but it suffices in order to show that the general order of the turbidities is similar to that of the rate of filtration.

TABLE V.

Lake Ontario Water—Toronto Island Plant.

Turbidities in Parts per Million.

	March, 1912 Ave.	Max.	Min.	April, 1912 Ave.	Max.	Min.	May, 1912 Ave.	Max.	Min.
Turbidity of Raw Water	9	73	1	44	163	2	68	44	2
Filter Rates in Million Gallons per Acre per Day	5.44	6.79	3.09	5.41	7.05	3.10	6.45	5.52	3.67
Turbidities of Effluents	0 63	0.59	0.54	2.35	2.63	1.29	0 60	0.63	0.53

The degree of fineness of the particles causing the turbidity was determined on many occasions. At the commencement of a storm the coefficient of fineness ($\frac{\text{suspended solids}}{\text{turbidity}}$ both expressed in parts per million) was often approximately 2, but this usually decreased as the total turbidity diminished until values of 0.4 were

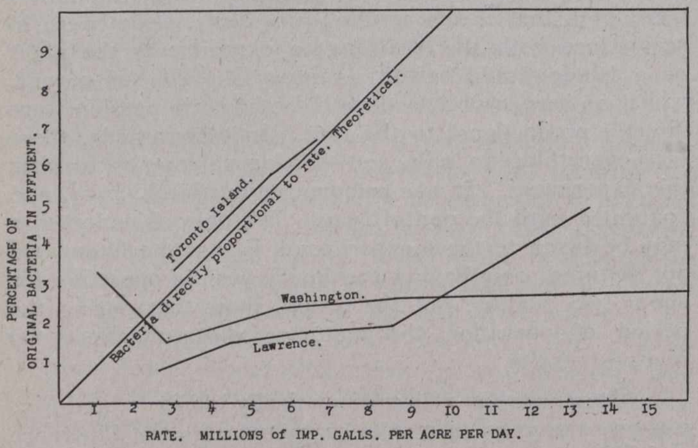

Fig. 2.

obtained. Such fine turbidities are more difficult to remove by filtration but do not affect schmutzdecke formation to the same degree as the coarser particles.

The average length of run and the average number of gallons filtered per run are given in the following table:

Filter rate. Million gallons per acre per day	3.29	5.46	6.76
Millions of gallons filtered per run per acre.			
Average	121.72	111.89	130.91
Maximum	177.92	165.35	222.40
Minimum	76.94	55.40	39.39
Length of run in days.			
Average	38	20	19
Maximum	59	32	32
Minimum	25	10	7

The length of run and volume of water filtered are both about three times the values obtained by the Provincial Board of Health with the experimental filters.

These results show that although slower rates of filtration tend to prolonged runs, the quantity of water filtered per run is approximately the same for the three rates used.

Taking bacterial purification, turbidity removal, and volume of water filtered per run into consideration, the highest rate, about 605 million gallons per acre per day, would seem to be the most economical, and where bacterial purification can be supplemented by chlorination, there seems to be no reason why such rates should not be advantageously used.

Removal of Odors.—The objectionable fishy and grassy odors of many waters are due to the decomposed or disrupted particles of algae and, being in solution in the water, cannot be removed by filtration. The organisms usually found to be the cause of such odors are Asterionella, Volvox, Uroglena, Eudorina, and Pandorina. The green color and fishy odor of the St. Lawrence River water in October is probably due to Uroglena Americana, an organism which contains many surficial oil sacs whose contents are discharged on the disintegration of the cell. An abnormal development of Asterionella at one of the filter works of the London Metropolitan Water Board during the summer of 1913 was the origin of many complaints of this character.

Filter Manipulation.—In order to obtain efficient working combined with a minimum expenditure, a thorough appreciation of the general principles of sand filtration is essential. New beds should be worked below their nominal rate until bacteriological examinations indicate the desired quality of filtrate or the effluents sterilized by chlorine before being sent into the supply. As chlorination as an adjunct to filtration is becoming more and more general, it will generally be found advisable to put the beds into operation at once at approximately their nominal capacity with the exception of the reserve ones which are matured as slowly as possible. If all the working beds are run at exactly their nominal capacity they would all require scraping at the same time and it is therefore preferable to vary the rates slightly until a rotation is secured in the runs. Once this has been established the rates should be kept as constant as possible and radical changes only made in cases of emergency.

As the rate of filtration varies with the head of water in a filter, this must be kept constant also. When a filter is taken out of service for scraping or raking, the water above the sand should be allowed to filter through into the reservoir if time will permit, and the level reduced to about six inches below the surface of the sand. This, of course, does not apply where the Brooklyn or similar methods of washing are in operation. After scraping, the filter should be slowly back-filled with the effluent from another filter until the water level is several inches above the sand before running raw water on the bed. This prevents the formation of ripples on the sand surface. When a filter is put out of operation owing to loss of capacity due to excessive friction in the schmutzdecke, the rate can be restored and the loss of head reduced by scratching the surface thoroughly with rakes. This is not so effective as scraping and cannot be repeated successfully twice in succession, but as the time and labor required are less it is probable that it is economical to alternate such treatment with scraping. The sand section removed after raking followed by scraping is, of course, thicker than when scraping alone is used, and this complicates the difficulty of arriving at the comparative cost of the two methods.

When the dirty sand is removed from the filter for washing it is desirable that either special provision be made for storage of this sand in the winter or else the sand-washing plant and storage bins covered and heated so as to permit of operation all the year round. In the former case the sand-washing plant generally must be of very generous dimensions and sand bins in proportion, but in this climate the latter is probably the better method.

Filter operators agree that the sand should not be washed thoroughly clean, as slightly dirty sand gives better results in the filter and does not require as much time to mature as clean sand. Some are of the opinion that sand should be allowed to mature for some time in the storage bins before being returned to the filter, but