizers such as phosphate and nitrate. The assured destruction of pathogens including viruses will remove one of the major factors inhibiting its re-use.

Environmental contamination with Salmonellae by the spred of animal waste and sewage sludge

C. Breer
Institute of Clinical Microbiology and Immunology, Frohbergstrasse 3, CH-9000 St. Gallen

Sewage sludge, used as a fertilizer in agriculture, is a main source for the pollution of the environment with Salmonellae. Among 370 samples of unsanitized sludge from 207 different sewage disposal plants in Switzerland, Salmonellae were detected in 339 samples (97%). All samples investigated from 199 plants proved to be positive with an average pf 780 Salmonellae per liter.

On the contrary, we were able to isolate Salmonellae only in 7 cases (1.3%) out of 555 samples of slurry from different cattle herds. In 55 farms, however, where the slurry was mixed up with sewage sludge, the percentage of Salmonellae recovery increased to 38.2%.

Among 100 samples of slurry from different pig fattening stations, we could isolate Salmonellae in 23.0% and in addition, the examination of 208 fecal samples from poultry herds revealed the presence of Salmonellae in 51 specimens (24.5%). The spread of animal wastes from intensive fattening plants of pigs and poultry has therefore the same importance for the environmental contamination by Salmonellae as the spread of sewage sludge.

Carotenoids from plankton and purple sulphur bacteria in lake sediments as indicators of changes in the environment

H. Züllig
CH-9424 Rheineck

The vast increase in the influx of phosphorus into our lakes during this century has led to a series of well-known phenomena associated with eutrophication, thereby altering a sector of our environment in a spectacular manner.

The primary effect, an increase in the production of plankton, has resulted in part of the pigments produced by biomass aggregating on lake beds, particularly carotenes, carotenoids, chlorophylls and phaeophytine. Alcohol and acetone mixed in a ratio of 1:1 release these coloring matters from bore samples. The amount of crude carotenoids can be determined almost exactly by photometry, measuring at 665 and 450 nm. The carotenes and carotenoids are separated by gradual development of the sediment extracts on silica gel thin layer plates, using hexane-acetone-propanol-2-mixtures. Their presence is not only proof of their conservation in lake sediment but also enables a qualitative and quantitative reconstruction of earlier plankton biocenosis according to order, family and sometimes also genus of the various algae.

The behavior of the dreaded *Oscillatoria rubescens* (so-called Burgundian blood) in Swiss lakes is manifested by

a specific carotenoid, oscillaxanthine. Its presence in the lakes in and around the Swiss Central Plateau during past centuries – even some 13,000 years ago – has likewise been established.

In the sediments of shallow lakes, carotenoids of photoautotrophic bacteria have also been observed. Okenone is widespread, currently particularly known from *Chromatium okenii, Chromatium weissii* and *Thiopedia*. Due to their anaerobic photosynthetic nature, the presence of their pigments in sediment strata are an indication that at the time of sedimentation, no oxygen was present at the floor of the lake or in the adjacent water zones, e.g. in the Lake of Cadagno (1950 m above sea level) for many centuries and in the Rotsee near Lucerne at least since the year 1300.

Stratigraphic study of pigments enables research into natural postglacial developments and into recent eras influenced by civilization.

Lichens as indicators of air pollution (zone scales of Geneva)

G. Turian
Laboratoire de Microbiologie générale, Université de Genève, CH-1211 Genève 4

Lichens are dual, algo-fungal, organisms which are often stated to be primary colonizers of substrates such as rock. However, in such a function and depending upon environmental conditions such as temporary humidity, they can be preceded by cyanobacterial pioneers developing not only as 'Tintenstriche' on calcareous alpine cliffs[1] but also on urban walls of concrete *(Chrysocapsa*[2]*)*. Such 'blue green algae' including *Gloeocapsa sanguinea* and *Chroococcus lithophilus*[3] share their resistance to air pollution with the subaerial green alga *Pleurococcus vulgaris* intermixed with a dematiaceous mold, *Coniosporium aeroalgicolum*[4] colonizing the bark of tree trunks in soot-polluted city areas. Only a few crustose lichens such as species of *Lepraria, Lecanora* (*L. dispersa,* etc.) and *Caloplaca* (*C. citrina, lithophila,* etc.) are equally poleo-resistant; *Lecanora conizaeoides* is especially noticeable in being a selective benefitor of air pollution but its remarkable resistance to SO_2 under acid conditions remains unexplained[5].

The sensitivity of lichens to air pollution upgrades from such crustose to fruticulose species (*Evernia, Usnea* spp., etc.) through the intermediary foliose types (*Physcia, Parmelia, Xanthoria* spp.). Crustose types are more or less embedded in their substrate, bark or rock, which can have a high base content as that of asbestos tiles or limestone walls providing them additional protection against acidic pollutants[6]; the reduction of their receptive surface is another factor of their poleoresistance.

In a general way, the extreme susceptibility of lichens to air pollution has been ascribed to their indiscriminate and rapid absorption of solutes over the thallic surface, their accumulation of pollutants without excretion possibility and their slow metabolic rate[7]. Such differential pollution sensitivity of lichens has led many researchers to use them as indicators of air pollution in urban and suburban areas and to propose sensitivity scales to evaluate their poleo-tolerance parallely to the chemical assays of pollutants (SO_2, NO_x, O_3, ...)[8]. From the start[9] it has been concluded that lichen distribution corresponded markedly with the levels of air pollution, mainly SO_2. It has been shown that 100 ppb of gaseous SO_2 can produce deleterious effects on lichen metabolism, but that such effects could be reversed in an SO_2-free atmosphere[10]. In an epiphytic *Evernia* species, metabolic processes such as photosynthetic CO_2-fixation, protein and lipid biosynthesis were found to be very sensitive to SO_2[11]. Photochemical oxidizing agents, such as ozone and PAN (peroxyacetylnitrate) have also been found to induce a decrease in the photosynthesis of lichens[12]. As for NO_x, it would only be toxic in synergic action with the other pollutants among which SO_2[13]. However, the lichen scarcity in built-up areas might partially at least, also reflect the low humidity of these areas. It is now widely admitted that both factors interact and that pollution is the overriding factor of the scarcity of lichens in wide areas surrounding cities. The main value of zone scales is that, "where correlations with pollutant levels have been established, large areas can be surveyed quickly and maps produced which give a valuable indication of pollution patterns"[8]. In Switzerland, Vareschi[14] had mapped Zürich in 1936; his polluted zones have greatly expanded until the most recent mapping of epiphytes of that city by Züst[15].

In Geneva, Turian and Desbaumes[16] have described three centrifugal belts of isopollution by SO_2: the 'greyish belt' ($\sim$ 1 km diameter) of the marker *Physconia grisea* circling the downtown lichenic desert area (only the Cyanobacteria, *Pleurococcus* + *Coniosporium,* and a few crustaceous epilithic lichens) assayed at $\sim$ 100 µg SO_2/m^3 in 1975; the 'yellow belt' ($\sim$ 2 km diameter) of *Xanthoria parietina* resisting at 60–70 µg SO_2/m^3; the 'green belt' of *Parmelia caperata* (not resistant over 50 µg SO_2/m^3), at only 2.5 km from the center of Geneva in 1975–1984, but at 25 km in Paris[7] and at least 40 km in London[8]. Among other markers, *P. scortea* is noticeable on tree trunks of the peripheral parks (Mont-Repos); it is sterile there while fertile (brownish apothecia) in Verbois ($\sim$ 10 km from the center). *Evernia prunastri* shows reduced fruticulous thalli in Grand-Lancy (3 km from center) while *Anaptychia ciliaris* occurs but sterile at Aire-la-Ville ($\sim$ 10 km).

In some areas of the canton of Geneva the situation is still deterioting. A recent example is that of the colonies of *Parmelia caperata* epiphytic on the bush trunks at the boundary of the forest fronting at 2 km south-west. the long axis of the aeroport of Cointrin; central brown-black necrotic spots which were small when photographed in 1974[16] have greatly expanded and some colonies have practically vanished except their peripheral greenish crown (Turian, unpubl. observations, March 1984). In other cases, the air quality has improved as in London (U.K.) where mean SO_2 levels have fallen markedly during the past 15 years. A survey of many sites demonstrated in 1981 that several species among which *P. sulcata* and even *P. caperata,* extinct or very rare in those areas in 1970, have extended their range considerably[17].

Similar improvement has also been noticed in the city of Geneva where air pollution by SO_2 could be reduced by half (J.-C. Landry, oral communication), with a parallel