make their values important factors in the economy of sewage disposal processes. That other is a new chemical precipitation process known as the Miles acid process, and to describe it and to indicate its possibilities is the object of this paper.

Further Information Necessary

While all of the large-scale trials of the Miles process have been giving promising results, it is true that the drying and degreasing of sludge has never been practised on a large scale. All of the estimates are based upon small-scale trials and the opinions of engineers and of manufacturers who have handled similar materials. There is great need, therefore, for a large-scale experiment with normal sewage to determine the actual possibilities in practice. This experiment should be made on a scale large enough to determined beyond all doubt the cost of drying and degreasing and the possibility of marketing the products. It might cost $50,000.

Adaptability of Miles Process

In the words of Winslow and Mohlman,—"For communities where clarification and disinfection are desirable, —where screening would be insufficient and nitrification unnecessary,—the process of acid treatment comes fairly into competition with other forms of tank treatment; and that it is particularly suited to dealing with sewages which contain industrial wastes and for use in localities where local nuisances must be avoided at all costs and where sludge disposal could be provided for only with difficulty." This means that in 90% of the cases where a large volume of strong sewage is discharged, the Miles process is worthy of consideration.

Conclusions

We conclude the following from the results of the various experiments and studies:—

(1) The Miles process will produce a well disinfected effluent from which 90% of the settleable solids have been removed.

(2) Whereas it requires for its accomplishment devices for the chemical treatment of the sewage and for drying and degreasing the sludge, competent supervision is necessary.

(3) On account of the nature of the plant and the relatively high cost of operation for small installations, it is not well adapted for the purification of small volumes of sewage.

(4) Its operation should cause no local nuisances.

(5) It causes the removal of over 99% of the bacteria.

(6) The effluent remains stable long enough for the neutralization of the excess acid, and the oxidization of the sulphites and the sulphates by dilution.

(7) As compared with the activated sludge process, the volume of sludge is very small.

(8) Compared with the cost of the oxidation processes, the cost of installation is low; it is somewhat higher than that for Imhoff tanks with chlorination.

(9) The products recovered are valuable, and their recovery would effect a conservation of natural resources.

(10) Apparently it is the most economical process for producing so well clarified and so stable an effluent, and under present conditions it seems as if it could be installed and operated at a profit in those larger cities where the conditions are favorable.

(11) To determine the costs of sludge drying and degreasing more accurately than is possible from the available data, a large-scale experiment is urgently needed.

History of Miles Process

Beginning about the year 1900, Mr. George W. Miles, a well-known Boston chemist, with the co-operation of the officers of the Boston Sewer Department, suggested the use of acid to accelerate the precipitation and separation of sludge, and proposed to recover fats and fertilizer from the sludge so produced. The most important factor in the new process consists in the application of the acid to the sewage itself, rather than to the sludge precipitated therefrom; and it lays emphasis upon the decomposition of the soluble soaps and the liberation of the fatty acids,* which latter do not appear as fats when unacidified sewage is tested by standard methods, and are only partially precipitated with the sludge in plain subsiding basins. Furthermore, Miles has suggested the use of sulphur-dioxide gas rather than the sulphuric acid† made from it, thereby avoiding several expensive steps in its manufacture and greatly reducing the cost, besides bringing into play the disinfecting action of the sulphur-dioxide gas upon the sewage itself. If desired, a combination of sulphuric and sulphurous acids may be used.

Sodium acid sulphate (niter cake) is the waste product from the nitric-acid plants, and, as a result of the war, there are enormous quantities of this material piled near nitric-acid plants, for which there is now little use. At the present time this is the cheapest source of sulphuric acid. Before the war, the cheapest source was either sulphur or pyrite (ferrous sulphide).

Experiments

Experiments conducted by one of us (E.S.D.), and by other officers of the Sewer Division of the city of Boston, were made at different times between June 20, 1911, and June 29, 1914. In all, eleven runs were made at different times during the four years, and 25,986 gals. of sewage were treated. The quantities of products recovered per million gallons of Boston sewage, during these experiments, were, as averaged, 1,738 lbs. of dry sludge, containing 21.7% or 436 lbs. of grease, and 1,361 lbs. of fertilizer base, having an ammonia content of 4.5%.

Early in 1915, one of us (E.S.D.) delivered a lecture before the students in the Public Health Department of the Massachusetts Institute of Technology, on the possibilities of the Miles process. The subject, as presented, greatly interested Prof. William T. Sedgwick, who later arranged with Mayor Curley for a large-scale experiment at the joint expense of the city of Boston and the Sanitary Research Laboratory of the Institute.

In the Technology experiments two continuous runs were made, one of seven days in July, and one of three days in November, 1915; and the volume of sewage treated averaged 8,241 gals. daily. The experiments are described elsewhere,‡ but the results obtained during the city's experiments were almost duplicated, as the following table shows:

During the summer of 1914, Mr. Langdon Pearse, division engineer of the sanitary district of Chicago, made experiments¶ to learn whether acidification could increase the yield of fat from the Centre Avenue sewage. Tests in barrels and in a tank holding about 1,500 gallons were made under his direction. A three-hour period of subsidence was used, and the alkaline sewage required about 3,200 lbs. of 100% H_2SO_4 per million gallons. Sulphur dioxide was not tried.

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* Most fats are combinations of glycerine with fatty acids. Soaps are combinations of fatty acids with sodium or potassium. Soaps are soluble, and if a sewage containing them be evaporated, and the residue extracted with ether (the ordinary method of obtaining the fats), the fatty acids in the soaps are not dissolved. On the other hand, if acids be added, they decompose the soaps, set free the fatty acids, and then, if the sewage be evaporated or extracted with ether or another solvent, the fatty acid is dissolved with the true fats. The fatty acids recovered by the extraction of the sludge from acid-treated sewage, may be remade into soaps by treatment with soda or potash.

† Theoretically, sulphuric acid is oxidized sulphur plus water, that is:

$$S + O = SO_2 \quad \text{(Sulphur Dioxide).}$$
$$SO_2 + H_2O = H_2SO_3 \quad \text{(Sulphurous Acid).}$$
$$H_2SO_3 + O = H_2SO_4 \quad \text{(Sulphuric Acid).}$$

Sulphurous acid is more effective than sulphuric acid for treating sewage. Furthermore, its use avoids the cost of oxidizing the sulphur dioxide. This is ordinarily accomplished by the use of nitric acid and the oxides of nitrogen in what is called a "lead chamber," into which nitrogen trioxide (N_2O_3), steam and air are introduced with the sulphur dioxide. The more modern way is to produce oxidization by direct contact of sulphur dioxide, oxygen and water with spongy platinum or some other catalytic agent, activated by electricity. From either the old or the new process dilute sulphuric acid results, and the cost of concentration as well as the cost of transporting the water, which is a necessary part of the finished product, ordinarily enter into the cost of sulphuric acid. It must, therefore, be added to the cost of sewage treated when sulphuric rather than sulphurous acid is used.

‡ Weston, R. S., 1916. Tests of a New Process of Sewage Purification, with Grease Recovery and Apparent Profit. American Journal of Public Health, 6, 334. Reprinted in Boston City Record, March 3, 1917.

¶ Sanitary District of Chicago, Report on Industrial Wastes, 1914, pp. 191-194.