acre-feet, assuming that the three upper ones could always be filled. The stream records of the total flow occurring above the lowest reservoir for 1911-1916 show an average water supply of 20,266 acre-feet varying from 8,660 acre-feet to 34,745 in dry and wet years. Lying below the four reservoirs there are 5,378 acres of irrigable land and above them 1,178 acres.

The development of the reservoirs as indicated above would give an assured and fully controlled supply to all the irrigable land now developed. It would also allow of new irrigable land utilizing the surplus spring flow during the wet years, say, four out of every six, but the new irrigable land would have no assurance of supply during the other two years if we accept the run-off for 1911-1916 as typical.

SOME CHARACTERISTICS OF THE ACTIVATED SLUDGE PROCESS OF SEWAGE TREATMENT*

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THE most recent development in the art of sewage treatment is the activated sludge process. This method of treatment is unique in that the process may be adapted to accomplish clarification without stability, or it may be carried to the point of producing a stable effluent without much excess of available oxygen, or it may be carried still further to the point of producing a highly nitrified effluent comparable with that from the intermittent filter.

Requisites of Process

The requisites of the activated sludge process are:

1. A sufficient proportion of bacterially-active sludge.
2. Intimate mixture of the activated sludge with the sewage to be treated.
3. A supply of atmospheric oxygen ample for the bacterial demand.
4. A time of contact, or period of aeration sufficient to accomplish the desired degree of purification.
5. A temperature of aeration not too cold nor too warm for bacterial growth.

Activated sludge may be obtained by sufficient aeration of successive portions of sewage. A proportion equivalent to about 25 per cent. of the volume of sewage to be treated, is usually sufficient.

Intimate mixture of the activated sludge with the sewage may be secured by the proper application of the air which is required to support the bacterial life upon which the process depends.

The air must be uniformly distributed through the mixture, in order to supply all parts of the liquid with ample oxygen. A period of aeration of 4 hours appears to be sufficient for ordinary sewage. The indications are that about 1.75 cu. ft. of air per gallon of sewage will suffice under ordinary conditions.

Satisfactory results have been obtained even during winter weather, although it appears to be difficult to secure nitrification at cold temperatures.

Means of Air Diffusion

Theoretically, at least, the air must be well diffused in order to be used economically, and as the compressed air is one of the chief elements in the cost of sewage treatment by this process, the question of air diffusion is a very important one. Porous plates—of such materials as filtros, corundum and certain woods—are well adapted for the diffusion of air, but fear is expressed that such materials will become clogged in spite of all precautions, such as washing the air to be applied.

The consensus of opinion at the present time appears to be that something must be sacrificed in theoretical efficiency in favor of the more practical means, such as perforated pipes.

Theory of Action

Activated sludge is a light, flocculent substance, brown in color and earthy in odor. It contains large numbers of bacteria which appear to be essential to the process. When activated sludge is brought into contact with sewage, it will attract and absorb the suspended and colloidal matters and a portion of the dissolved matters, and submit them to bacterial oxidation.

The extent of oxidation of the absorbed organic matters will depend upon the period of contact afforded. It is possible, by lengthening the period of aeration, to secure a large percentage digestion of the sludge, occasioned by the transformation of organic matters into gases. It is possible to carry the aeration to the point of over-activation of the sludge, resulting in the disintegration of the sludge flocculi and a consequently muddy-appearing effluent.

Under-activation is characterized by a darker, more feathery and more voluminous condition of the sludge. If the sludge remains without sufficient air it will become disagreeable in odor, due to purification, and will finally become deactivated.

Method of Operation

The activated sludge process is carried out in tanks operated either on the fill-and-draw plan or upon the continuous flow principle. In the former case the tank is filled with the sewage, aerated for the required period of time and then allowed to settle, after which the clear, supernatent water is drawn off ready for the next tank-filling. In the latter case, sludge will be carried out of the aeration tank with the effluent and must be removed by sedimentation tanks and returned in proper proportion to the incoming sewage. It may be advantageous to re-activate the sludge so removed, before it is returned to the sewage.

Disposal of Activated Sludge

The activated sludge in excess of that required for the treatment, must be disposed of, and as the volume of such sludge is relatively large, the problem of its disposal is a serious one. Owing to its gelatinous nature and high water content—about 95 per cent.—it does not dry out as readily on sludge-drying beds as some other kinds of sewage sludge. After drying to a spadeable condition it is likely still to contain in the vicinity of 75 per cent. water. It may be readily filter-pressed to about the same water content.

Analyses of dried activated sludge indicate that it has greater fertilizing value than other sewage sludge, owing principally to a larger nitrogen content and a greater proportion of nitrogen available for plant food. Attention is now directed to the problem of dewatering and drying this sludge, at a cost which will either greatly reduce the cost of sludge disposal or actually make sludge disposal commercially profitable.

*From an address to the American Chemical Society.