Columbus testing station, and consists in the digestion of the sample by concentrated sulphuric acid, subsequent neutralization and direct nesslerization. The free ammonia is distilled previous to nesslerization. Very often the sample is nesslerized directly after adding a few drops of potassium hydrate and copper sulphate, the resulting precipitate being allowed to settle. The nitrates are determined by the napthylamine-sulphanilic acid method, and the nitrates by aluminum reduction in alkaline solution.

Formation of Hydrogen Sulphide.—Another interesting topic in the chemistry of sewage is the formation of hydrogen sulphide, the history of the sulphur cycle resembling that of the nitrogen cycle. Its presence in sewage indicates putrefactive changes as a rule, since sulphur is an element of the protein molecule, and as such is always present in small quantities in sewage. Plants absorbing mineral sulphates convert them into organic sulphur. On breaking down, organic sulphur yields hydrogen sulphide which becomes oxidized again to sulphates, either by chemical or biological means. Just as nitrates can be reduced to free ammonia, so are sulphates capable of reduction to hydrogen sulphide. Apparently the sulphur cycle is influenced more by purely chemical reactions than is the nitrogen cycle, but in both cases the changes are largely the result of bacterial activities.

The principal question for further study is the generation of hydrogen sulphide from inorganic sulphates, since hydrogen sulphide is one of the constituents most intimately connected with the development of a nuisance, and may also be responsible for damage to concrete work. Practically all sewage bacteria will form the gas in artificial media containing sufficient organic sulphur. Any sewage containing hydrogen sulphide may form a black sediment typical of septic conditions, the sediment consisting mainly of ferrous sulphide, since iron is almost always present in sewage in varying amounts. Other gases, however, may originate from the destruction of organic sulphur, as for instance, mercaptan. The formation of hydrogen sulphide, however, from sulphates is of more importance perhaps than its formation from organic sulphur, since sulphates are often present in large quantities. The reaction is undoubtedly due to specific types of bacteria, rather than to a wide group. Beyerinck first noted the phenomenon, and stated that the best conditions for the reduction of sulphates were the absence of oxygen, the absence of sugar in the culture media, and the presence of phosphates and other suitable solids. Only small quantities of nitrogen compounds are necessary. The optimum temperature is around 25° Cent. Beyerinck isolated an organism, the spirillum desulphuricans, a strictly anaerobic organism reducing sulphates. Other important work has been carried on by Van Delden, Letts, and recently by Dr. Buchanan.

Significance of Hydrogen Sulphide.—Hydrogen sulphide in sewage may not only be responsible for a local nuisance, since amounts as small as 3 p.p.m. can be noted under outside conditions, but on discharge into a stream it will draw upon the dissolved oxygen present, and often to such an extent that fish life will be seriously interfered with. In addition, hydrogen sulphide by itself is a poison to fish. The reduction of sulphates has been observed in many sewages in the United States and abroad, particularly when the sulphates are high from the introduction of trade wastes. In some cases the disintegration of concrete has been a serious matter, due to the oxidation of hydrogen sulphide to sulphuric acid by the atmospheric oxygen.

One of our settling tanks, a modified Dortmund tank, or, as Professor Phelps calls it, a biolytic tank, affords a typical case of active sulphate reduction. At times as much as 40 p.p.m. of hydrogen sulphide have been observed in the effluent. This can be traced directly to bacterial activity.

Before dismissing this topic, I will mention the classic work of Winogradsky, who made an exhaustive study of the oxidation of free sulphur by higher bacteria, such as beggiatoa. The beggiatoa utilize the sulphur as a source of energy, taking up from two to four times their weight without increasing in growth. Requiring but small quantities of organic matter they flourish in sulphur springs, the decomposing hydrogen sulphide liberating amorphous sulphur. The sulphur in turn is oxidized to sulphates. The effluent of our biolytic tank is quickly oxidized in a sprinkling filter. The effluent of the filter, however, contains abnormally large amounts of sulphate, and the top of the filter is covered by a silk-like growth of sulphur bacteria.

In a sewage-disposal plant there is, as a rule, no occasion to test for hydrogen sulphide as a routine procedure. The sense of smell or a simple lead acetate paper test should suffice, unless some peculiar case requires special investigation.

Chlorine.—The chlorine in a domestic sewage originates largely from the urinary chlorine, and indicates approximately the strength of a sewage. It can be easily determined by direct titration with silver nitrate solution, using potassium chromate as an indicator. Except as an index to the strength of the sewage, the chlorine determination has no further significance. The presence of industrial wastes containing chlorine, or of ground waters or sea water, may prevent us from drawing conclusions. On an average, the sewage of 39th Street contains about 40 p.p.m. of chlorine, indicating a dilute sewage.

Alkalinity.—The alkalinity has little significance in the interpretation of results, since industrial wastes may cause abnormal figures. Sewage ordinarily is slightly alkaline, considerable quantities of acid waste being required in order to turn it acid in the sewer. The average alkalinity of our sewage is 220 p.p.m., calculated as calcium carbonate. We titrate our sample with 1/50 normal sulphuric acid. Methyl orange is used as in indicator.

Fats.—In domestic sewage the fats and fatty bodies result largely from the use of soap in laundries and from household wastes containing grease. On Monday there is a slight increase in the fatty content of our sewage, but the addition is not great, since on our watershed there is a large proportion of apartment houses where washing is spread over several days of the week. No attempt is made to separate the fat from the soaps. On the addition of sulphuric acid, a certain quantity of sewage is evaporated to dryness, and the total fat extracted with ether. The average amount present in our sewage is approximately 25 p.p.m.

Total Solids.—The total solids in sewage are not now determined as a routine procedure, being largely of scientific interest. In our case the amount is about 600 p.p.m., or 0.6 of a gm. per liter. This indicates the extreme dilute character of our sewage.

Dissolved Oxygen and Stability.—Dissolved oxygen and putrescibility will be discussed together, since while both are determined separately, neither is by itself as instructive as when studied in connection with the other. The two determinations not only furnish a key to certain phenomena in biologic sewage disposal, but when their relation is better understood the solution of many problems will be attained. In a popular sense, putrescible matter is material which draws upon the oxygen in solution for its oxidation. However, inorganic compounds sometimes utilize oxygen in solution for their oxidation as well. From the standpoint of sewage disposal by dilution, or in studying the effect upon fish life, it is immaterial how the oxygen is used up. During the colder season, fresh dilute domestic sewages contain, as a rule some oxygen which in a short time becomes exhausted, and anaerobic conditions set in. The liquid then enters a stage where oxygen is quickly absorbed when supplied in any form.