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AUGUST 1962

dry summer the sludge was removed easily in an unfrozen state without the need of using the ripper at a cost of $0.78/ton of dry solids.

Summary

It is now felt that this is an acceptable arrangement of removing the sludge from the lagoons under all climatic conditions. If the sludge is dry it can be removed in the early fall without scrapers; if it is wet the operation is delayed until the early winter when the sludge has frozen and can then be removed by using the ripper and scrapers.

MEETINGS OF INTEREST

Aug. 20–25	**15th International Congress of Limnology,** Madison, Wis. Dr. John C. Wright, Birge Hall, University of Wisconsin, Madison 6, Wis.
Aug. 26–29	**American Institute of Chemical Engineers,** Denver Hilton Hotel, Denver, Colo.
Aug. 26–30	**American Institute of Biological Sciences,** Annual Meeting, Corvallis, Ore. Dr. John R. Olive, 2000 P St., N. W., Washington 6, D. C.
Aug. 26–Sept. 1	**7th Convention of the Union Panamericana de Asociaciones de Ingenieros,** *San Juan Hotel, San Juan, Puerto Rico.* Steering Committee, 7th UPADI Convention, P. O. Box 218, Roosevelt, Puerto Rico.
Sept. 3–7	**International Conference on Water Pollution Research,** Church House, London, England. Write Federation office for information.
Sept. 9–14	**American Chemical Society,** 142nd National Meeting, Atlantic City, N. J.
Oct. 1–12	**Plankton Identification and Control,** Cincinnati, Ohio. Chief, Training Program, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Parkway, Cincinnati, Ohio, or a Regional Public Health Service office.
Oct. 15–19	**American Public Health Association,** 90th Annual Meeting, Fontainebleau Hotel, Miami Beach, Fla.
Oct. 15–26	**Bio-Oxidation of Industrial Wastes,** Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio; see above.
Nov. 1–3	**National Society of Professional Engineers,** Westward Ho Hotel, Phoenix, Ariz.
Nov. 26–30	**Radioactive Pollutants in Water,** Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio; see above.
Dec. 3–7	**Radionuclides in Water,** Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio; see above.
Dec. 3–14	**Chemical Analyses for Water Quality,** Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio; see above.
Dec. 10–12	**National Conference on Air Pollution,** Sheraton-Park Hotel, Washington, D. C. Public Health Service, Washington 25, D. C.
Dec. 10–14	**Sewage Treatment and Public Health Education,** Central Public Health Engineering Research Institute, Nagpur, India. Papers and abstracts by Sept. 15 to Dr. N. U. Rao, C.P.H.E.R.I., 70/1, Civil Lines, Nagpur, India.

BIOLOGICAL TREATMENT OF FINE CHEMICAL PLANT WASTES

W. R. Horne, H. E. Hartman, U. S. Rinaca, and R. L. St. Clair

The purpose of this paper is to describe the methods and performance of the treatment of the strong, complex waste streams which result from the manufacture of fine chemicals and pharmaceutical products.

The Stonewall Plant of Merck & Co. is located near Elkton, Va. on the South Fork of the Shenandoah River. The operations include organic syntheses, fermentation, extraction, and solvent recovery, and are involved in the production of vitamin B-1, vitamin B-2, vitamin B-12, the antibiotic streptomycin, the amino acid lysine, the coccidiostats sulfaquinoxaline, nicarbazin, and amprolium, and various feed supplements.

Figure 1 shows the South Fork from a position just above the plant outfall. The Shenandoah River is a recreational type, high quality stream that serves as a source of potable water for municipalities. It is a relatively clear, fast flowing, fertile stream renowned for its bass fishing. The North and South Forks, separated by Massanutten Mountain, flow northward through the Shenandoah Valley some 150 miles to Front Royal, Va. From that point, the main Shenandoah continues north to Harpers Ferry, W. Va., where it joins the Potomac River.

The wastes from the plant are segregated into three separate streams, which are:

1. Cooling water.—Some 6 to 7 mgd of uncontaminated cooling water are discharged directly to the river without treatment.

2. Sanitary wastes.—Approximately 20,000 gpd of sanitary wastes are collected via a separate sewer system for primary and secondary treatment.

3. Chemical waste.—This stream is the primary concern of this paper. Its characteristics are: flow, 1.25 to 1.5 *mgd*; COD, 4,000 to 5,500 mg/l; BOD, 1,700 to 2,300 mg/l; SS, 500 to 1,200 mg/l; pH, 1.0 to 11.0.

As might be expected in operations which vary from fermentation and extraction to multi-step organic syntheses, the waste streams are complex and varied in their amenability to biological degradation. In general, however, the nutritive elements such as nitrogen and phosphorus are present in quantities generally regarded as adequate for biological metabolism. At the inception of a new process, the waste streams from each step are sampled and analyzed to determine treatability and to assist in in-process reduction of waste strength. All processes are re-sampled periodically in order to measure the effect of changes in process. Figure 2 is a flowsheet of the entire waste treatment system, except for the facilities used for at-source neutralization. Figure 3 is an overall view of the treatment plant.

Pretreatment

The strong chemical wastes are collected and treated as described in the following.

W. R. Horne is Department Head; H. E. Hartman is Staff Engineer; U. S. Rinaca is Senior Process Supervisor; and R. L. St. Clair is Senior Staff Engineer; all of the Stonewall Plant of Merck & Co., Elkton, Va.

The paper was presented at the 34th Annual Meeting of the Water Pollution Control Federation in Milwaukee, Wis., Oct. 8–12, 1961.

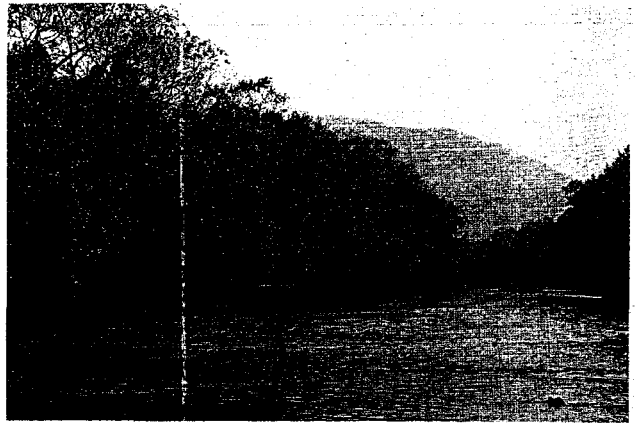


FIGURE 1.—South Branch Shenandoah River at Stonewall Plant outfall.

At-Source Neutralization

To reduce chemical corrosion in the sewer mains and laterals and to lower the cost of neutralization at the treatment plant, strongly acid wastes are routed to wooden neutralizing tubs located strategically in the manufacturing area. Here the wastes are automatically neutralized with alkaline wastes from various processes or with fresh ammonia water. In addition to the advantages mentioned, the technique of at-source neutralization is beneficial to the extent that it minimizes hydraulic and organic surges. However, such a program must be preceded by a careful analysis of the many chemical waste streams.

Grit and Trash Removal

The chemical wastes then enter the treatment plant through a mechanical grit and trash removal unit where the grosser detritus is settled and removed continuously via timer-actuated movement of an endless-chain bucket elevator. Floating debris is retained by a bar screen and continuously removed.

Equalization and pH Adjustment

The chemical wastes then flow into a combined equalization-sedimentation basin. This 60-ft diameter basin has a sidewall depth of 15 ft. Its 315,000-gal capacity retains the waste for 5 to 6 hr, during which time additional sedimentation, acid and alkaline equalization, and removal of immiscibles occurs. The floating immiscibles are continuously removed by a surface skimming mechanism and burned. The settled solids are raked by a continuous bottom scraping mechanism to a sump and pumped to stabilization basins. The effluent from the equalization basin is neutralized to a final pH of 7 to 8 by automatic addition of acid or base at the effluent weir, and thereafter joins the sanitary waste effluent from the primary treatment unit. From here the combined streams proceed to secondary treatment.

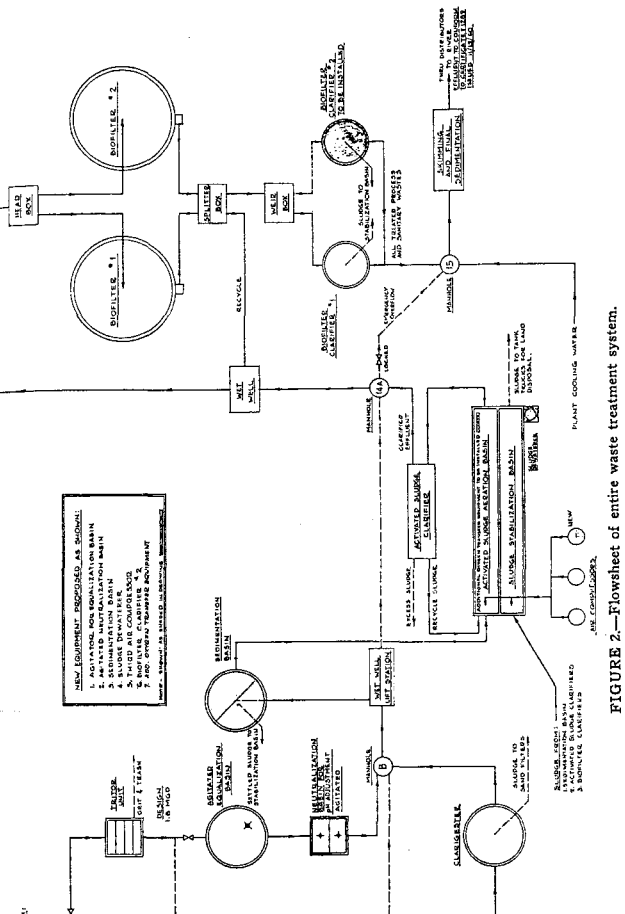


FIGURE 2.—Flowsheet of entire waste treatment system.

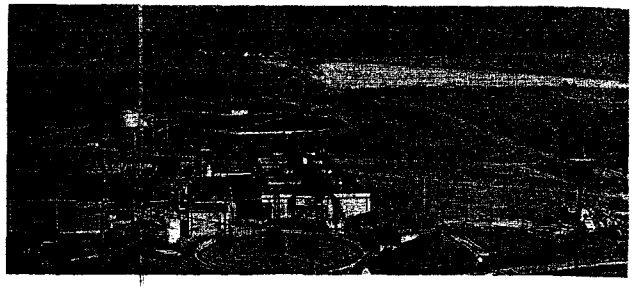


FIGURE 3.—Waste treatment plant handles both chemical and sanitary wastes.

Improvements in Pretreatment Facilities

The company is making extensive changes in the waste treatment plant. This capital outlay includes the following changes in pretreatment facilities:

1. Equalization.—It is recognized that the functions of equalization and sedimentation cannot be effectively performed concurrently. Therefore, a new 60-ft diameter sedimentation basin is being constructed. The present equalization-sedimentation basin will be altered to provide agitation and variable level for maximum equalizing and hydraulic surge control.

2. pH control.—A new two-stage agitated neutralization basin is being constructed. This basin, with a 15- to 20-min retention time, will provide precise pH control of the equalized wastes prior to sedimentation.

TABLE I.—Turbine Aerator Data

Agitator speed	68 rpm
Motor	25 hp
Current rating	31 amp
Operating current	24–28 amp
Impeller diameter	45 in.
Impeller blade radial length	12 in.
Impeller blade height	10 in.
Top impeller submergence	4 ft
Bottom impeller submergence	10 ft
Stabilizing ring diameter	20 in.
Stabilizing ring height	6 in.

Activated Sludge

The sanitary wastes from the combined clarifier and digester, and the overflow from the equalization basin are combined and treated by the first biological unit, the activated sludge system. The wastes are subjected to turbine aeration in two rectangular concrete basins and are then clarified by flotation of the mixed liquor solids. Design of this system was based on data obtained during successful pilot studies at the Stonewall Plant and the Cherokee Plant in Danville, Pa. (1), and installation was completed late in 1958.

Mixed Liquor Aeration

The chemical and sanitary wastes are combined in a well and are pumped into a splitter box, where they join the return sludge. The two aeration basins are fed by gravity flow from the splitter box, either in parallel or in series. The identical aeration basins are each 21 ft wide, 64 ft long, and 14 ft deep, with operating volume of 120,000 gal at 12-ft liquid depth.

Two turbine agitators, driven by 25-hp motors, are located symmetrically in each basin (Figure 4). The agitators have dual 45-in. diameter, plain flat-bladed, non-finned impellers. A stabilizing ring at the end of each agitator shaft eliminates the necessity



FIGURE 4.—Turbine aeration arrangement as viewed from catwalk.

of steady bearings. Equal amounts of air at 6 psi, supplied by two centrifugal blowers, are metered by Pitot tube flow meters and introduced below the bottom impeller of each agitator. Table I gives the physical characteristics of the turbine aerators. The level in the basins is maintained by gravity overflow into a 3,000-gal steel flotation feed tank.

Flotation

The flotation unit (Figure 5), a modified commercial flotator, is very flexible in its mode of operation. The pressurization system permits use of (*a*) all the mixed liquor feed, (*b*) part of the mixed liquor feed, or (*c*) recycled clarified effluent, as the pressurized dissolved air carrier. Air is dissolved into the pressurized stream by aspirating it into the suction side of the pressurizing pumps. Excess air is purged from the stream as it passes through a tank with 2- to 3-min retention time. The pressurized flow is split into three equal parts by manual adjustment of plug-type valves, which



FIGURE 5.—Flotation unit is a modified commercial flotator that is flexible in its mode of operation.

also serve to adjust the operating pressure.

After flowing through the regulating valves the streams are mixed with any unpressurized mixed liquor feed in three coaxial double-pipe line mixers that discharge into the inlet section of the flotation vat. The unpressurized feed flows by gravity from the flotation feed tank to the line mixers. The air released from solution after passage through the regulating valves attaches itself to mixed liquor solids, lowers their bulk density, and raises them to the surface of the flotation vat, forming a sludge blanket. Scraper paddles traversing the length of the unit discharge the float into a hopper at the other end.

The float is then pumped, in any desired ratio, through a magnetic flow meter and an automatic three-way valve alternately to the aeration basin as return sludge or to the stabilization basin as waste sludge. Outlet tubes withdraw clarified effluent from throughout the bottom of the flotation vat. The effluent is metered through a Kennison nozzle and flows by gravity to the trickling filters for further treatment (Figure 6).

Flotation offers two advantages which make it an attractive method for clarification of mixed liquors: low capital outlay and rapid return of the activated sludge to its aerobic environment. The original activated sludge pilot work was performed using both flotation and sedimentation for sludge removal. On the basis of results obtained, flotation was deemed suitable; consequently, a commercial flotation unit was installed. It was anticipated that this unit would be able to handle 1.8 mgd of mixed liquors and give a 2- to 3-percent (by weight) sludge concentration and a clarified effluent of less than 250 mg/l suspended solids.

The unit failed to perform as anticipated and major modifications of it were made (Figure 7) in an effort to improve its performance to acceptable levels. The double disc valves originally used in the unit for mixing of the streams and pressure release were replaced by the coaxial line mixers to

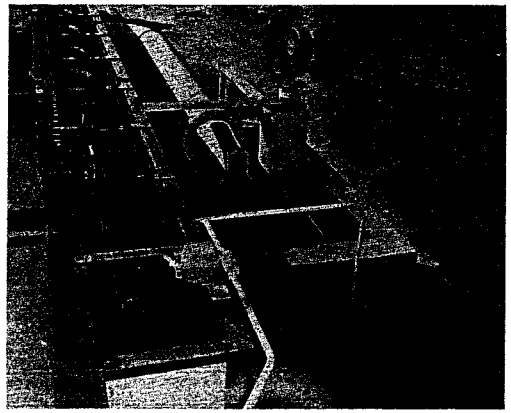


FIGURE 6.—Effluent from flotator is collected from bottom pipes, measured through Kennison nozzle, and conducted to trickling filters.

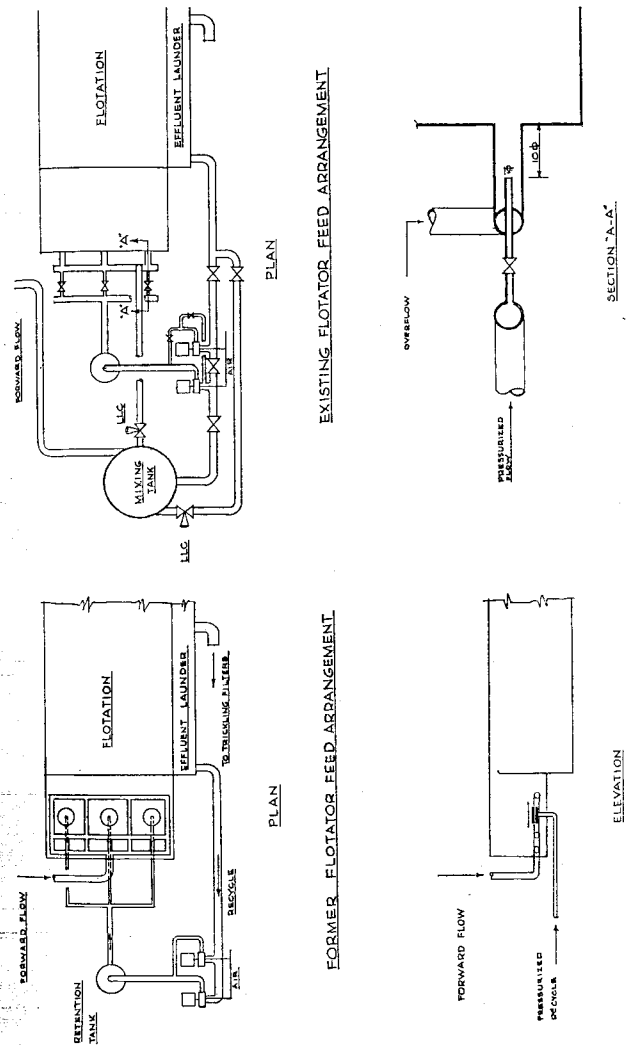


FIGURE 7.—Original and revised flotator feed arrangements.

TABLE II.—Flotation Operation and Performance Data

Mixed liquor feed	850 gpm
Floated sludge	200,000–350,000 gpd
Clarified effluent	810 gpm
Mixed liquor SS	1,000–2,500 mg/l
Sludge suspended solids	10,000–15,000 mg/l
Effluent suspended solids	600–900 mg/l
Pressurization	100% of mixed liquor feed
Operating pressure	40–50 psi
Air input, mixed liquor	1 scfm/100 gal

improve solid-air contact. The pressurization system, originally capable of employing only clarified effluent, was modified to give it the flexibility previously described. Experimentation led to the selection of pressurization of all the mixed liquor feed, with no recycled effluent, to about 40 to 50 psi and an air input of 1 cfm of air per 100 gal of mixed liquor, as the best set of operating conditions. Even under these conditions, however, the performance of the unit was erratic.

Subsequent laboratory and pilot experimentation has revealed that the flotability of the mixed liquor solids is markedly variable. The solids "free rise" rate in a quiescent laboratory batch flotator will range from less than 1 to as high as 7 in./min. Mixed liquor solids with high rise rates floated well in a continuous pilot flotator and the performance of the unit could be controlled by varying operating conditions such as pressure, air input, and recycle ratio. During periods when the mixed liquor solids exhibited low rise rates the pilot unit's performance was poor and could not be improved by altering the operating conditions. The flotability of the mixed liquor solids has been observed to vary with their "quality"—low ash solids generally exhibited high rise rates whereas high ash solids showed low rise rates. It has been concluded that further improvement in the plant unit's performance must be brought about by improving the quality of the mixed liquor solids. It is anticipated that the planned revisions and additions to the existing pretreatment facilities will accomplish this by reducing or eliminating pH, flow and organic shocks to the aeration basin and by reducing the amount of inactive solids in the chemical waste stream fed activated sludge. Table II summarizes typical current operation and performance of the flotation unit.

Activated Sludge Performance

The activated sludge system was designed to remove 11,700 lb of BOD from a feed of 1.8 mgd containing 18,000 lb BOD (65 percent removal). This performance has never been attained; nevertheless, the unit has performed creditably in removing up to 3.7 lb BOD/day/lb MLSS and 319 lb BOD/day/1,000 cu ft. Table III presents a summary and analysis of the performance of the unit during the first six months of 1961. The aeration basins were operated in series prior to February 19, and in parallel thereafter. All values given are weekly averages.

TABLE III.—Data for Activated Sludge System, First Six Months of 1961

Month (1961)	Mixed Liquor SS (lb)	Flow (mgd)	Ret. Time (hr)	Biochemical Oxygen Demand							Air Input (cf)		Sludge Produced (lb/lb BOD Removed)
				Input			Removed						
				(lb/day)	(lb/day/lbMLSS)	(lb/day/1,000 cf)	(lb/day)	(%)	(lb/day/lbMLSS	(lb/day/1,000 cf)	Per Lb BOD Load	Per Lb BOD Rem.	
Jan.	4,570	0.97	5.9	13,750	2.94	419	6,360	45	1.42	187	130	281	0.64
Feb.	3,880	1.07	5.4	17,730	4.56	553	7,730	44	2.00	242	159	364	0.51
Mar.	3,740	1.15	5.0	18,490	4.99	576	8,130	44	2.18	253	193	442	0.75
Apr.	3,560	1.14	5.1	20,050	5.65	611	8,190	41	2.29	255	153	378	0.48
May.	2,830	1.33	4.3	21,120	7.49	659	8,240	39	2.93	257	137	352	0.55
June.	2,660	1.41	4.1	23,190	8.14	723	9,060	39	3.41	282	121	312	0.51
Aug.	3,690	1.18	5.0	20,510	5.81	611	8,250	44	2.46	255	155	382	0.60

Of the two factors that have limited the performance of the activated sludge, the inability to maintain a solids level of more than 2,000 mg/l has been most detrimental. This inability has resulted from (*a*) partial kills of the active floc by pH shocks, (*b*) dilution of the floc by inactive solids in the feed, and (*c*) poor flotation performance. It is anticipated that the previously mentioned alterations and additions to the pretreatment facilities will permit maintenance of a highly active floc at higher concentrations than currently possible by eliminating partial kills and dilution by inerts and by improving flotation performance.

The second limiting factor in the activated sludge performance has been the inability to transfer sufficient oxygen to the mixed liquors during periods when a good quality, rapidly respiring floc was available. The aeration system was designed for a mixed liquor having a respiration rate of 106 mg/l O_2/hr. Uptake rates (determined with a dropping mercury-calomel polarograph) as high as 190 mg/l O_2/hr have been encountered. Dissolved oxygen profiles of the mixed liquor basin have been made with semipermeable membrane dissolved oxygen probes. During periods of good operation these profiles have revealed little or no dissolved oxygen except at the surface.

To increase the capacity of the activated sludge system it is planned to treble the agitation horsepower currently in use. This will be done by the addition of four 50-hp turbine aerators similar in design to the existing four 25-hp units, and by installing an additional air compressor. Clarification of mixed liquors will be supplemented by installing additional flotation or sedimentation facilities, provided such supplementation proves necessary.

Trickling Filters

Basis for Design

The first biological waste treatment facilities installed at the Stonewall Plant consisted of moderately high-rate single-stage trickling filters with attendant clarification. This installation, completed in 1953, followed an investigational and piloting program of more than two years.

The initial screening studies also included laboratory evaluation of anaerobic digestion and the activated sludge process. Anaerobic digestion of the plant's fermentation broths was proven unsatisfactory due to high sulfate ion content, which resulted in poisoning of the biological culture when sulfide was formed as a by-product of the reducing metabolism. Amenability to activated sludge treatment showed promise under controlled laboratory tests; however, the choice for emphasis on trickling filters, rather than activated sludge, was based at the time on (*a*) a prevailing thesis that trickling filters were substantially less subject to shocks from fluctuations in pH, organic loading, and chemical toxicity, than was the activated sludge

TABLE IV.—Trickling Filter Design Criteria *

Item	Value
Forward flow rate (gpm)	625
Forward flow rate (mgd)	0.90
BOD of clarified influent (mg/l)	1,400
BOD of clarified influent (lb/day)	10,450
pH of clarified influent	7.0
Recycle ratio, direct recirculation	5.1
Hydraulic capacity, constant (mgd/acre)	7
Unit BOD loading (lb/cu yd/day	1.9
BOD of clarified effluent (mg/l)	420
BOD of clarified effluent (lb/day)	3,140
BOD removal (lb/day)	7,310
BOD reduction (%)	70
Unit BOD removal (lb/cu yd/day)	1.3
Clarifier overflow rate (gpd/sq ft)	700
Clarifier retention time (hr)	2.5
Sludge production (gal/day)	12,000
Sludge total solids (%)	3.0
Sludge dry solids (lb/day)	3,000

* Filter application temperature, 30 to 32° C.

TABLE V.—Trickling Filter Performance Data *

Item	Average	Range
Forward flow rate (gpm)	810	600–1,400
Forward flow rate (mgd)	1.16	0.98–1.38
BOD of clarified influent (mg/l)	1,200	900–1,400
BOD of clarified influent (lb/day)	11,430	6,500–14,500
pH of clarified influent	7.2	6.6–7.0
Recycle ratio	9	7–11
Hydraulic capacity (mgd/acre)	14	—
Unit BOD loading (lb/cu yd/day)	2.1	1.2–2.7
BOD of clarified effluent (mg/l)	565	375–750
BOD of clarified effluent (lb/day)	5,400	3,000–7,000
BOD removal (lb/day)	6,030	4,000–10,000
BOD reduction (%)	53	40–66
Unit BOD removal (lb/cu yd/day)	1.1	0.7–1.8
pH of clarified effluent	7.3	6.8–7.8
Clarifier overflow rate (gpd/sq ft)	920	700–1,600
Clarifier retention time (hr)	1.9	1.1–2.6
Sludge production (gal/day)	16,000	—
Sludge total solids (%)	2.4	—
Sludge dry solids (lb/day)	3,300	—

* Filter application temperature, 18 to 34° C.

process, and (*b*) the economics of a low operating cost conventional system.

The studies and experiences of others (2) (3) (4) (5) (6), and the company's own extensive pilot efforts (7) with trickling filters provided the design criteria presented in Table IV.

Physical Facilities

At the time of construction, the filters were the largest known units operating on industrial antibiotic wastes. The installation has the following physical characteristics.

Filters.—The two units are each 153-ft diameter (inside) reinforced concrete basins with 4-ft media depth and standard underdrainage system. The filter media consists of 2½- to 4-in. graded limestone. Each filter is provided with two distribution arms, which rotate by the hydraulic reaction from 5 ft of static head, distributing the forward flow and recycle from 56 1¼-in. outlet nozzles hydraulically spaced. The nozzles have individual splash plates, which effect distribution on the stone surface and control rotational speed from a free-fall height averaging 18 in. The dosage cycle at present conditions is 35 sec.

Recirculation.—The forward flow (clarified activated sludge effluent) and the unclarified recycle are combined in a wet well and pumped by means of two 4,000-gpm single-stage centrifugal pumps to the filter distribution head box. A gasoline engine is provided to furnish power for one of the lift pumps in the event of an electric power failure.

Clarification.—The net filter effluent, essentially equal to the forward flow rate at all times, is split off from the total filter effluent and flows by gravity to a circular concrete sedimentation basin of conventional design with center feed well. Dimensions are 40 ft inside diameter by 10 ft side wall depth. The clarified overflow passes over a peripheral notched weir to a collection launder. Settled sludge on the basin floor is raked to a collection pit, then is automatically pumped by the preset timer to the aerobic sludge stabilization basin for further treatment and subsequent disposal on soil.

Final Effluent Disposal.—Clarified effluent from the overflow launder, after continuous sampling, is combined with untreated plant cooling water and is proportioned to five 12-in. diameter submerged discharge pipes which effect equal distribution of the plant effluent at five points equally spaced across the width of the river.

Operational Performance

Table V presents current operating data for the trickling filter system while operating in series with the activated sludge unit at filter application temperatures (18 to 34°C) encountered in winter, spring, and summer. These data should be compared with the design basis of Table IV, for which the data were determined at summer temperatures of 30 to 32°C.

The forward flow and the BOD loading are increased 30 percent and 10 percent, respectively, above the design basis. Due to the appreciable increase in average hydraulic flow, as well as extreme, intermittent fluctuations, it was necessary to double the hydraulic capacity of the facility from the intended 7 mgd/acre to 14 mgd/acre in order to increase recirculation.

Anticipated Clarification Improvements

The most evident deterrent to improved BOD removal on the trickling filter unit is the limitation on clarification efficiency. This has been imposed by the 30-percent increase in average hydraulic loading and the fluctuations in flow which are inherent in pharmaceutical manufacturing. The increased forward flow has resulted in increasing the clarification overflow rate to an average of 920 gpd/sq ft and peak overflows of 1,600 gpd/sq ft. The retention time is similarly decreased, as shown in Tables IV and V. These conditions do not permit efficient concentration and removal of sludge solids and frequent sacrifice of BOD in the form of sludge to the clarifier effluent results. Present plans are to double the existing clarification capacity to prevent this loss of efficiency.

Specific Temperature Effects

The operating temperature on the trickling filters has been found to have a marked influence on BOD removal efficiency. This relationship is shown in Figure 8, which shows the effect of filter application temperature (forward flow plus recycle) on BOD removal efficiency in the temperature span of 18 to 34°C. This is in substantial agreement with work done by others on the combined effect of temperature on trickling filter treatment and attendant clarification (8).

Filter Biological Life

An abundance of *Psychoda* flies has populated the trickling filters since initial break-in in 1953, even at the 35-sec dosage cycle which prevails at the hydraulic loading of 14 mgd/acre. The population, however, reduces noticeably during the coldest months of winter and the hot summer conditions. Because the waste treatment area is remote from the manufacturing area, there has been no nuisance resulting from the tiny insects. The constantly squirming fly larvae perform an excellent function in aiding the sloughing of filter sludge from the films on the media. In eight years of operation there have been no ponding problems with the exception of a short period

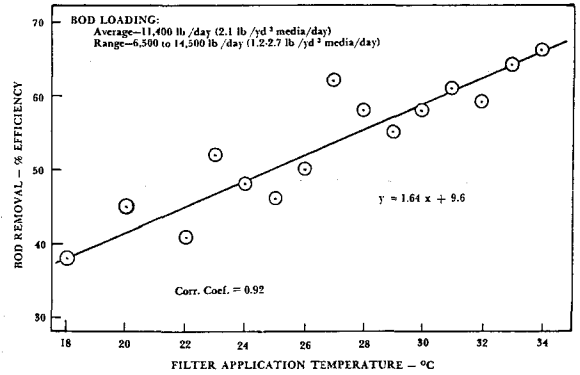


FIGURE 8.—Effect of temperature on trickling filter efficiency.

TABLE VI.—Sludge Data from Three Sources

Source	Volume (gpd)	Total Solids* (%)	Dry Solids (lb/day)
Primary clarifier	12,000	2.3	2,400
Flotation basin	52,000	1.2	5,300
Trickling filters	16,000	2.4	3,300
Combined sludge	80,000	1.6	11,000

* The combined sludges have a suspended solids content of 1.3 percent.

when the filters were loaded in excess of 4 lb BOD/day/cu yd.

Filter slimes are observed frequently with the aid of the microscope. A healthy growth of vigorous zoogleal bacteria is normally present. Algae are prolific on the surfaces of stones exposed to the sunlight. Besides filter fly larvae and pupae, other large predators frequently observed are nematode worms, water mites, rotifers and ciliates such as *Colpoda, Opercularia* and *Lionotus*. Among the smaller protozoa normally present are the flagellates.

Sludge Stabilization and Disposal

Sludge Characteristics

Sludges from the three sources in the treatment system are combined in a stabilization basin for aerobic digestion in the average volumes and concentrations shown in Table VI.

These sludges are extremely difficult to dewater and the cost of conditioning agents to aid sedimentation or filtration rate is prohibitive. These considerations and the availability of company-owned property have made ultimate disposal on tilled soil quite attractive.

Sludge Stabilization

The combined sludges are subjected to aerobic stabilization prior to ultimate soil disposal to preclude any septic conditions and subsequent objectionable odor. The stabilization basin is adjacent to the activated sludge mixed liquor basins and consists of an initial 120,000-gal compartment containing two 25-hp turbine agitators and two additional 60,000-gal compartments in series, each containing one 25-hp turbine agitator. The characteristics of these turbines are identical to the 25-hp units used in the activated sludge mixed liquor basins and have been previously described. Sparged air is introduced to each turbine at a rate of 50 to 100 cfm to effect aerobic digestion. The retention time is three days.

Soil Disposal

Ultimate disposal of sludges and certain other concentrated waste streams onto tilled soil has been practiced at the Stonewall Plant for approximately 10 years. This method of disposal is one of the oldest forms of wastewater treatment known to man. Recently it has become widely adopted by the vegetable, fruit, and milk processing industries (9) (10) (11), and in many cases has economically solved pollution problems to the satisfaction of pollution regulating agencies. The unique variation at the Stonewall Plant is a simple application of the principles of soil microbiology, giving due consideration to the hydraulic limitations of the local soil strata.

Experimental Work

Extensive pilot data (12) on test plots showed that the sludges could be sprayed on tilled soil at a hydraulic rate of 0.04 gpd/sq ft for extended periods of time. Soil microorganism counts taken at various times indicated high activity. Before treatment with waste the count was approximately 19 million microorganisms per gram of soil (dry basis); within four weeks the count increased twenty-fold to about 400 million.

Tests run with laboratory soil columns of 1-ft soil depth indicated BOD reductions in the range of 80 to 95 percent at daily loading rates 6 times heavier than applied on actual soil plots.

Soil Plot Operation

Under actual operating conditions, an all-weather sludge hydraulic loading of 0.02 to 0.03 gpd/sq ft has been employed on the plant soil plots. The land in use is reasonably contoured to prevent runoff and was formerly under cultivation.

The aerated sludge is transported from the stabilization basin to the plant soil plots in a 4,000-gal tank wagon. The unit is equipped with a 200-gpm centrifugal pump driven by an auxiliary gasoline motor mounted at the rear of the tank. Sludge is sprayed in a fan-shaped trajectory covering a distance of 40 ft on either side of the road from twin nozzles mounted at rear corners of the tank truck.

At the present sludge production rate of 80,000 gpd, total soil area alloted to spray irrigation is 70 acres. Cinder roads for transportation requires 13 acres, resulting in a net utilization area of 57 acres for sludge application.

The soil plots are periodically tilled (about four times annually) to a depth of 3 to 4 in. during fair weather to prevent any surface accumulation of solids caused by uneven distribution.

During a period of low plant production activity portions of the soil area after two years' treatment were returned to corn cultivation after a year's rest. There was no evidence of damage to the crop.

Sludge Concentration

In anticipation of future plant production increases and the attendant increase of combined sludge volume in excess of 80,000 gpd, it has been found advisable to develop a method of concentrating sludge. By this plan increased acreage for spray irrigation will not be required because the hydraulic loading capacity of the sandy loam soil is the limiting factor, rather than organic loading.

It has been found that the three-day aerobic stabilization of the sludge enhances its filterability. Pilot centrifugation studies have been instigated with the aim of concentrating the stabilized sludge, which averages 1.3-percent suspended solids, to a mobile pumpable concentrate of 4 to 8 percent (three- to six-fold concentration) which can be distributed on soil by the present spray irrigation technique or a similar method using a stationary spray nozzle system.

Process Control and Evaluation of Results

Control of the biological treatment facilities is achieved by measuring as required the air flow to activated sludge, the temperature of the feed and effluents from activated sludge and trickling filters, the O_2 and CO_2 content of the off-gas from activated sludge, and the solids concentrations in the feed, mixed liquors, flotation sludge, and all effluents. The efficiency of each phase of treatment is evaluated by sampling continuously the feed and effluent of each unit in the system. The flow is measured and the samples are analyzed for BOD, COD, pH, dissolved and suspended solids. The plant effluent is tested for these characteristics, and also for toxicity using the microcrustacean *Daphnia magna*. Results of the daily plant effluent analyses are submitted quarterly to the Virginia State Water Control Board.

Periodic stream analysis affords a measurement of the effect on the receiving stream. Biweekly river samples are obtained from one location 3 miles upstream from the plant and 3 downstream stations located approximately 3, 10, and 30 miles from the outfall. These samples are evaluated for dissolved oxygen, temperature, dissolved and suspended solids, pH, BOD, COD, color, total alkalinity, and toxicity thresholds. Results are reported quarterly to the State Water Control Board and the Interstate Commission on the Potomac River Basin. Several times each year surveys of river conditons

are conducted by an independent consultant.

Summary

Merck & Co. has invested about $1,500,000 in facilites for the treatment of chemical wastes from this plant and spends approximately $170,000 per year to operate these facilities. This includes the cost of labor, supervision, repairs, utilities, and supplies, but does not include non-controllable period costs such as taxes, insurance, depreciation, personnel services, administration, etc.

It is believed that these installations have permitted the plant to expand without impairing the high quality of the Shenandoah River. The effectiveness of the present facilities has been impaired by the less than adequate provisions for the important pretreatment functions of equalization, precise pH control, and solids removal. In addition oxygen transfer to activated sludge has not been adequate. Nonetheless, these facilities as they now exist have removed BOD in quantities which exceed the unit loading of conventional units. As mentioned in the various discussions, construction is now near completion on new facilities which should provide an even more satisfactory solution to the problems of treating strong pharmaceutical wastes.

References

1. Dryden, F. E., Barrett, P. A., Kissinger, J. C., and Eckenfelder, W. W., Jr., "High-Rate Activated Sludge Treatment of Fine Chemical Wastes." *Sewage and Industrial Wastes*, **20**, 2, 183 (Feb. 1956).
2. Heukelekian, H., "Characteristics and Treatment of Penicillin Wastes." *Ind. Eng. Chem.*, **41**, 1535 (1949).
3. Hilgart, A. A., "Design and Operation of a Treatment Plant for Penicillin and Streptomycin Wastes." *Sewage and Industrial Wastes*, **22**, 2, 207 (Feb. 1950).
4. Muss, D. L., "The Treatment of Penicillin Wastes." *Sewage and Industrial Wastes*, **23**, 4, 486 (Apr. 1951).
5. Smith, R., Walton, G. McCabe, L., and Miner, J., "Direct Recirculation for High-Rate Trickling Filters." U. S. Pub. Health Service, Environmental Health Center, Cincinnati, Ohio (1951).
6. Grantham, G. R., Phelps, E. B., Caloway, W. T., and Emerson, D. L., "Progress Report on Trickling Filter Studies." *Sewage and Industrial Wastes*, **22**, 7, 867 (July 1950).
7. Reimers, F. E., Rinaca, U. S., Poese, L. E., "Trickling Filter Studies on Fine Chemical Wastes." *Sewage and Industrial Wastes*, **26**, 1, 51 (Jan. 1954).
8. Schroepfer, G. J., Al-Hakim, M. B., Seidel, H. F., and Ziemke, N. R., "Temperature Effects on Trickling Filters." *Sewage and Industrial Wastes*, **24**, 6, 705 (June 1952).
9. Dennis, J. M., "Spray Irrigation of Food Processing Wastes." *Sewage and Industrial Wastes*, **25**, 5, 591 (May 1953).
10. Seabrook, J., Lectures (1951–1953).
11. Sanborn, N. H., "Disposal of Food Processing Wastes by Spray Irrigation." *Sewage and Industrial Wastes*, **25**, 9, 1034 (Sept. 1953).
12. Reimers, F. E., Rinaca, U. S., Poese, L. E., and Foerster, E. L., "Disposal of Fine Chemical Wastes to the Soil." Presented at Fall Meeting, Production and Engineering Section, American Drug Manufacturers' Association, Chicago, Ill. (Nov. 5, 1953).

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TIPS AND QUIPS

Security Check List *

The famous Pinkerton's National Detective Agency has recently issued a check-off list for security guards. The items seemed to be of such general value that they are presented here. You should know:

1. How to call the local fire and police departments and other sources of help.
2. The locations of hydrants, standpipes, small hose, and fire extinguishers.
3. The layout of the area you are to protect, including all buildings and occupancies, yard areas, entrances, stairways, elevator shafts, and other features of the premises.
4. Whether alarms are only internal or are connected directly to the fire department.
5. The locations of all regular telephones; also, switchboard operations.
6. How to start and operate fire pumps.
7. The proper pressure on the regular sprinkler-system gauge.
8. The locations of all doors and fire exits.
9. The locations of all fire-alarm boxes and telephones inside and outside the plant, and how to use them.
10. The locations of valves controlling sprinkler systems, inside riser valves, and post indicator valves.
11. The locations of dangerous or extra-hazardous machinery or material.
12. How to use switches so as to control the power and lighting systems and how to shut off current in case of emergency.
13. How to give basic first aid.

* *CWPCA Newsletter.*

Engineering Index

The Engineering Index, a non-profit organization, annotates and indexes selectively on the basis of engineering significance, the available current technical periodicals received by, and permanently housed in, the Engineering Societies Library. Included are the regular professional journals, trade journals, publications of engineering societies, scientific and technical associations, universities, laboratories and research institutions, government departments and agencies, and industrial organizations. Papers of conferences and symposia, separate and non-serial publications of various kinds, and selected books are also covered. Patents are excluded. In all, over 3,300 publications are received. These are printed in 22 languages and come from 42 countries. The Engineering Index service is divided into 249 "Field of Interest" divisions.

Water Resources

In the humid regions, the major water problem centers around pollution. But our water purification methods are primitive in relation to the increasing problems of organic wastes and associated algae growth. Left unchecked, algae, thriving on plant nutrients dissolved in the effluent of even treated sewage, can decrease the oxygen content of a stream to a level at which such wastes cannot be assimilated through the stream's natural self-purification process. Appearance, taste, and odor of the water become affected, and fish cannot live. A few people have experimented with harvesting algae from ponds in which rapid growth is stimulated. But we are still a long way from developing