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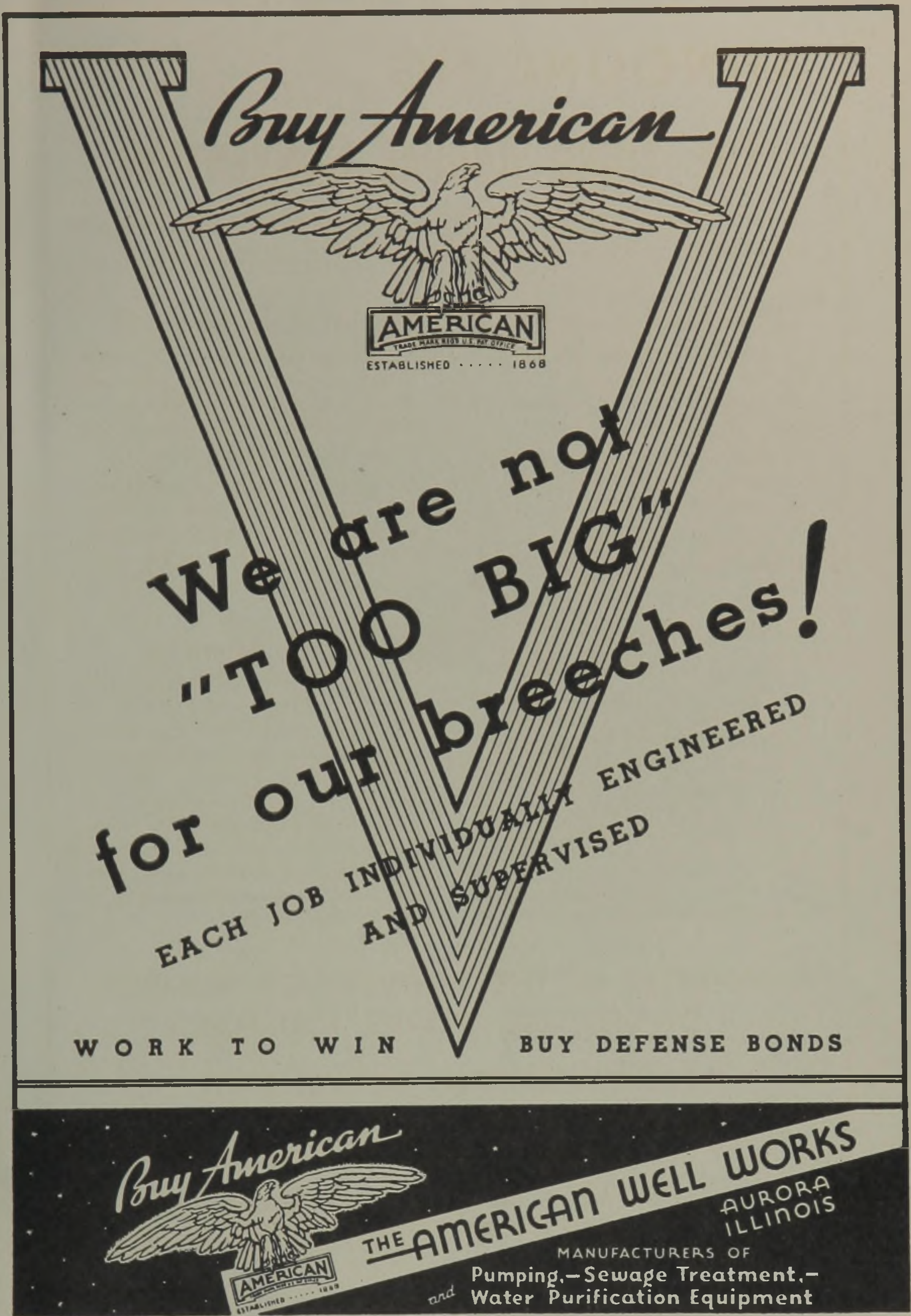

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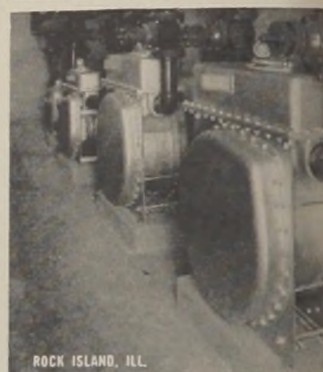

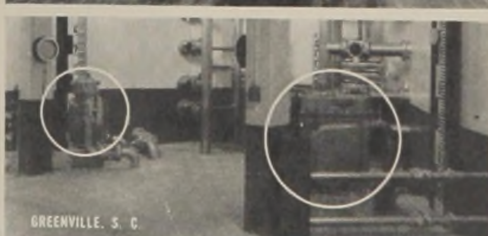

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Plant Operation

SEWAGE TREATMENT WORKS OPERATION RECORDS *

By Roy S. Lanphear

Supervising Chemist, Bureau of Sewers, Department of Public Works, Worcester, Mass.

All engineers and plant operators recognize the value of operating and laboratory records of sewage treatment plants, in connection with plant operation and the planning of future improvements or additions to the plant. Unfortunately, all operators are not in a position to develop laboratory work to the same point as do many of the larger plants. However, there is no reason why the operator, possibly with the assistance of the engineer of the State Department of Health, cannot develop an operation record which will be quite complete.

Other than those above mentioned, there are a number of reasons why operation and laboratory records should be made as complete as possible. They are:

1. An excellent defense against abusive criticism in case of a single mishap in plant operation. A good example is the control of the trickling filter fly, which may fail possibly once in a single season.
2. Together with a certain amount of laboratory test results, an excellent defense against criticism in the case of an overloaded plant.
3. Good effect upon the operating personnel. The fact that records are made and the operator's signature is required impresses upon him that his work is an essential part of the efficient operation of the plant.
4. Availability for favorable cooperation with the sanitary engineering division of the State Department of Health. The fact that we have this Federation of Sewage Works Association is an indication that the day of the policeman in the operation of sewage treatment plants is gone forever. Where plants lack sufficient laboratory facilities, it is necessary that certain samples be collected from time to time. Assistant sanitary engineers of the State Department of Health should make periodic plant inspections. Reports of these analysis and inspection should be made a part of the plant records for two reasons: first, encouragement of the small plant operator to continue good work; and second, to furnish the basis of discussion between the operator and the engineer as to how best to improve the results of plant operation.

* Presented at the Second Annual Convention of the Federation of Sewage Works Associations, New York City, Oct. 10, 1941.

In some states, the plant operator is required to fill out certain forms of daily records each month and submit them to the State Department of Health. If the Department Assistant Engineer makes his inspection a visit worth while, the operation record as made by the plant operator can be reviewed by the two men together with much benefit to the operator and the development of a spirit of cooperation.

The permanent assembled records of plant and laboratory operation at Worcester are kept in four cloth-and-leather-bound ruled books. It is the intention to reduce the purchase expense and the handling of these books by using sheets of uniform size, appropriately ruled, contained in a suitable temporary cover. Then at the end of each year, these records may be bound in a single volume.

The actual working operation records consist of four loose-leaf sheets, one of which is printed and the other three mimeographed.

1. Daily Operation Record.
2. Daily Sample Record.
3. Daily Sludge Pump Operation.
4. Removal of Dried Sludge from Drying Beds.

The Daily Operation Record is printed and is used by the Foreman; it is contained in an inexpensive loose-leaf cover and is given to the Supervising Chemist each morning when works operation is discussed. This record gives the time sheet, sewage flow, dosing tanks counter readings, use of by-passes, screenings, grit chamber cleaning, tank and filter operation, sludge drawing and all routine operations. These records are filed in a similar loose-leaf cover in the speaker's desk until four months' records are bound in red pressboard covers to serve as original records.

The second record sheet shows alongside an employee's signature the time of collection of every sample for which he was responsible.

The third record is made out by the employee operating any one of the three sludge pumps and contains complete data as to pump operation and disposal of wet sludge.

Both of these records are also contained in loose-leaf covers and are discussed each morning along with the operation record.

The fourth record, removal of dried sludge, is a seasonal record and is used to facilitate computation of cost records and to check payment for hired trucks. The best illustration of the use of this record is the data presented in Reviews and Abstracts, Section 6, *This Journal* for March, 1941, wherein cost figures are presented for removal of dried sludge using welfare and temporary labor.

Once each week, river water samples are collected at each of four stations. The collector records his observation of river conditions and signs the record form, which includes his statement that he collected the four samples as recorded. These records are also bound in pressboard covers each year.

The laboratory bench work is contained in six ordinary blank books, with heavy pressboard covers, each of which is properly labelled so as to contain similar work and at the same time, avoid all conflict in their use.

To facilitate the use of monthly average data, 4 by 6 in. cards are ruled and filed according to data contained in the Annual Report of the Superintendent of the Bureau of Sewers. It is possible to lay a card on the desk for each of the sixteen years of works operation, containing similar data and affording ready comparison. Each card also contains the yearly average or total. Similar cards contain a summary of the yearly figures. Provided entries are made each month, the work involved is less than this description might indicate. The value of this record is appreciated when discussing works operation with the Bureau Superintendent, engineering visitors, teaching classes of engineering students, and writing annual reports.

Finally, the tables for the annual report are on loose-leaf sheets in a pressboard cover and entries are made for each month during the year. The written portion of the report is placed in the same cover and upon return to the compiler some months after completion, the cover and contents are filed, with the year plainly marked on the back.

Discussion

Dr. Mohlman: It is important to keep records. Record keeping is characteristic of the United States, for in England and Germany practically no daily routine analyses are made. Dr. Imhoff felt that daily analyses were not so essential as a record of sludge handling and disposal. Although American operators make most complete analyses and keep excellent records, it is rather hazardous for an operator to point with pride to one year's improvement over the previous year, because the next year may show less favorable results. Therefore, records are not of value to prove better or worse results from year to year, but rather to show a long-term average of the results of plant operation.

Mr. Bloodgood: We keep a lot of records but even then we often find that certain data we have not recorded we really do need. I think there ought to be a committee formed to standardize record forms and the necessary data that should be kept.

Mr. Schroepfer: In 1932 there was an article published on standardization of records. (See *This Journal,* **4**: 3–27, 1932.)

Mr. Donaldson: There was such a report made by the New York State Sewage Works Association.

Mr. Lanphear: Many of the records we keep are entirely for our own benefit. The effect of iron in our sewage on digestion—the control of the filter fly by flooding, etc.

Mr. Frazier (*Oshkosh*): Of what use are records? The Board of Trustees usually is not interested in the data. They are necessary for future expansion, costs, value of equipment, etc.

Mr. Molitor: It is very necessary to keep complete records. We have 28 years of them and they are valuable to shows the trustees.

Mr. Larson: Reports are no good unless they are read and they are also of no use unless readily available.

Mr. Merrill (*Mass.*): No records were kept at one plant even of the flow and when an industry started to discharge wastes to the plant it was found, much to the embarrassment of the State, that the industry's flow was five to eight times that of the sewage plant.

RECORD FORMS FOR A LARGE SEWAGE TREATMENT WORKS *

By George E. Symons and George F. Fynn

Chief Chemist and Statistician, Buffalo Sewer Authority, Buffalo, N. Y.

The number, kind, and complexity of record forms for an industrial organization depend upon the magnitude and type of the operations performed within the physical plant of the industry concerned. These forms must be integrated in such a manner as to make the data, records, and information readily available to those charged with management and supervision of plant operations. In any large sewage treatment works, such as that of the Buffalo Sewer Authority, the problem of forms for recording data and results is one that must be attacked early in operation, if not before operation is inaugurated.

Frequently, as in New York State, standardized forms from the Department of Health for reports from treatment works may be available, but whereas they may suffice for smaller plants, they are likely to be inadequate for larger works. These standard forms, however, do show the information desired by the Health Department, and therefore indicate certain items that must be included if the disposal plant develops its own forms. Basic considerations of record forms must be concerned, not only with plant operations, but also with analytical data that may be translated into production quantities. It is essential, therefore, that samples be collected at such points as will produce information relative to the actual operation of the treatment plant, and that laboratory forms be provided for recording the results of analyses of these samples.

Preliminary forms for the Buffalo treatment works were prepared on a Ditto machine, or as black line prints of pencil tracings, but the need for standarized and permanent record forms soon became apparent.

The final layout and number of forms evolved from seven major premises.

1. All forms should be of the same size on standard 8½ in. by 11 in. paper with punchings, to allow for filing in a three-ring note book; monthly records thus, of necessity, become a multiple leaf report.

2. Forms should be so laid out that a standard heading could be used on all sheets.

3. Forms were to be printed by mimeograph. Not only is mimeographing less expensive than printing, but it eliminates the necessity for storing large quantities of printed forms, and makes it possible to change a form quickly and at low cost, if experience indicates need for revision.

* Presented at the 102nd Meeting of the American Chemical Society, Atlantic City, Sept. 9, 1941. Released by courtesy of the A. C. S.

4. Columnar spacing is based on the number of digits to be entered under the heading concerned.

5. In addition to the daily entries, the monthly summary sheets should contain the totals, maximum, minimum and daily average plus the daily average for the previous month, and the normal daily average for the same month of all previous years.

6. Average data determined on concentrations and analyses should be calculated on a weighted basis from quantitative data, which have been computed from flows and analyses. This condition dictated the necessity for a whole series of computed data summaries in the laboratory forms.

7. The forms fall into four categories:

a. Daily Logs—For plant equipment and unit operations.
b. Laboratory Data, Record and Report Sheets.
c. Plant Reports—Daily, Monthly, Yearly.
d. Miscellaneous.

Daily Logs

The plant daily logs consist of ten forms for the following locations or processes, (1) pumping station, (2) screen room, (3) grit room, (4) main building (chlorination, sewage flow meters), (5) raw sludge pumping station (settling tanks), (6) sludge control building (sludge digestion tank operation), (7) sludge conditioning and filtration, (8) sludge incineration, (9) boiler room operation, and (10) a daily summary.

These daily logs, an example of which is shown in Fig. 1, contain entry spaces for machine unit operation records, meter integrator readings by shifts, and measured quantities or hourly readings from indicators or meters. Also provided on each log is a place for remarks on which operators can enter unusual operating conditions. Daily logs keep the operator informed as to what is happening or has happened at his post, as well as serve as a record of operation. Daily logs and meter recorder charts are delivered to the statistician each morning. From these the summary daily log is prepared showing the hours of operation of pump and other equipment, metered quantities and other pertinent data.

Laboratory Forms

The laboratory forms are divided into four classes: (1) "Statistical Records," which comprise the record of laboratory operations, samples collected, analyses and tests performed; (2) "Bench Sheets," upon which original entries of analytical base data are entered as the analysis is performed; (3) "Report Sheets," upon which both original analytical data and computed quantities may be entered as monthly summaries; this group, likewise, includes forms used to report individual analyses particularly those of lime, ferric chloride and fuel oil; (4) miscellaneous forms to report miscellaneous analyses and those that serve as work sheets for data tabulation.

BUFFALO SEWER AUTHORITY
SEWAGE TREATMENT WORKS
MAIN PUMPING STATION
DAILY LOG

Date ______________

Hours of Pump Operation															
1 - Low		1-High		2		3		4		5		6 - Low		6 - High	
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
TOTAL															

Venturi Readings	East	West	Flow	Totalizer
8A End				
8A Start				
Difference				

	ELECTRIC METERS			TRASH RACKS CLEANED	WATER METERS	
Time	No. 1	No. 2	Demand		No. 2	No. 3
8A End				E		
8A Start				W		
Total				Yds.		

	Inlet		Venturi			Pump #			Pump #			Pump #		
	Well Level		Pump Rate			Amp.			Amp.			Amp.		
Time	East	West	East	West	Total	Fld.	Mot.	Temp.	Fld.	Mot.	Temp.	Fld.	Mot.	Temp.
8A														
9														
10														
11														
Noon														
1P														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
Mid.														
1A														
2														
3														
4														
5														
6														
7														

Remarks:	Operators
	8A - 4P
	4P - Mid.
	Mid. - 8A

FIG. 1.—Example of a daily log sheet.

In the statistical record group there are two forms, the first of which is the Sample-Analysis Log. Each sample collected is assigned a laboratory number and the date and source of the sample are entered with this number. In addition, the type of analysis (sanitary-chemical, bacteriological, etc.) and the number of analytical tests made on each sample are recorded. These data are necessary for the monthly report made to the State Department of Health as a laboratory approved by that Department.

The second form in the first class is the Monthly Laboratory Record, which summarizes the data from the Sample-Analysis Log by listing the number of samples from each source, the number of each type of analysis, and the distribution of the analytical tests as to type.

In the second class (Bench Sheets), there are ten forms. All bench sheet forms have space for the laboratory number and the date in the upper right hand corner, which makes for ready reference and filing. All bench sheets have a place for date of completion of analysis and signature of the analyst.

The first of these is for Sanitary Chemical Analysis; the second is for Bacterial Examinations. Both the chemical and bacterial bench sheets are so designed that either sheet may be applied to sewage or water analysis, whether the source be sewers, industry, treatment plant or river samples. Essential space is provided for notations required on samples that are taken from sources other than at the treatment plant.

The third important form in this class is the bench sheet for the Chlorine Demand Determination. This sheet may be used for any source or any size of sample used. On it may be recorded the flow, temperature and the chlorine demand as determined according to the method of the test, at any and all hours of the day. This form also provides space for standardization of the chlorine water reagent and a place for the shift sampler to sign, thus giving a record of the attendants for the 24 hours.

Other bench sheets include: Gas Analysis—a form with appropriate space for recording entries on CO_2, O_2, Illuminants, H_2, CH_4, N_2, and B.t.u. B.t.u. Analysis—a form for the determination of the heat value of either liquid (oil) or solid (sludge) fuels by oxygen bomb calorimetry with standard entries being made. Lime Analysis—a form specifically for use in determining (duplicate analysis) the available CaO (by the A. S. T. M. modified Scaife Method), in lime purchased under contract specifications. Ferric Chloride Analysis—a form specifically for use in determining (duplicate analysis) the anhydrous ferric chloride in solution purchased under contract specifications. Oil Analysis—a form used in the analysis of a monthly composite sample of oil deliveries, including weights, B. t. u. and density. Gauge Tests—a form on which is recorded the dead weight and the gauge reading before and after adjustment.

As in any laboratory, there must, of course, be some miscellaneous analyses which cannot be classified under the regular routine categories. For that reason a miscellaneous chemical analysis bench sheet has been prepared, which, except for the source of sample, is blank and thus permits data entries on any kind of analysis that is made. This sheet is used in connection with the determination of sieve tests of lime or grit, the determination of alkalinity of milk of lime solution, and other miscellaneous samples, such as soil, sludge fertilizer, and ash analysis.

The third class of laboratory forms, viz., Reports, may be divided into three groups; first, reports of daily or individual tests; second, monthly reports or records; third, miscellaneous reports. The first of these divisions includes the *daily analysis summary* and the reports of the analysis of lime, ferric chloride, monthly oil composite and gauge testing. The former contains the most pertinent analytical and quantitative data, and the latter reports contain, in addition to the laboratory number and the date, the source, delivery number, weights, method of analysis, analytical data, etc., where applicable.

The second group of report sheets are the laboratory monthly data summary forms and records. These forms were designed in accordance with the major premises with these two additional considerations:

1. The base data (*i.e.,* original data collected either by direct reading of measuring devices, or by direct analysis) should be tabulated in one series of sheets, and computed data (*i.e.,* those data which utilize the calculation involving both the volume and analysis of the particular sample) should be tabulated in another series.
2. The monthly report sheets for base data should be applicable to as many different samples as possible.

Typical examples of these forms are shown in Fig. 2.

These report sheets, on which daily entries are made of the base and computed data, all have a space for the month in the upper right hand corner and a place for numbering the sheets in order that they may be kept in proper sequence. Headings across the top include all of the necessary information on data collected on the various samples.

In the keeping of these laboratory data, forms are set up in the following sequence: First, base data sheets; secondly, the computed data sheets.

Base data sheets include the following forms:

Weather and Flow.—Maximum, minimum and average sewage temperatures are taken from the hourly determinations made by the samplers. Weather data is a combination of the data collected at the Treatment Plant and that collected by the U. S. Weather Bureau. The flow is an integrated value from the venturi meters.

Parts Per Million.—This form which contains space for entering the source of the sample may be used for the analysis of any of the various sewage samples including the raw, grit free, influent and effluent samples. It may also be used for raw sludge, supernatant liquor, digested sludge and filtrate liquor. Not all of the determinations listed are made on every sample, but columnar space is available for several determinations so that if made on a sample, they may be entered on this sheet. In addition to the columns for recording the regular analysis, blank columns are available for the entering of additional determinations not listed.

Bacterial Results.—This is also a utilitarian sheet which may be applied to several samples. In particular, there is a columnar space for seven different hourly analyses for coliform bacteria. There is space also left for the entering of total counts or for entering data on samples collected from the Niagara River.

BUFFALO SEWER AUTHORITY
SEWAGE TREATMENT WORKS
Bird Island Laboratory

Month of ____________
Sheet ____ of ____

BASE DATA - PARTS PER MILLION

Date	Day of Week	Source ________					Chlorine Demand								
		Flow			Susp.Solids	Volatile Susp.Solids	Max.	Min.	Avg.	Comp.	5 Day B.O.D.	Total Nitrogen	HCO_3 Alk.	pH	
1															
31															
Total															
Max.															
Min.															
Avg.															
Pre.Mo.															
Normal															

BUFFALO SEWER AUTHORITY
SEWAGE TREATMENT WORKS
Bird Island Laboratory

Month of ____________
Sheet ____ of ____

COMPUTED DATA - B.O.D. & CHLORINE DEMAND

Date	Day of Week	B.O.D. - 1000 Pounds						Chlorine Demand - 1000 Pounds per 24 Hours										
								Raw Sewage					Dosage					
		Raw Sewage	Grit Free Sewage	Clarifier Influent	Clarifier Effluent	Removed	% Removal	Max.	Min.	Avg.	Supernatant Return	Total Chlor. Dem.	Max.	Min.	Avg.	% Satisfact.	Clarifier Effluent	% Sat. Calc. from Effl. Dem.
1																		
31																		
Total																		
Max.																		
Min.																		
Avg.																		
Pre.Mo.																		
Normal.																		

FIG. 2.—Examples of laboratory base data and computed data monthly summary sheets.

Sludge Digestion.—This form contains no analytical data, but records only that collected from plant readings.

Sludge Dewatering.—This form contains data on chemicals used in sludge conditioning and the analysis of the sludge filter cake.

Grit, Ash and Gas Analysis.—A summary sheet containing the data on measured quantities and analysis of grit, ash, and gas.

In order to evaluate the operation of the treatment works, and to weight all analytical values in accordance with one of the major premises mentioned above, all analyses are calculated to quantitative results. In the case of solids, B.O.D., and chlorine demand, the unit is 1000 pounds per day; bacterial results are reported in quantity units, and all such data are recorded on computed data summary sheets.

Not only do the computed data sheets give quantitative results, but, as desired, it becomes possible to evaluate the averages back to *weighted* values for average p.p.m. or percentages. This method of treating the data overcomes the objection that arithmetical averages of analytical data are incorrect. It has been suggested (1) that the median value in a series (*i.e.,* monthly data) of analytical data is more nearly correct than the arithmetical average. But the method used here is the only method that will give a true weighted average analysis where that analysis depends on two variables (*i.e.,* flow and concentration). The determination of p.p.m., per cent of solids, chlorine demand and coliform bacteria per ml. are all weighted averages. Less important data, such as per cent volatile matter in some samples, are not weighted because of the additional work of calculation involved in this method of computing averages. All removals and reductions are calculated on the basis of quantitative results.

The Computed Data group follows the same general form as the Base Data monthly summaries and includes the following:

Thousand Pounds of Solids.—This form is so designed as to record thousand pounds of solids in the raw, grit free, influent and effluent samples, difference in removals and the percentage removals. This sheet can be applied to any method of determining solids, whether Gooch, aluminum dish, non-settling, settleable or total solids. The flow is also recorded.

B.O.D. and Chlorine Demand.—On this sheet B.O.D. of the raw sewage, grit-free sewage, settling tank influent, and effluent may be entered in thousand pounds. B.O.D. removed (1000 lb.) per day and the per cent removal are also entered. Chlorine Demand of raw sewage and supernatant liquor, total chlorine demand and the dosage are all given in thousand pounds per 24 hours. The per cent satisfaction is determined according to the definition of Chlorine Demand (2).

Bacterial Results.—This form may be used for the various hours at which bacterial analyses are made. At the present time, six different samples daily are being analyzed and thus there are six of these computed sheets in the monthly summary. There is also an additional sheet prepared for the average of the six analyses.

This form contains (1) the data on the coliform bacteria in the raw sewage and the plant effluent at the respective hours of detention period; (2) the removal and the per cent removal of quantity units; (3) the chlorine demand and dosage at that hour, (4) the per cent satisfaction at that hour, and (5) corresponding hourly rate of flow. The data on these forms make it possible to summarize information on the effects of chlorination on bacterial kill in sewage and to compare the reduction of coliform bacteria to the per cent satisfaction, contact time and the relation between the demand and dosage. In this manner, routine data are applied to research purposes. The binding of these computed data sheets into a monthly summary folder keeps the forms in the general sequence of plant operations; digester operation follows sedimentation and disinfection.

Digester Operation.—This form provides columnar space for data on solids and volatile matter loading as calculated from different original data, *i.e.*, suspended solids, raw sludge, gas production and incineration.

Solids Disposal.—A summary sheet for recording quantitative data on sludge filter cake, grit removed and burned, total solids incinerated and ash produced.

The miscellaneous class of laboratory forms includes a graphic report for recording the concentration of sludge solids in the sludge digestion tanks as indicated by the monthly sludge tank inventory; also, a monthly report on the quantities of solids by layers in each of the four sludge tanks as determined from the inventory. Other miscellaneous forms include a blank columnar form for tabulation of any special data, miscellaneous analyses, blank forms and other sheets used in the calculation of data.

Plant Reports

In the category of plant reports, the Daily Report consists of a single sheet on which are entered the most pertinent items of each day's operation, particularly the sewage flow, pump operation, solids removed, chlorine used, gas produced and burned, and sludge incinerated. In short, this sheet is a summary of the daily production and serves to acquaint the management with daily plant operation. The data entered on this report are obtained by abstracting the desired items from two sources, the Plant Daily Log Summary, as prepared by the statistician, and the Laboratory Daily Analysis Summary, which contains the production quantities calculated from the volumes and the analyses.

The Monthly Report forms consist of ten pages (multiple sheet report) containing columnar headings for all items on which monthly reports are made. The first sheet of this report contains the daily data (of the particular month) for all items on flow, sedimentation, chlorination and disinfection (bacterial kill), which are desired by the New York State Department of Health. The remaining sheets, examples of which are shown in Fig. 3, record data on Weather, Flow, and Power; Primary Treatment; B.O.D. and Disinfection; Grit and Raw Sludge; Digester Operation (two); Incineration (two); and Miscellaneous Data. These monthly report sheets utilize a unique idea suggested by Mr. Harold Epstein, General Manager of the Buffalo Sewer Authority,

BUFFALO SEWER AUTHORITY
SEWAGE TREATMENT WORKS
Monthly Report

Month of ______________
Sheet 3 of 10

PRIMARY TREATMENT
(Daily Averages)

Month	Suspended Solids - Gooch					Removal of Raw Susp. Solids		Settleable Solids		pH Raw Sewage
	Raw		Grit Free p.p.m.	Infl. p.p.m.	Effl. p.p.m.	% Overall	% By Clar.	Infl. p.p.m.	% Clar. Efficiency	
	p.p.m.	Lbs. Per Cap.								
1941 July : June										
This Month Max. Min.										
This Year Max. Min.										
Previous Year Max. Min. Avg.										
Normal Average										

Remarks:

Additional Example of Heading Spacing and Entries.

BUFFALO SEWER AUTHORITY
SEWAGE TREATMENT WORKS
Monthly Report

Month of ______________
Sheet 8 of 10

INCINERATION
(Calendar Day Averages)

Month	Sludge Cake								Grit	ASH	
	Tons Wet	Per Cent Dry Solids	1000 Lbs. Dry Solids	Per Cent Vol. Mat.	1000 Lbs. Vol. Mat.	B.t.u. Per Lb. D.S.	Per Cent CaO	Per Cent $FeCl_3$	1000 Lbs. Burn.	1000 Lbs. Dry	% Vol. Mat.

FIG. 3.—Examples of sheets from the multiple leaf plant monthly report.

namely, that the monthly report consist of a running record of the daily averages for the months of the year as they are completed. Thus, in addition to the daily average for all items for the particular month reported, the average data for each preceding month of the year is also shown. There are also included the maximum and minimum data for the month and the year; the daily average for the previous year, together with maximum and minimum values, and the daily average for the same month in the previous year. From each report a comprehensive idea of the normality of operations for each month may be obtained, as it is related to the current and the past year. Mimeograph stencils of data are cut each month and are then run onto the previously prepared blank forms. A running analysis sheet is kept by the statistician for totals necessary to obtain the daily average for the year, and when the twelfth month's data have been entered on the monthly report, the annual report is practically complete, requiring but a few arithmetical procedures.

Written comments on the data of each month are prepared by the Chief Chemist for the Works Superintendent, who in turn writes a short commentary on the plant operation for that particular month. This, with the data sheets, comprises the Monthly Report of the Treatment Works. The annual report of the Treatment Plant is prepared in similar manner.

Miscellaneous Forms

Among the miscellaneous record forms used in the Buffalo Sewage Treatment Works are; (1) a daily record of equipment condition in the sludge disposal building (sludge conditioning, filtration, and incineration) for the use of the mechanics and maintenance department; (2) a monthly log of meter readings and pump operation at the two outlying pumping stations; (3) scale records (recording weight tickets) of all chemicals purchased, all grit removed and burned, and ash hauled away for fill. In addition, there is a loose-leaf ledger for posting storeroom stock receipts and disbursements, and various forms and records have been set up for use in connection with work orders and the operation of the maintenance department. These, together with a number of miscellaneous forms, concerned with plant administration and personnel, were designed by Mr. Velzy, Works Superintendent. Cost records are not kept at the treatment works as the auditing department is a part of the general administrative offices.

At first consideration of the foregoing account, one might believe that the number of forms is unusually large and that the amount of statistical work is overburdening. Neither of these beliefs is correct. Except for the bacteriological examinations and analyses of lime, ferric chloride, and oil, the sewage testing is no more extensive than in many sewage plants. Even where a number of daily entries of items are made, although not used in the monthly or yearly records, it requires but little time to record such items against the day when a need arises to summarize these data to obtain the answer to some previously unexpected question.

Likewise, it must be remembered that the multiple sheet report contains no greater number of items than would a long, wide and unwieldy report of a single sheet. Furthermore, many of the laboratory sheets may be used for several different samples, and contain blank space for entering data that may for some reason be of special nature. Thus the above delineated forms serve to keep a complete record of the operation of the laboratory and treatment plant of the Buffalo Sewer Authority, to maintain pertinent data available at all times, and to furnish integrated summaries of operating results.

The authors are indebted to Mr. Charles R. Velzy, Works Superintendent, Mr. John W. Johnson, Assistant Works Superintendent, and the members of the Bird Island Laboratory staff for their many helpful suggestions during the development of these record forms.

References

1. C. C. Larson, "Suggestions for Increasing the Value of Sewage Treatment Works Data," *This Journal*, 4, 101 (1932).
2. G. E. Symons, J. W. Johnson, and R. W. Simpson, "Dosage Control in Sewage Chlorination," *Water Works & Sewerage* 88, 519–24 (1941).

CROSS CONNECTIONS BETWEEN POTABLE WATER SUPPLY SYSTEMS AND SEWERAGE SYSTEMS *

By J. R. Hoffert

Civil Engineer, Pennsylvania Department of Health, Harrisburg, Pa.

When, some years ago, one of the men in a sewage treatment works laboratory opened a water faucet and was amazed to see sewage sludge issue therefrom, not only was his astonishment shared by all who heard of it but it again served notice upon operators and engineers alike that, *regardless of probabilities, where a possibility exists there is always the chance that the possibility will become a reality.* If danger can result from it, then the possibility should not be permitted to exist, even though the danger be an improbability.

In public waterworks practice there was a time when a cross connection between the regular potable water supply and an emergency fire fighting water supply—which often was a polluted stream—was not only fairly common, but in the minds of many factory managers was only a proper and necessary precaution—against fire, not public health. Wasn't there a valve between the two supplies and wasn't it always closed except at times of fire? Well, unfortunately it wasn't always so closed as experience demonstrated. Furthermore, valves even though apparently well maintained were shown upon occasion to have leaked with fateful and fatal consequences.

So further precautions were deemed necessary and the double valved section with a drain or drip between, was devised and used to a considerable extent. Theoretically, it should be quite safe. Unfortunately, even two valves can leak at the same time and if the drain between them is left closed either accidentally or purposely and without warrant by some workman, the supposed security may prove to be dangerous insecurity.

Therefore, the latest public health policy is that there shall be *no direct cross connection* between a potable public water supply and an inferior supply regardless of how safe such a connection may seem to be.

A few years ago most people even among the engineers, would have felt that there was little real danger in the usual flushometer connection with a watercloset or in many other accepted and widely used plumbing connections. But a few actual experiences in which the utterly improbable happened, have changed that complacency. Now we know that if a thing is possible, it may happen—which after all is just in accordance with definition. Now we provide a venturi vent or some other safeguard against back-siphonage from waterclosets and whatever precautions may be necessary in the case of other fixtures so that contamination of a safe water supply cannot possibly occur.

* Presented at the Fourteenth Annual Conference of the Pennsylvania Sewage Works Association, State College, June 27, 1940.

Well, if actual and sometimes painfully sad experience has shown that there should be *no* physical connection between a safe water supply and a contaminated water supply whereby under any possible circumstance the safe supply may thereby become contaminated, how much more important is it that such a policy be strictly enforced when dealing with sewage which is not only a contaminated water but by its very nature a *grossly contaminated* water.

No designing engineer consciously arranges for any connections whereby he feels there is any probability of contaminating a safe water. Neither does any sewage works operator intentionally, later on, make any connection of his own or follow any operating procedure which he feels would endanger health. But good intentions are not enough. It is imperative that each person concerned with the design and operation of sewers and sewage treatment works examine every connection with a safe water supply, to see whether under any circumstance, however improbable, sewage or sludge *could* be either forced or sucked into the safe water supply. If it can be, then that connection should be broken and replaced with one which will prevent such an accident. Careful examination of many sewage treatment works will show cross-connections which are potential sources of danger and others which are even probable avenues of contamination. Some of these have arisen from the design and construction of the plant; some from changes to the original plant design made by the operator; and some from operating procedure.

To define the obvious, let us say that a cross connection is any physical connection whereby there may be an interchange between two systems—for purposes of present discussion, a back-flow of sewage or sewage solids into a safe water supply. Let us repeat, cross connections arise, in general, from provisions made in the design of the plant and installed at the time of its construction; from changes made to the plant for operating convenience; or from certain operating procedure which results in an actual cross connection which might not even be recognized as such.

For instance, the original plant design may have provided for sealing the suction side of the shaft of the raw sewage pump by a direct water line from the potable supply. Or an operator, tired of having to flush sewage solids out of a float well, may have piped a running water connection from the potable supply to a point below the surface of the liquid in the float well.

There are also unrecognized operating cross connections. Have you ever seen a hose attached to a hydrant or pave wash, after having been used to wash down a settling tank or to beat down the scum in a gas vent, be dropped onto the ground with its free end below the surface of the liquid in the tank and with the water still running through the hose? Most likely, this only results in fouling the end of the hose, but suppose a vacuum should occur upon that water line! Not a cross connection in the usual sense but a dangerous operating cross connection nevertheless!

Cross connections may be made for a variety of purposes but the most frequent reasons are to provide a means for flushing out sewage solids, to provide a water seal, or to prime some piece of equipment.

Let's consider a few typical examples and then, since it is our intent to arouse thought rather than to go into details, leave the reader to think over possible cross connections which may exist at his own plant and which should be corrected.

As an example of a cross connection for flushing purposes, consider the old-time and still existing ring of perforated water pipe so frequently placed around the top of the sludge hoppers in Imhoff tanks. Frequently, these lines are given but scant maintenance. Such a connection is all the more dangerous in the case of tanks built considerably above the natural grade and where the water line comes up to the top of the tank from the lower level through the side fill banked around the tank.

It is quite common practice to attempt to keep meters, float wells and float tubes and manometer connecting piping free of sewage solids by permitting clean water to flow or drip through them. Examples of this practice are the flushing rings and manometer connections to Venturi meters, connections to Parshall flumes, the float chambers of float operated meters, etc. When the water simply drips or flows through an air gap into the device from above, there need be no danger; where the connection is a pressure connection or lies below the surface of the liquid, there may be danger.

A direct flushing connection may be provided into some pipe line, such as the discharge line from a sludge pump, to insure having the line stand full of water instead of sludge when pumping ceases. Water-spray flushing connections have been provided in gas domes of sludge digesters to permit breaking up of scum. Water lines have been connected to sludge conditioning equipment, to equipment for macerating or otherwise handling screenings, for flushing pump sumps, etc. Such connections may be safe or potentially dangerous according as they do or do not provide a link whereby under adverse conditions contamination of a safe water may take place.

It is common practice to insure proper suction of centrifugal pumps by connecting a water line under pressure to the stuffing box on the suction end of the shaft. If the pump handles sewage or sludge, such a connection to a potable water supply would be dangerous.

In some instances a direct connection has been made between the municipal water supply and the suction line of a pump leading to a clarifier or a sludge sump.

Centrifugal pumps located above the level of the sewage in their suction connection, must be primed before they can discharge. It is common practice to provide a priming connection to the high point of the pump casing or to prime from below this point and vent the air from the high point. Frequently the priming water is taken directly from the potable supply, thereby making a dangerous cross connection.

Sludge or sewage sampling lines in which the potable water supply lifts the sample in the manner of an aspirator, also offer possibilities of danger.

In some plants the plant effluent is used for flushing, lawn sprinkling, and similar inferior usage, using a pump and pressure system for the purpose. A cross connection may be provided between such a system and the potable supply but such a connection would be especially dangerous, particularly if made on the pressure side of the inferior supply.

With the marked mechanizing of modern sewage treatment works and the multiplicity of piping between the various plant units, conditioning tanks, chemical feeders, and feed tanks, pumps, filters, gas engines, and control apparatus and operating "gadgets," the present day plant offers so many possibilities of cross connections that it behooves all connected with the design and operation of sewage treatment works to be on their guard. True, in many cases the probabilities are that no real harm would result from the cross connection. But very serious harm *might* some day come suddenly and from the seemingly improbable and the waterworks industry spends too much money and the energy of too many faithful workers and is too responsible for the public health to have its efforts nullified even once because a cross connection with a sewage contaminated water permitted the possible but seemingly improbable to happen.

We have pointed out the dangers of cross connections and have referred to various examples, but—what are the remedies? Well, they are rather obvious and fairly simple. The difficulty is to have people sufficiently realize the dangers to put them into effect and *continue* them in effect.

First of all, let there be no direct connection between a potable supply and sewage or sewage solids. This is most completely effected by having the water obtained from the potable supply discharge by gravity over the top into a tank provided with an overflow and whose water level is controlled by a float valve operating upon the potable water supply line. The pump which delivers this water to the connections with the sewage treatment works piping should take its suction from this tank and no possible vacuum on the potable supply can contaminate it with any sewage. Individual connections with the potable supply when not required to be under pressure can be made over the top of the receiving connection with an air gap between the two. When the potable supply must be used under pressure, a temporary hose or pipe connection can be used, so designed that the connection will be maintained only so long as the connecter is held in place by the operator's hands. Such a connecter should be so designed that it cannot be secured in place; otherwise the temptation to fix it in position and so save the operator trouble, is too great and it is apt to be wired or otherwise permanently fixed in place, thus defeating its very purpose.

Of course, *no cross connection of any kind* should be permitted between a potable supply and one utilizing the plant effluent.

Everyone seems to be becoming increasingly color conscious. The various piping systems around a sewage treatment works can be color-coded to great advantage. Care should be taken to paint all lines carrying inferior water or plant effluent, with a distinctive and warning color and to paint all water lines with a similarly distinctive color.

But in the matter of cross connections as in all public health work, eternal vigilance is the price of safety.

CROSS CONNECTIONS IN SEWAGE PLANTS *

By G. E. Arnold

Chief Water Purification Engineer, San Francisco Water Department

The subject of cross connections has been of particular interest to sanitary engineers for a number of years. In 1930, the Surgeon General of the U. S. Public Health Service issued instructions to all state sanitary engineers to refuse certification to water supplies where cross connections existed within the water system. A cross connection is defined as a physical pipe connection between a potable water supply and any other source of water supply or fluid material which may permit the flow of a potentially dangerous material into a potable supply.

From the waterworks standpoint, the first attention in this line was given to wells, salt water, polluted rivers and other secondary sources of water supply. In 1933, an outbreak of amebic dysentery in two Chicago hotels focused attention on the danger of cross connections within building piping. Numerous articles have appeared in the technical journals pointing out the danger of such cross connections. It should be of interest to sewage works engineers and operators to examine their systems and plants for cross connections which may endanger the health of the operators or residents of their communities. The purpose of this paper will be to outline the location of such cross connections as may exist and to suggest remedies for their protection or elimination.

Water works engineers have devoted much time and attention to the protection of their supplies. The source of the water is constantly surveyed for evidence of pollution, the water is carefully treated, constantly tested, and, in most cases, delivered to the consumers in first-class condition. All of this care and expense can be offset by dangerous connections within consumers' premises or by careless handling of the sewage disposal works of a community. A search of the literature will reveal many cases of water supply pollution with attendant outbreaks of disease caused by improper piping or careless handling of equipment.

In September, 1940, the following resolution was adopted by the California Sewage Works Association:

> *Whereas:* Cross connections between water supplies and sewage lines are known to exist at most sewage treatment plants and pumping plants, and
>
> *Whereas:* Such cross connections are a menace to the safety of the water supply, through possible back-flow and back-syphonage, and
>
> *Whereas:* There is need for the operators to discover and correct all possible cross connections, including cooling lines to compressors and gas engines, pump priming and water seal lines, submerged inlets, including hoses, water-operated skimming nozzles, chlorinator water feed lines, lines to venturi cleanouts and float wells, and back wash lines to sludge and sand filters: now therefore

* Presented at the Spring Conference of the California Sewage Works Assn., Santa Cruz, April 22, 1941.

Be it resolved: By the California Sewage Works Association in convention assembled at San Diego, California, September 17, 1940, that operators of sewage plants, pumping stations, and similar structures be urged to study the problem of cross connections existing in such works, and take such steps as are necessary to protect the water supplies by a break in connection, vacuum breakers, and/or valves designed to prevent back-flow and back-syphonage.

The foregoing resolution was prepared by the Board of Directors persuant to unanimous authorization of the membership of the Association in convention assembled at the Hotel U. S. Grant, San Diego, California, on the seventeenth day of September, 1940.

This resolution mentions various places where cross connections may exist in sewage plants. The writer has visited a number of sewage plants recently with the particular purpose in mind of looking for such connections. Their prevalence is indicated by conditions found. In one plant, it was observed that water and sewage connections existed throughout the plant, performing a total of thirty-eight different functions within this one plant. In some cases, one operation or function occurred as many as ten or twelve times within the plant. The total number of dangerous connections would, therefore, total a hundred or more. Following is a brief outline of such connections found in this and several other plants visited.

Water is used to some extent in the collecting and transmission works of a sewerage system. Collecting sewers are frequently flushed with a water hose connected to a fire hydrant. These flushing operations are usually not of long duration and are always done in the presence of an operator or other employee, but should a partial vacuum occur in the water system during such flushing operations, sewage might readily be drawn into the water system. In many buildings, water connections are made to sewer lines for the purpose of flushing them should a stoppage occur. This is a particularly dangerous practice as sewers are likely to be flushed at any time without supervision or by persons unfamiliar with the dangers attendant. Storm sewers are frequently cleared of accumulated sediment by flushing with fire hoses from fire hydrants. Catch basins are sometimes cleared with water or water ejectors and agitators are used to dislodge deposited material. Water-sewage connections in buildings are too numerous to elaborate and are beyond the jurisdiction of the sewerage engineers but should be exposed and broken by plumbing inspectors.

Automatic flush tanks are frequently installed in main sewer lines to flush out deposits of sediment which tend to clog sewers. Most tanks are placed in the sewer or a manhole where they may become submerged at times of high flow or stoppage of the sewer. The water connection is open all the time and should any partial vacuum occur during submergence, sewage would be drawn into the water system.

As sewage enters the plant, the first operation performed is usually that of screening. Bar racks and screens are usually mechanically cleaned. In some instances, water is used to aid this cleaning operation, either in the form of sprays or wash lines. Spray nozzles are sometimes located in such a position that they may become submerged at periods of high sewage flow. Hoses are sometimes used to wash down racks and are occasionally allowed to drop into the sewage.

Shredders and grinders are also used in connection with screening operations, this equipment usually being washed by sprays, flush nozzles or hoses. In some cases, the ground or shredded material is carried back to the incoming sewage with water.

Meters are used in many places throughout sewage plants. They measure the incoming sewage, sometimes from several sources. The water used around the plant is also metered. Meters are installed at different points about the plant to measure the amount of material being handled, such as sludge, return or recirculated sludge, influent and effluent from digesters, water and sewage in elutriation process, plant effluent, and for other uses. In most cases, mechanical metering is employed and there is no water connection to the meter. In some cases, however, venturi meters are used and water is employed in the connections to recorders and indicators. In a few cases, flushing water is connected to the meter to clear moving parts of obstructions. These meters are essential and in some cases water connections to meters are essential but in all cases the water should be protected against pollution by sewage.

Water is used for operation of chlorinating equipment, connections being made to injectors, for tray supply and for other uses. Under certain operating conditions, it may be possible to contaminate the water supply with sewage.

Pumps are probably more numerous than any other pieces of equipment in a sewage works. Sewage is pumped from one point to another in the collecting system, is frequently pumped into or out of the treatment plant. Pumps are used on the influent lines; to remove sand and grit from receiving tanks or sedimentation basins; to remove grease, scum, and other material; are used on raw and digested sludge lines; for pumping sludge to digesters; to pump effluent around the plant and away from the plant; and to pump filtrate from mechanical filters. In many cases pumps are equipped with priming lines and water seals. Vertical impeller pumps frequently require priming and in many cases a water line is connected to the pump to fill the case, thus priming the pump before it is started. Water lines are frequently connected to bearings and glands in sewage pumps to prevent cutting and wearing of the bearings by gritty sewage. The danger is always present that sewage may be pumped back into the water lines or may be sucked in by a partial vacuum in the water system.

Clearing sludge lines is a frequent activity in most sewage plants. Sludge deposits build up in pipes and impede or prevent the flow of sludge. In many cases, water connections are made to sludge lines to flush them, removing obstructions and deposits. Sludge lines are found on sedimentation tanks, sand traps, flocculating basins, raw and digested sludge lines and in mixing tanks. A stoppage of sludge lines may result in building up fairly high pressures which could force sewage into the water lines.

Sprays are used quite generally in sewage plants to remove scum, grease, and other floating material. Sprays are found on clarifiers, sedimentation basins, grease removal tanks, flow chambers, elutriation tanks and in other places throughout sewage plants. Spray nozzles are customarily installed a few inches above the surface of the liquid in the tank or basin. They may, however, become submerged by stoppage of the drainage or overflow works or may be dropped into the tanks by failure of supporting devices.

Hose connections for washing and flushing are common throughout sewage plants. Hose bibbs are installed in many places and hoses connected to them for general use. Floors and working platforms are washed, basins and tanks are hosed down for cleaning, sludge lines and other pipes are equipped with hose connections for washing or flushing. In many instances hoses are connected to water faucets and left in place for use whenever needed. It is common practice to allow the open end of the hose to drop into a tank or basin and to be left there. The writer observed many such instances in plants recently visited. Sometimes, hoses are used to aid sprays running continuously or intermittently as needed. Hoses are also used for filling equipment and starting operations after a plant has been shut down or drained.

Vacuum ejectors are frequently used around sewage plants for removing water from sumps and drainage basins. Pumps and other equipment are frequently located in pits and when this equipment is drained for maintenance or repair some material drains onto the floor of the pit where it is collected into a sump and a vacuum ejector used to empty the sump. These vacuum ejectors are invariably operated by water pressure. In a few cases air and water is used in combination to prevent the packing of sand or grit in sedimentation basins. These air-water ejectors are operated with high-pressure water.

Water is used in many other ways around sewage plants. Following are but a few of the uses: boiler makeup, digester heating coils makeup, digester seals, hydraulic valve cylinders, irrigation of grounds, in the laboratory, in toilets and showers.

It therefore appears that the use of water around sewage plants is quite essential and that in many instances water and sewage connections are made in such a manner as to be dangerous to the safety of the water supply. The fact that this danger exists, and is apparent to the operators was noted, in that bottled drinking water is supplied in many plants for the use of the operators and visitors. Under normal operating conditions, the danger of back-siphonage or back flow from the connections enumerated above is slight. Water pressures are in general much higher than sewage pressures. The sewage plant is invariably located at the lowest elevation in the sewerage system where water pressures are apt to be highest. However, normal operations in water systems frequently require shut-downs for maintenance or repairs, sometimes breaks occur which reduce the pressure in the water system and occasionally fires result in low pressure or even a partial vacuum in the water piping. Sewage is probably the most dangerous material handled in connection with water from a disease standpoint and extreme precaution should be taken to assure continued safety of the water supply. In some cases, it is permissible to install double check valves in a water line where a cross connection exists with another source of supply or with some potential hazard. In the writer's opinion, however, double check valves are not sufficient protection in sewage plants because of the nature of the material handled. In some cases, double check valves are installed at each of the cross connections with sewage. For example, a small water line connected to the bearings on a sewage pump may be equipped with double check valves just ahead of the connection to the pump or a water line connected to several sludge lines for flushing may be thus equipped. This probably affords partial protection but should not be considered entirely satisfactory. In one case, blank flanges were installed in the water piping and a hose connection made around the blank flange to be used only when flushing operations were actually being made. It has been noted, however, that hoses are usually connected up and left in place between operations thus nullifying the effect of the blank flange. The common practice of allowing hoses to drop into tanks and basins containing sewage and leaving them there may be noted at almost any plant. The ideal situation for any sewage plant is to receive water from the domestic system by free-fall into an open tank and then to repump the water to obtain the desired pressure for water around the plant. This free-fall into an open tank should be through a pipe which is terminated above the overflow level of the tank.

Many sewage plants contain such a maze of piping that anyone not familiar with the design and construction of the plant may find it difficult to determine which are water lines, which are sewage lines and which are chemical lines. Painting these pipes that carry different materials a suitable color is a decided aid in tracing out the piping in the plant. In one plant recently visited, a suitable combination was noted. Here, all sewage lines were painted black; sludge lines were brown; water lines were blue; air lines were white; chemical lines were yellow. In another plant, the entire piping was not painted a distinctive color but a stripe of color was painted around each joint of pipe or fitting. With a system of this kind, it is easy to trace out the piping layout of a plant and to determine just what material is carried by each pipe inspected.

There are on the market some valves mechanically designed to prevent back flow in a safe manner. One such valve is made by a West Coast manufacturer and is equipped with diaphragms and discharge outlets so operated that should a pressure in the discharge side or a partial vacuum on the inlet side occur, the valve would open with a free-fall to the drain. These valves can be set to operate at any desired differential in pressure and will function should these differential limits be exceeded. Such a valve installed in the main water line to a sewage plant would afford adequate protection and could be used in lieu of an open tank and repumping the water. These valves are, however, somewhat expensive.

At one pumping station visited, the water used for seals in pumps and meters was discharged into an open tank from the public water system and was re-pumped for use in the plant thus affording a complete separation between sewage and water. In the same plant, there were some connections for flushing sewage lines and removing deposited sediment. These flushing connections were for hoses and the hoses were provided to connect the water piping to the sewage lines. A sign was conspicuously posted in this station which read, "Hoses To Be Connected For Flushing Only When Essential And Are To Be Disconnected Immediately After Use. To Be Used Only Under Operator's Supervision. Safety Comes First."

Every possible precaution should be taken to protect the safety of the operators in the plant and the public on a domestic water supply system from such potentially dangerous sources of pollution.

In passing, it is desired to bring to the attention of the Sewage Works Association the matter of hotel sanitation. The American Water Works Association for a number of years has insisted on certain sanitary precautions in any hotel used for a convention of the Association. Several other organizations adopted the same provisions. It is suggested that the Sewage Works Association give some thought to this matter as concerted action on the part of numerous organizations will be effective in rectifying serious health hazards which now exist in many hotels.

In making the examination of the hotels, a standard form was used to facilitate the work and assure complete inspection. This form listed the various pieces of equipment and piping layouts to be examined. Appended to this paper is a proposed form to be used in examining sewage plants for cross connections. This form, while not complete or detailed, may be of some assistance to operators in following the suggestions outlined in this paper.

Cross Connections in Sewage Plants

Location of Plant.................... Type of Treatment....................
Capacity.................... Population Served....................
Sources of Water Supply.................... Date of Survey....................

Water Connections

Incoming Sewage
Meters.......... Bar Racks.......... Screens..........
Mechanical Cleaners.......... Sprays.......... Hose..........
Grinders.......... Shredders.......... Flushing..........
Pumps.......... Sand Removal.......... Flush Tanks..........

Sedimentation
Clarifiers.......... Sprays.......... Skimmers.......... Grease Pumps..........
Sedimentation Tanks.......... Coagulation Tanks.......... Mixing Tanks..........
Chemical Feeders.......... Sludge Lines.......... Sludge Pumps.......... Hoses..........

Digestion
Digestor Water Seal.......... Heating Coil Makeup.......... Sludge Pump..........
Sludge Lines.......... Seeding Pump.......... Hoses..........

Miscellaneous
Air Compressors.......... Laboratory.......... Wash Rooms..........
Showers.......... Toilets.......... Drinking Fountains.......... Filters..........
Pumps (all types).......... Chlorinators.......... Wash-down Hoses..........

Summary of Connections Found:

Work Done:

Inspector....................

PLANT DESIGN FOR DISSOLVED OXYGEN *

By M. W. Tatlock

Superintendent, Sewage Treatment, Dayton, Ohio

Plans for the first sewage treatment plant for Dayton provided only primary treatment and indicated that secondary treatment would be necessary by 1935. When these plans were approved by the State Department of Health (June 27, 1927) one of the conditions attached to the approval read as follows: "The date set forth as the time for consideration of additional treatment of sewage, namely 1935, is not accepted by the Director of Health, but rather that this shall be made the subject of study by observation of actual conditions after the plant has been constructed and operation commenced; and, therefore, that when deemed necessary by the Director of Health, additional devices for the treatment of sewage shall be provided." In compliance with this condition, preliminary studies on secondary treatment were begun by the writer about September 1, 1934.

Stream Flow and Dissolved Oxygen

An examination of all available records on stream flows, or thirty-five years data beginning in 1893, showed that there had been but one month when the average flow in the Miami River was less than 350 cu. ft. per second. This fact caused the engineers to adopt 350 c.f.s. as the minimum flow which might be expected in their calculations of oxygen available to meet the demands of the treated sewage. On the basis of this fact and the analysis of numerous samples of the Miami River water the engineers reported: "The average discharge of the river at Dayton, in September, 1923, has been estimated by the Engineers of the Miami Conservancy District as 558 c.f.s. It is probable that with lower flows, such as the 350 c.f.s. estimated as the reasonable minimum to be expected in a ten-year period, a lower dissolved oxygen content of the river waters above Dayton would occur. It is impossible to predict with exactitude the minimum dissolved oxygen content which would occur at times of minimum flow, but *it seems reasonable to* expect that the dissolved oxygen content would not drop below 7.0 p.p.m., which is 0.66 p.p.m. less than the average found in our investigations." These investigations also indicated that the one-day oxygen demand of the stream would be 1 p.p.m. and the engineers assumed that 1.5 p.p.m. should be taken as the minimum to which the dissolved oxygen content of the river could be reduced, and still remain inoffensive and provide enough oxygen to support fish life. These facts and assumptions indicated that there would be 4.5 p.p.m. dissolved oxygen available for the

* Presented at the Fourteenth Annual Convention of the Central States Sewage Works Association, Fort Wayne, Ind., Oct. 6, 1942.

satisfaction of the one-day oxygen demand of Dayton sewage at times of extreme low flow (7.0 — 1.0 — 1.5 equals 4.5).

Data obtained after the plant went into operation indicated the fallacy of assuming that any stream will never be lower than past records indicate. Although thirty-five years flow records were available, and the average flow of the Miami River had never been below 350 c.f.s., the actual flow was lower than the estimated average for one month of 1930, three periods of 1932, and for six periods of 1934. Table I shows the stream flows for the years 1930 to 1934.

TABLE I.—*Stream Flows—Average Monthly C.F.S.*

Period *	1930	1931	1932	1933	1934
1	13,792	435	7,520	5,410	935
2	5,876	550	3,240	1,850	369
3	3,077	890	1,952	5,650	1,321
4	1,619	2,155	1,780	6,320	1,935
5	804	1,105	785	10,230	460
6	693	427	455	2,070	*352*
7	492	514	1,627	880	407
8	*313*	921	*324*	613	*217*
9	453	714	*165*	595	*343*
10	426	520	*265*	1,480	*341*
11	400	480	443	542	*288*
12	423	806	1,695	543	*264*
13		4,090	2,820	1,078	*294*

* Beginning 1931, all plant records are based on a thirteen period calendar instead of the regular twelve months calendar.

The italicized average figures indicate the flows which are equal to or less than the estimated monthly minimum average flow.

The effect of these reduced stream flows on the dissolved oxygen and five-day B.O.D. for the aggravated period of 1934 is shown in Table II. These data indicate that for six of the last eight periods of the year the dissolved oxygen in the stream above the plant was below the allowable average of 4.5 p.p.m., and that it was above the average only during November and December, after cooler weather prevailed. The effect of the addition of Dayton sewage is indicated by the reduced dissolved oxygen content, particularly at Stations "C," "D" and "E," located 2½ miles, 4 miles and 5½ miles below the plant outfall. Station "A" is ½ mile above the plant and Station "B" is within ½ mile of the plant outfall, and just below a riffle which gives adequate mixing of sewage with the water. Station "F" is 7 miles below the plant outfall, and just above a dam which forms a pool extending upstream to the riffle just below the plant. The stream had all the visible appearance of a grossly polluted stream during the latter portion of the year.

The observed stream conditions, and the conditions of approval of the State Department of Health, indicated the necessity of immediate action to relieve the conditions before legal action was instituted by offended neighbors below the plant. On January 19, 1935, a report was

TABLE II.—*Dissolved Oxygen—Low Water Stages 1934*

Period	Flow, C.F.S.	Sampling Stations					
		A	B	C	D	E	F
6	352	4.2	3.6	0.8	0.8	1.3	3.2
7	407	3.4	3.5	1.5	2.1	1.4	2.1
8	217	2.3	3.2	0.0	0.9	0.7	1.9
9	343	3.3	3.7	1.9	1.2	1.4	2.5
10	341	4.0			1.3		1.6
11	288	4.2	3.7	0.6	0.6	0.6	1.0
12	264	8.5			4.3		2.4
13	294	5.8			5.1		4.5
Average	313	4.5	3.5	1.0	2.0	1.1	2.4

TABLE III.—*5-Day B.O.D.—Low Water Stages 1934*

Period	Flow, C.F.S.	Sampling Stations					
		A	B	C	D	E	F
6	352	5.6	18.7	10.1	10.8	7.8	8.4
7	407	2.8	19.0	4.8	5.4	6.2	7.1
8	217	12.7	17.2	8.0	18.0	1.6	15.0
9	343	20.8	27.2	2.4	5.6	4.8	10.0
10	341	2.0			10.0		7.3
11	288	1.8	24.0	6.7	10.6	5.0	4.7
12	264	3.8			15.5		6.6
13	294	2.6			13.5		7.3
Average	313	5.3	18.8	7.2	11.1	5.1	8.8

filed by the writer with the Director of the Department of Water of the City of Dayton, which recommended the employment of the necessary help to prepare detailed plans for a trickling filter plant, since this type of secondary treatment had been proven to provide constant performance under many varying conditions, and 90 to 95 per cent reduction in five-day B.O.D. might be expected. This action was advisedly taken, for on February 15, 1935, the following communication was received by the City Manager from the State Board of Health: "You will recall that assistant engineers of this Department have from time to time visited the Dayton plant, checked its operation and observed the stream conditions. During the past year these stream conditions point decidedly to the necessity for further treatment of the Dayton sewage before disposal of the effluent into the Miami River, if proper cleanliness is to be obtained in this stream and a nuisance, as a result of Dayton sewage, prevented. It is the judgment of this Department that these additional devices should now be constructed as promptly as possible." Final plans were submitted to the State Department of Health on June 29, 1935. Approval was given and construction was begun on January 28, 1936, under the Federal Works Program known as the W.P.A.

The design of the hydraulic features of the secondary units was much easier because the original plant plan had been laid out with the idea that the added secondary treatment would likely be trickling filters, and the Imhoff tanks had been built at a high enough elevation to permit gravity flow to the filter dosing tanks, to provide sufficient operating head for reaction-type rotary distributors, to allow 7½ ft. for filter depth, and still keep the overflow weirs of the final settling tanks above maximum high water in the Miami River. This established weir elevation was 18 ft. above the minimum low water stage.

The polluted conditions of the river indicated that the most improvement might be expected if the plant effluent carried a low five-day B.O.D. and a high dissolved oxygen content. The 18 ft. difference in elevation between the effluent weirs and the low water stage offered an opportunity for design features to utilize possible natural aeration processes. The total distance from the final tanks to the river was 1450 feet. An effort was made in the final design to utilize the 18 ft. fall in every possible manner along the entire 1450 ft. from the final tanks to the river.

The use of V-notch weirs, with the weir tops 4½ in. above the concrete, allowed full exposure of the sewage to the air from the underneath side from each sewage stream, as well as the top surface. Each individual stream dropped onto the concrete ledge and over a 45 deg. slope into the collecting troughs, providing as complete exposure as possible to surface aeration. The effluent, after leaving the settling tank collecting troughs, flows through 50 ft. of open channel with three 5-in. drops, all of which cause great turbulence and considerable oxygen absorption, then through 250 ft. of closed conduit, from which it drops over a 3 ft. 8 in. fall into a large storm sewer, 6 ft. square in cross section. Four hundred and ten feet from this point this sewer opens into an open paved ditch, the bottom of which is a segment of a circle with a 6 ft. chord and 6 in. depth. The slope of this ditch (0.4 per cent) is sufficient to produce a ripply surface over the full width of the stream, and to provide excellent surface aeration. This section of the ditch is 440 ft. long. The last section of this ditch, 300 ft. long, has a grade of 1.38 per cent and large granite boulders were embedded in the concrete bottom for 100 feet, providing great turbulence and exposure to the air. The outfall end of this channel was set 2 ft. above low water stage so that there would be this added fall for oxygen absorption when the river stages were lowest and the best effluent was required.

The following data tables are given to show what these design features are accomplishing toward producing an effluent which provides protection to the receiving stream. The samples were taken on different days, at different times of the day, and at the indicated stations along the entire effluent channel, or conduit.

Tables IV, V, VI, VII, VIII and IX

Station "A"—Behind effluent weirs in the tank.
Station "B"—Entrance covered conduit, 50 ft. from tank.
Station "C"—End of storm sewer, 710 ft. from tank.
Station "D"—End of 440 ft. open ditch, 1150 ft. from tank.
Station "E"—End of 300 ft. open ditch, 1450 ft. from tank.

Dissolved Oxygen Tests on Sewage Plant Effluent, Dayton, Ohio

Table IV

Date	Time	Station		
		A	D	E
6/5/41	9:00 A.M.	4.2	6.6	7.1
	10:00 A.M.	5.0	6.7	7.3
	11:00 A.M.	5.1	7.4	7.5
	12:00 Noon	5.1	7.2	7.6
	1:00 P.M.	5.2	6.9	7.4
	2:00 P.M.	4.8	7.0	7.5
	3:00 P.M.	4.9	6.7	7.1
	4:00 P.M.	5.0	6.5	7.2
Average	....	4.9	6.9	7.3
Maximum	....	5.2	7.4	7.6
Minimum	....	4.2	6.5	7.1

Table V

Date	Time	Station		
		A	D	E
6/6/41	9:00 A.M.	3.0	5.5	6.4
	10:00 A.M.	3.4	5.8	6.5
	11:00 A.M.	4.2	5.7	6.5
	12:00 Noon	4.4	5.9	6.9
	1:00 P.M.	4.6	6.9	7.5
	2:00 P.M.	5.0	6.3	7.3
	3:00 P.M.	4.6	6.5	7.2
	4:00 P.M.	4.5	6.1	7.0
Average	....	4.2	6.1	6.9
Maximum	....	5.0	6.9	7.5
Minimum	....	3.0	5.5	6.4

Dissolved Oxygen Tests on Sewage Plant Effluent, Dayton, Ohio

Table VI

Date	Time	Station		
		A	D	E
6/7/41	9:00 A.M.	3.2	5.8	6.6
	10:00 A.M.	3.9	6.2	6.9
	11:00 A.M.	4.5	6.4	6.7
	12:00 Noon	4.8	6.4	7.0
	1:00 P.M.	4.7	6.7	7.4
	2:00 P.M.	5.0	6.5	7.2
	3:00 P.M.	5.3	6.5	7.1
	4:00 P.M.	4.7	6.3	6.7
Average	....	4.5	6.3	6.9
Maximum	....	5.3	6.7	7.4
Minimum	....	3.2	5.8	6.6

Table VII

Date	Time	Station				
		A	B	C	D	E
6/13/41	9:30 A.M.	3.6	4.1	5.9	6.0	6.2
	10:45 A.M.	4.3	4.5	5.9	6.1	6.6
	1:00 P.M.	4.5	4.7	6.2	6.6	7.1
	2:00 P.M.	3.8	4.4	6.0	6.1	6.6
	3:45 P.M.	3.9	4.3	5.7	5.7	6.2
Average	....	4.0	4.4	5.9	6.1	6.5
Maximum	....	4.5	4.7	6.2	6.6	7.1
Minimum	....	3.6	4.1	5.7	5.7	6.2

Dissolved Oxygen Tests on Sewage Plant Effluent, Dayton, Ohio

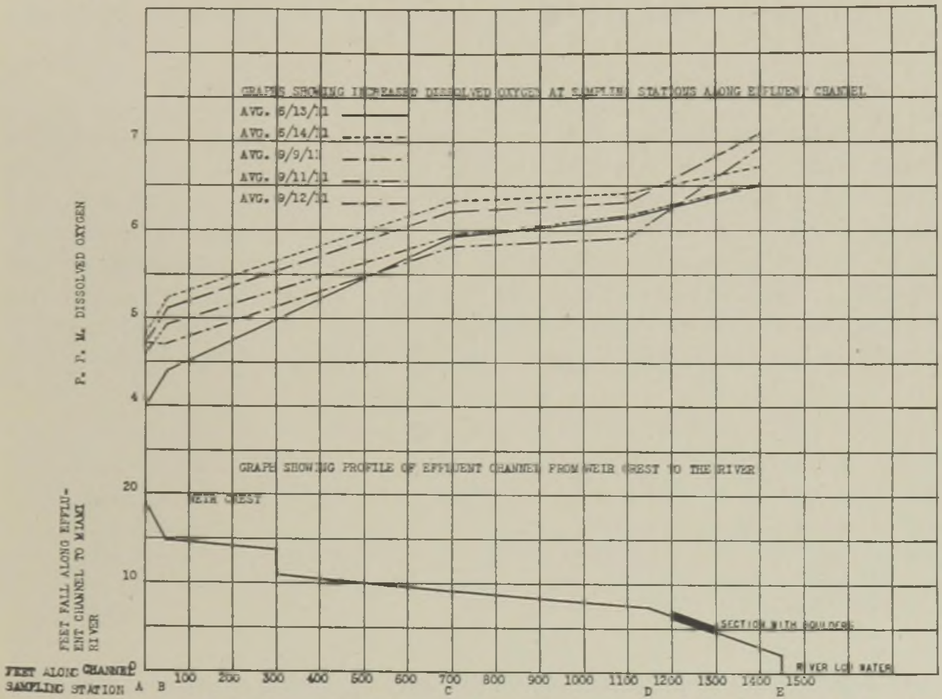
Table VIII

Date	Time	Station				
		A	B	C	D	E
6/14/41	8:45 A.M.	4.3	4.9	6.2	6.3	6.8
	10:00 A.M.	5.0	5.1	6.2	6.4	6.5
	11:15 A.M.	5.3	5.4	6.4	6.6	7.0
	12:30 P.M.	5.0	5.5	6.4	6.5	6.6
	2:30 P.M.	4.8	5.3	6.4	6.6	6.7
	3:30 P.M.	4.6	4.9	6.3	6.3	6.5
Average....	....	4.8	5.2	6.3	6.4	6.7
Maximum..	....	5.3	5.5	6.4	6.6	7.0
Minimum..	....	4.3	4.9	6.2	6.3	6.5

Table IX

Date	Time	Station				
		A	B	C	D	E
9/9/41	1:30 P.M.	4.7	4.7	5.8	5.9	6.9
9/11/41	3:00 P.M.	4.6	4.9	5.9	6.1	6.5
9/12/41	4:00 P.M.	4.7	5.1	6.2	6.3	7.1

The graph shows the profile of the effluent channel and the increased dissolved oxygen at the sampling stations indicated. The average D.O. content on the test days was used in plotting these graphs.



An examination of these data indicates that each portion of these channels is serving well in supplying dissolved oxygen to the effluent, and that the sewage delivered to the river, carrying an average of 6.9 p.p.m. and a minimum of 6.2 p.p.m. dissolved oxygen on the test days is well above the minimum required to avoid indications of pollution.

Proof of the high degree of treatment and prevention of stream pollution given by the trickling filters and final settling tanks is shown in the following Table X, which shows the condition of the Miami River during the 1941 dry season:

TABLE X.—*Stream Survey—Miami River, Summer 1941*

Date	Station A		Station B		Station C		Station D		Station E		Station F	
	D.O.	B.O.D.	D.O.	B.O.D.	D.O.	B.O.D.	D.O.	B.O.D.	D.O.	B.O.D.	D.O.	B.O.D.
June 25	8.2	8.3	7.5	11.5	6.7	9.3	5.8	7.5	6.7	7.5	6.7	8.0
July 2	7.3	5.5	6.9	8.5	6.4	4.3	4.8	5.5	6.4	6.3	6.9	4.0
July 9	6.6	6.3	6.9	4.7	6.6	6.0	6.5	6.3	6.5	6.6	6.0	6.3
July 17	6.6	2.8	7.2	11.8	6.7	5.8	5.3	7.5	6.4	6.0	6.1	5.5
July 23	6.7	5.5	7.7	10.3	6.0	4.5	6.7	3.8	6.4	3.5	8.2	2.5
July 30	6.1	6.8	6.2	14.0	4.8	7.8	4.6	8.8	4.7	5.0	7.3	5.3
Aug. 6	6.2	7.3	5.6	4.5	3.5	5.5	3.4	4.0	3.7	2.0	6.0	3.8
Aug. 13	6.3	8.8	5.6	6.0	3.5	7.3	3.1	5.3	1.7*	5.3	2.1	6.5
Aug. 20	6.5	3.5	6.4	Lost	5.5	Lost	5.7	Lost	4.6	Lost	5.0	Lost
Aug. 27	7.0	8.3	6.6	6.5	4.7	5.8	3.8	7.3	3.6	4.3	6.6	6.5
Sept. 4	5.1	6.5	4.8	3.5	2.7	3.8	2.3	3.3	2.6	3.5	2.7	2.0
Sept. 11	5.7	3.5	5.7	12.8	2.9	4.0	2.8	2.0	3.1	2.5	3.5	6.3
Sept. 17	5.1	3.5	4.9	13.3	3.0	3.3	3.0	5.0	3.3	1.3	3.3	1.8
Sept. 24	5.1	6.3	6.1	15.2	2.5	7.1	2.9	5.6	3.6	4.1	4.3	5.0
Oct. 1	5.6		6.0		3.6		4.2		4.2		4.1	

* Result of flash run-off (1.8 ft.) on August 11, and moving downstream.

The average one-day B.O.D. at Station "A," above the treatment plant, for the period covered in Table X is 1.73 p.p.m. which is above that used in the original Engineers' report, and the minimum D.O. (1.7 p.p.m. on August 13) is still above the minimum estimated by them to be necessary to maintain the river in an inoffensive condition and to provide enough oxygen to support fish life. The river condition, shown by the table, is more remarkable when the present low water stage is considered. The river has never been lower than at the present time.

TABLE XI.—*River Flow C.F.S.*

Date	Daily Flow		
	Maximum	Minimum	Average
August, 1941	690	130	240
First half of September, 1941	560	90	191
Last half of September, 1941	238	90	132

In spite of stream flows well below any ever contemplated, either at the time of construction of the primary treatment plant or at the time of design of the secondary treatment units, the Miami River below the Dayton Sewage Plant shows no evidence of pollution. Not many operators have an opportunity to design, to supervise the construction of, and to operate their own plant, and the biggest thrill of my life is to be able to say "IT WORKS!"

EXPERIENCE WITH SLUDGE ELUTRIATION AT THE METROPOLITAN DISTRICT SEWAGE TREATMENT PLANT, HARTFORD, CONN.*

By George H. Craemer

Engineer-in-Charge, Metropolitan District Sewage Treatment Plant, Hartford, Conn.

With the formation in 1928 of a "Commission for the Study of Sewage Disposal and Stream Purification" in relation to the City of Hartford and the adjoining Connecticut River, one of the first duties of the Commission was the retaining of Metcalf and Eddy of Boston, Mass. as consultants. Late in 1929 they submitted a comprehensive report, including extensive studies based on data assembled by the consultants with the assistance of the Department of Engineering of the City of Hartford. Recommendations of the consultants for the construction of a sewage plant and intercepting sewers were embodied in a Report which in 1930 was turned over to the newly organized Metropolitan District. Problems of water supply and collection and disposal of wastes were recognized as intertown functions and the primary reason behind the formation of the District was the facilitation of administration of such functions.

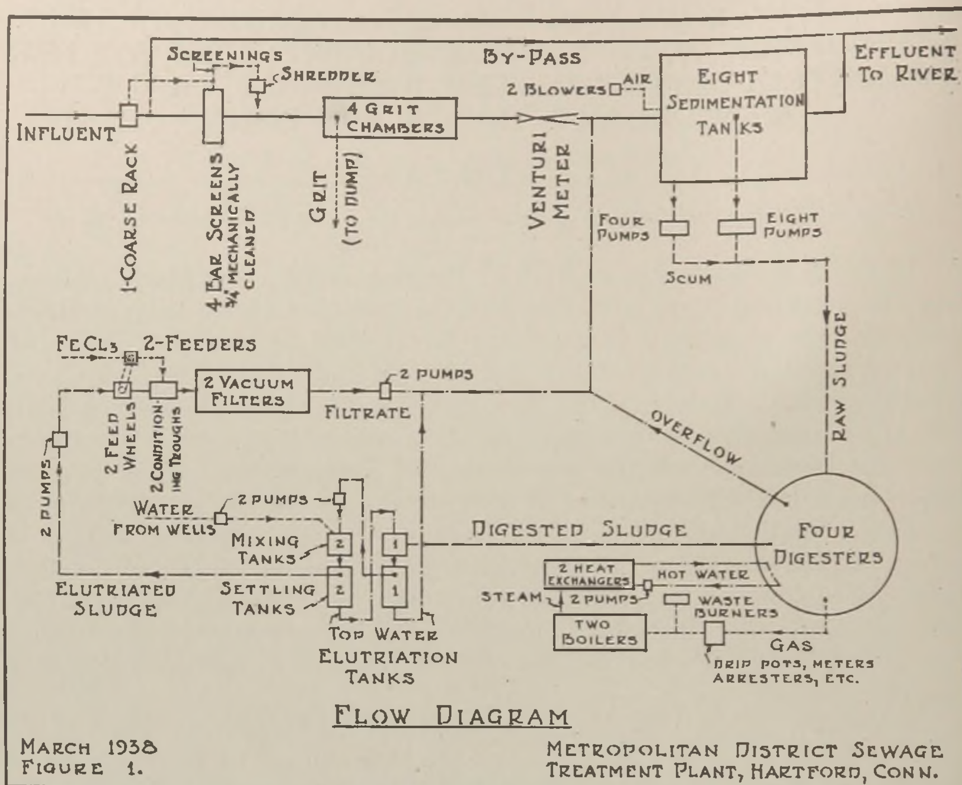
Inasmuch as the City Engineer of Hartford became ex-officio Manager of the Bureau of Public Works, the Department of Engineering of the City of Hartford undertook the design of the treatment plant for the Bureau of Public Works of the Metropolitan District. The firm of Metcalf and Eddy was again retained, this time as consultants on basic design and for review of plans and specifications prepared in the City Engineer's office.

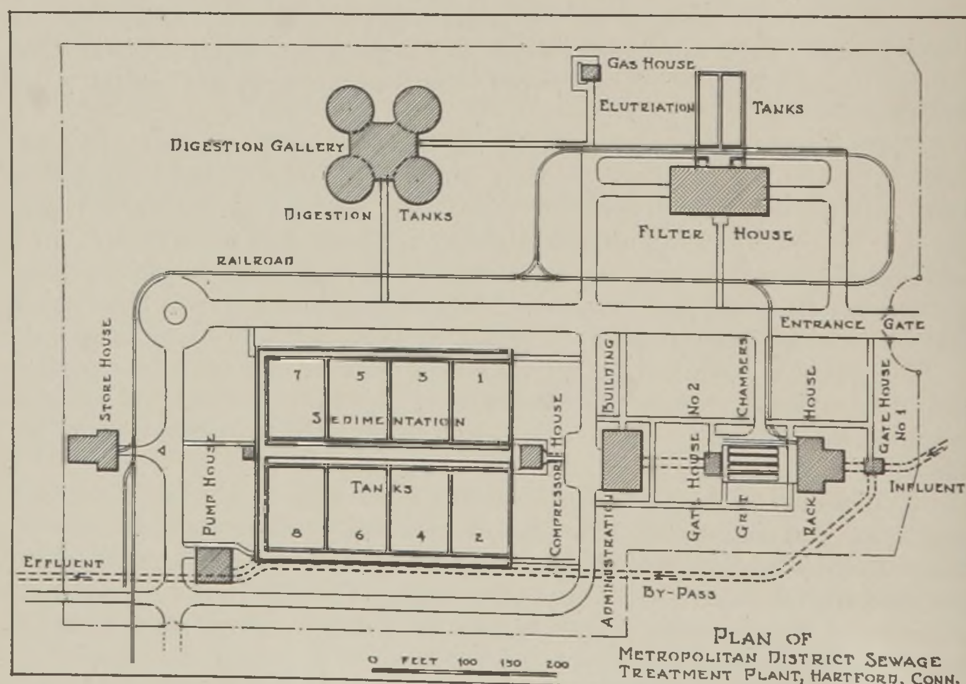
The plant at present treats all the sewage, with small amounts of industrial wastes, of the City of Hartford and Town of West Hartford and, in addition, now serves the Blue Hills District of Bloomfield and the north central (Folly Brook Valley) portion of Wethersfield. The present population served by the plant is approximately 200,000. This produces a flow of approximately 25 m.g.d. with variations in night and day rates from a minimum of 15 m.g.d. to a maximum of about 30 m.g.d.

The plant is designed for a population increase of 50 per cent, which may be expected to occur within the next 20 years, resulting in a total population tributary to the plant of 300,000 and an ultimate flow of about 40 m.g.d.

Hydraulics of the plant will permit the passage of a total flow of 85 m.g.d. or approximately twice the normal rate. This permits storm water to flow to the plant from combined sewers in Hartford up to an amount approximately equal to the sewage. The excess is by-passed at a series of overflow structures beginning about two miles upstream of the plant.

* Presented at the Twelfth Annual Meeting of the New England Sewage Works Assn., Providence, R. I., Sept. 19, 1941.


Screenings
Shredder
By-Pass
Effluent To River
Influent
1-Coarse Rack
4 Bar Screens 3/4 mechanically cleaned
4 Grit Chambers
Grit (to dump)
2 Blowers
Air
Venturi Meter
Eight Sedimentation Tanks
Four Pumps
Eight Pumps
Scum
Raw Sludge
FeCl3 2-Feeders
2 Feed Wheels
2 Conditioning Troughs
2 Vacuum Filters
2 pumps
Filtrate
Overflow
2 pumps
Water from wells
2 pumps
Mixing Tanks
Settling Tanks
Elutriated Sludge
Top Water
Elutriation Tanks
Digested Sludge
Four Digesters
2 Heat Exchangers
Hot Water
Steam
2 pumps
Waste Burners
Two Boilers
Gas
Drip pots, meters arresters, etc.
Flow Diagram
March 1938
Figure 1.
Metropolitan District Sewage Treatment Plant, Hartford, Conn.


Gas House
Elutriation Tanks
Digestion Gallery
Digestion Tanks
Filter House
Railroad
Entrance Gate
Store House
7 5 3 1
Sedimentation
Tanks
8 6 4 2
Pump House
Compressor House
Administration Building
Gate House No 2
Grit Chambers
Rack House
Gate House No 1
Influent
Effluent
By-Pass
0 Feet 100 150 200
Plan of Metropolitan District Sewage Treatment Plant, Hartford, Conn.

The various stages of treatment are shown in the diagram. Plain sedimentation, digestion, elutriation and vacuum filtration compose the main stages. The units themselves are as follows:

4 Coarse Racks, mechanically cleaned.
1 Shredder, for reduction of screenings.
4 Grit Chambers, 60 ft. long, 1 ft. per sec. velocity, with mechanical collectors.
1 Venturi Meter, 100 m.g.d. capacity.
8 Sedimentation Tanks, each 68 ft. wide by 100 ft. long and 9 ft. deep, 2 to 3 hour detention period. Mechanical sludge collection and skimming. Aeration in influent channels.
8 Sludge Pumps, and 4 Scum Pumps.
4 Digesters, 50 ft. dia., 30 ft. deep, heated, with provisions for gas collection and utilization.
2 Mixing and 2 Settling Tanks, for elutriation of digested sludge.
2 Conditioning Tanks, for addition of ferric chloride, etc.
2 Vacuum Filters (350 sq. ft. each), for sludge.

At the time studies were being made as to the type and method of treatment of the sewage from the Metropolitan District, emphasis was placed on the yearly cost of operation of the plant. When the method of dewatering the digested sludge, namely by vacuum filtration, was being studied, the cost of the chemicals necessary to accomplish this purpose was estimated inasmuch as this cost is a considerable part of total expenditures. With this thought in mind, Mr. W. A. D. Wurts, at present Assistant City Engineer of Hartford, and at that time (1934) in charge of all design work in preparing plans for the sewage treatment plant, made a very thorough and comprehensive study of the various experiments, tests and trial runs which Mr. A. L. Genter, of Baltimore, had made some two years previously. Mr. Genter had conducted a series of laboratory tests to determine whether or not the amount of ferric chloride necessary for sludge filtration could be reduced. His experiments led him to believe that a material saving could be effected by the adoption of a process worked out as a result of these experiments, which process has been called "elutriation of sludge."

The Baltimore authorities conducted an extensive group of field experiments on elutriation which began in August, 1933, and were continued in May, 1934. These tests were on a commercial scale and were conducted at the Baltimore sewage plant by Mr. C. E. Keefer, Principal Assistant Engineer, and Herman Kratz, Junior Chemist, both of the Bureau of Sewers of the City of Baltimore. These experiments indicated that elutriation reduced by more than 50 per cent the amount of ferric chloride necessary to coagulate digested sludge prior to filtration. This process, after having been in use during the past three years at the Hartford plant, has substantiated the results of these experiments.

Elutriation

Digested sludge when withdrawn from the digestors is still in a semi-liquid state. It cannot be disposed of on a dump or sold or given away to gardeners until it is dried. At the Hartford plant, as at many of the modern plants throughout the country, the rotating drum type of vacuum filter is used for the drying operation in lieu of the tremendous acreage of open or glass greenhouse covered sand beds. Prior to filtration Genter's "counter-current" elutriation process is employed. Two mixing tanks and two sedimentation tanks (see flow diagram) are used. Digested sludge is mixed in the first mixing tank with water from the top of the *second* sedimentation tank. The mixture then passes into the first sedimentation tank, from which the supernatant water overflows, returning through the entire plant. The solid matter settling in the first sedimentation tank is transferred to the *second* mixing tank and there mixed with approximately three times its volume of clean water pumped from a group of 36 well points driven into the coarse sand underlying the plant. This mixture is settled in the second sedimentation tank and the supernatant water overflows to the first mixing tank as stated above. The sludge passes to the conditioning troughs and then to the filters.

The mixing tanks at the Hartford plant are about 8 ft. square, 10 ft. deep and contain a vertical paddle agitator driven by a variable speed motor. The settling tanks are 85 ft. long, 24 ft. wide and 10 ft. deep with two scraper collector units per tank. These units are similar in principle to those used in the primary sedimentation tanks. No cross collectors are used, however, there being three hoppers at the ends of the tank. A withdrawal pipe leads to each hopper.

Results of Elutriation

The results of two years of operation with elutriation have shown the following advantages:

(1) Lower consumption of ferric chloride showing decided savings per year in plant operation.

Ave. rate $FeCl_3$, dry solids basis	2.51 per cent
Per cent moisture in filter cake	61.9
Yield = lb./sq.ft./hr. from filters	6.13

In arriving at a figure showing the savings per year by this process, it is interesting to note the results of the Baltimore experiments in determining the probable saving in chemical costs. Voluminous tabulations and graphs of the results of these tests appear in *This Journal* for September, 1934. These results show that at any rate of filtration the coagulant necessary for elutriated sludge is approximately four-tenths of that necessary for unelutriated sludge.

Using this figure for comparison it is safe to assume that 5.6 lb. of $FeCl_3$ would be used for 100 lb. of solid matter for unelutriated, against 2.5 lb. of $FeCl_3$ for elutriated sludge, at the same filter rate.

Comparison of Costs

In the following parallel tables the cost of filtration of elutriated sludge has been compared with the cost of filtering unelutriated sludge.

Flow through plant 23 m.g.d.

1 filter in operation—4 days per week—6 hr. per day.

First Cost	Filtration of Elutriated Sludge	Filtration of Unelutriated Sludge
Filtering apparatus and accessories	$35,000	$35,000
Coagulant feeding apparatus, etc.	5,000	6,000
Piping and valves	4,500	2,400
Sludge pump, etc.	5,500	3,200
Elutriation tank and machinery	35,000	0
Royalties	6,000	0
Total first cost	$91,000	$46,600
Add. Cost (Chargeable to Elutriation $44,400)		
Yearly—Operation Costs		
Interest (at bond issue rate, 3 per cent)	2,730	1,398
Depreciation 5 per cent	4,550	2,970
Power	3,500	2,330
Attendance	4,300	4,300
Lime (Ferric chloride)	2,760	7,900
	$17,840	$18,898
	Saved at present	$1,048 per year.

However, it is estimated that when the time arrives at which the normal designed flow of 40 m.g.d. is reached, necessitating the longer operation of the vacuum filters, an investment of approximately $44,000 will result in an annual saving of approximately $2,800.

(2) Another interesting feature in connection with elutriation is the fact that the period of digestion can be shortened. Results at the Hartford plant have shown that 15-day digested sludge can readily be filtered, although the consumption of ferric chloride is greater and rates as high as 3.5 per cent $FeCl_3$ (dry solids basis) have been reached. However, the sludge (elutriated) is readily filtered, output is good but, as stated above, more $FeCl_3$ is necessary. This fact results in material saving in digestion space and capital investment. In Hartford the original plans called for digestion tanks approximately 70 ft. in diameter, to provide 60-day digestion, as compared with those of 50 ft. in use today at 30-day digestion. This reduction resulted in a saving in original cost of approximately $59,800 and if this figure be used to offset the cost of the elutriation tanks, machinery, etc., as stated heretofore the

resulting saving in original cost including royalty charged would be as follows:

Saving in construction due to smaller digestion tanks	$59,800
Cost of elutriation tanks and equipment	56,000
Saved by using elutriation	$ 3,800

Sludge Odors Eliminated

Filter cake from the sludge has little or no odor, with no noticeable odor around elutriation tanks. Filter cake taken to borrow pit and deposited therein produces no odor. It is unnecessary to cover the material when dumped.

Since lime is not needed for coagulation, there is no expense for handling and storing lime, dry feeders, and a separate room to prevent lime dust from spreading through the building.

Long Life of Filter Cloths

Filter cloths used at the plant are of wool with a nap. They have given approximately 800 actual working hours apiece and even at the end of this time, when replaced, showed no signs of deterioration. However, the nap itself was worn and clogging of the pores had caused an increase in $FeCl_3$ consumption to approximately 3 per cent. Although washing the cloths with a dilute solution of muriatic acid had helped to relieve the clogging, it was not a permanent solution. This clogging of the cloth seemed to a certain extent to be due to the use of chemicals other than $FeCl_3$ in conducting experiments with coagulation of the elutriated sludge. When cloths have been removed from filter drums there has never been any evidence of the blinding of wire mesh in the filter itself.

The results obtained from the utilization of the elutriation process at Hartford have been most gratifying. Ferric chloride rates as low as 1.2 per cent have been reached with yields of 9 to 10 lb. per sq. ft. per hr. and moisture content of sludge cake at 60 per cent. However, during operation for the past two years certain changes have occurred which have resulted in higher ferric chloride consumption. After approximately a year of operation there was a noticeable lack of ground water available for the washing of the digested sludge. This water is derived from a series of well points (36 in number) set at the plant and driven down into what was presumably coarse sand. Various means of blowing these points were tried, but no increased output was obtained. Borings were then taken at the site and evidence showed that the points themselves were inadequate in length. The points were pulled, the proper length added, and they were redriven. At the present time sufficient water is available to obtain washing in the ratio of 7 to 1 if need be, although the ratio used at present is approximately 5 to 1. It may be of interest to compare the results of filtration with inadequate water with those when this deficiency was corrected.

Taken from monthly summary of daily records:

	Per Cent of Volatile, Dig. Sludge	Water Ratio
June, 1939	40.1	3 to 1
April, 1941	43.0	1.9 to 1
May, 1941	38.6	5 to 1

	$FeCl_3$ Ave. Rate, Per Cent Dry Solids	Cake, Per Cent Moist.	Filter Rate, Lb./Sq. Ft./Hr.
June, 1939	2.09	60.9	7.86
April, 1941	3.07	68.2	6.49
May, 1941	1.51	61.4	9.04

Accurate measurement of the sludge withdrawn from the digestion tanks is necessary when the elutriation process is used in order that the sludge may be washed with a proportionate amount of water. At the Hartford plant, digested sludge withdrawn, sludge pumped from elevation Tank 1 to Tank 2, and water used in washing and recirculation are measured by Venturi meters and passed through what are called rate controllers. These are motor-operated valves, adjustable for any desired quantity.

The valves measuring water have given no trouble, but those measuring sludge have a tendency to stick and register inaccurate readings. This is due to the gas in sludge and also to a certain amount of grit contained therein. The remedy for this, however, is a periodic checkup, flushing, etc.

Mixing Tanks

The only trouble encountered and now corrected was the lack of lubrication to the lower bearing of the shaft holding the paddles of agitators. Grit is deposited on the floor of the mixing tanks and must be removed at least once each year. This grit had a tendency to get into lower bearing, causing it to freeze. As this bearing was submerged it was necessary to pipe grease down to it from above. This was done and grease is now fed to the bearing at sufficient intervals to prevent this condition from recurring.

Sedimentation Tanks

The design of tanks is such that no cross-collecters are employed. There are three hoppers at the influent ends. This has led to quite a variation in the density of the elutriated sludge. Naturally, when sludge is withdrawn the heavier is at the bottom of the hopper and the lighter at the top. As this variation in sludge density occurs every time the operator makes a change in withdrawal from one hopper to another, it is necessary to change the rate of feed at the $FeCl_3$ feeders. This requires the operator to change the $FeCl_3$ feeder at various times during a day's run. However, if a cross collecter were utilized this variance in density would not be so great nor so frequent.

Arching of the sludge in the hoppers requires that the operator paddle the sides of the hopper, which would probably be unnecessary with a cross collecter and one main hopper instead of three hoppers as at present.

Another difficulty experienced has been in winter operation of the elutriation tanks. During *severe low temperatures* there has been a tendency for ice to form on the tops of the tanks, during the interval of shutdown over night. This has necessitated the use of labor and time lost in breaking up and removing the ice to prevent any damage to the wooden flights. Covering or enclosing the tanks would help solve this problem.

In conclusion let me make the following comments in regard to elutriation as experienced at the Hartford plant:

(1) Sufficient water for washing the sludge is necessary.

(2) Elutriated sludge with a uniform density of approximately 92 to 94 per cent moisture leads to excellent filter results.

(3) Time of digestion affects filter output even with good elutriation. However, sludge of only 15 days digestion may be filtered with slight increase of $FeCl_3$ consumption.

(4) Best results in output of filter at Hartford plant are obtained by keeping pH of filtrate between 6.0 and 6.3.

(5) The yearly cost of operation has justified the initial sum invested in the equipment, etc. necessary for elutriation.

(6) Hartford plant operators are certain that elutriation is a satisfactory link in the chain of operations leading to successful sewage treatment.

I wish to acknowledge the privilege of using certain material presented by Mr. W. A. D. Wurts, Asst. City Engineer, Hartford, before the 54th Annual Meeting of the Conn. Society of Civil Engineers at Hartford, March 16, 1938.

SEPARATE SLUDGE DIGESTION PROBLEMS *

By Walter Kunsch

Supt., Danbury, Conn. Sewage Treatment Plant

Separate sludge digestion in Danbury is in its tenth year. During this time it has had many ups and downs, in fact there were few extended periods of normal operation. Lack of tank capacity has not been the reason for this. Rather, the reason has been the lack of equipment for process control.

This paper is concerned strictly with our local problems. In fact, it is an epic of problems and their solution, or perhaps dissolution, which I hope you will find interesting and amusing.

General Information

The Danbury plant receives the domestic wastes of 22,000 people and the industrial waste of several hat and fur factories. The latter waste contains considerable hat fur, which has given the plant operator much grief throughout the years. From 1897 to 1931 raw sewage was dosed directly on sand filters without preliminary treatment. In an attempt to eliminate the rapid clogging of filters the city built the first units for the removal of solids in 1930–31. These units consisted of hand-cleaned bar screens, grit chambers, two square settling tanks with Dorr mechanism, whose capacity is 3½ m.g.d. at two hours' detention, also a cylindrical digester with Dorr mechanism, ⅚ acre of sludge beds, a sludge pump, and other appurtenances. The plant capacity was increased between 1934 and 1936 to 6 m.g.d. Additions consisted of a mechanically cleaned bar screen and detritor, two Riensch-Wurl fine screens with 1/32 in. slot openings, for the removal of hat fur, two rectangular settling tanks and a rectangular digester, all with Link-Belt mechanism, four round trickling filters with American Well Works motor-driven rotary distributors, chlorination equipment for odor and fungus control, and final settling tanks. These latter secondary treatment units replaced the sand filters for all normal flows although the remaining sand filters provide treatment for short storm flows up to 14 m.g.d.

Dorr Digester Construction and Problems

The Dorr digester is 55 ft. in diameter and 20 ft. deep, having a capacity of 47,000 cu. ft. or 2.25 cu. ft. per capita. It is of the fixed-cover type with the familiar roof truss which carries the weight of the mechanism. The center shaft is driven by a worm and gear from a 3 hp. motor and carries sludge stirrers at the bottom and scum breaker arms at the top. The overflow level is 5 ft. above the settling tanks, 20 to 30

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ft. above the sludge beds, and 16 ft. above the pumps. Originally there were three coils of 2-in. heating pipe rising from 2 to 8 ft. above the tank floor and placed so that they hung 8 in. from the sidewalls. A fourth coil was added in 1938. There are four manholes on the tank periphery, three containing pipes for the removal of scum to the sludge

FIG. 1.—General view of plant. Foreground, left to right: Dorr settling tanks, Link-Belt settling tanks and digester, Dorr digester mound. Background: Trickling filters.

FIG. 2.—Foreground: Sludge drying beds. Background, left to right: Dorr digester mound, sludge control buildings, fine screen building.

beds, the fourth being the overflow manhole, with a pipe carrying supernatant liquor to the Link-Belt settling tanks. Only one outlet, 2 ft. below the roof, is provided for supernatant liquor.

Raw sludge was first pumped to this digester in March, 1932. The meager records of those days do not indicate the exact manner in which the tank was started. It is known that an average of 100 lb. of lime per day was added for four months until the pH outfit, which had not been acquired till near the end of this period, recorded 7.6 +. Gas in sufficient quantities for measurement was obtained two months after operations started.

It was not long before the presence of hat fur in the digester made itself known. Little or none of this waste could be removed on bar screens and in consequence the greater percentage of it was pumped to the digester with the raw sludge. Here it began to pile up as scum, in ever-increasing depth and solidity. It blocked the gas dome and caused the gas to escape from the four manholes. Gas production dropped from 18,000 to 6,000 cu. ft. per day and tank temperatures dropped with it for lack of heat.

One day in January, 1933, ten months after the start of operation, it was noticed that the scum breaker arms were not working. The Dorr Company was called in and their advice to empty the tank was followed. All available sludge beds were filled, and seed sludge saved for re-starting put one settling tank out of service. With no room for raw sludge to be taken care of, raw sewage had to be sent to already overloaded sand filters, or to the brook.

After two months the broken spider, supporting the scum breaker arms, had been replaced and the digester was again ready for action.

This digester has had to be emptied twice more to date, once in 1934 for the removal of a dropped tool which had caused the overload alarm to operate, and once in 1938 when sludge cake was removed from the heating coils, an additional coil added, and the mechanism painted.

With the installation of fine screens in September, 1935, the scum problem was considerably alleviated. However, some fur still passed through the fine screens and gave a thick scum, though in much smaller quantity. One problem remains unsolved. If the mechanism is not run continuously the gas will not reach the dome through the scum, but forms in pockets, the pressure in these pockets forcing out supernatant liquor, eventually dropping the tank level to the point where all gas comes out the overflow. This condition is prevalent in both digesters. In the Dorr tank the stoppage of the scrapers for more than 2 or 3 hours causes another condition far more serious than the loss of gas.

A series of unusual incidents in 1939 gives an example of this. In July a grease line leading to the thrust bearing on the countershaft became plugged. Grease still went through, but not to the proper place, and there was no noticeable indication of the plugging until a noise started. The countershaft, thrust bearing, and a bronze bushing had to be replaced, and the mechanism was off for two months until the parts came and repairs were made. In that time little gas could be collected; the tank got cold; the scum got thick. In starting the tank the level was dropped sufficiently to relieve the scum breaker pressure. The scum could not be removed as there was no way of reaching it, and it had to be broken up with hose pressure. When the level was brought up, only scum came out the overflow, no supernatant liquor. An attempt was made to decrease the depth of scum by running it to the sludge beds, but not enough beds were available. The supernatant scum caused very poor conditions in the settling tanks and finally, to decrease the volume of supernatant, the final settling tanks were bypassed, thus eliminating humus sludge.

With the application of heat, conditions gradually improved until March, 1940. Then the severe ice storm on the 4th of that month cut off power for 60 hours. When current again came on we could not start the digester motor because the building was cold, the oil was cold, the grease was cold, and the scum was heavy. The oil had to be thinned, and the building warmed before operation could again proceed. Soon after, all sewage flow to the plant was cut off for 24 days while a new trunk sewer, being constructed at the time, was cut into the old line. In the interval there was no gas generated, the digester contents became cold, and digestion poor. It was midsummer before conditions again were normal.

New Digester Construction and Problems

The newer digester with Link-Belt mechanism is 16 by 86 ft. in plan, has an average depth of 15 ft., and a capacity of 21,000 cu. ft., or almost 1 cu. ft. per capita. It has four heating coils of 1½ in. pipe, with the top coil at one-third depth. The mechanism is similar to that in rectangular settling tanks. A shaft driven by a 1 hp. motor drives two endless chains to which are attached scrapers. These act both as sludge stirrers and scum breakers. Unlike settling tank scrapers, these do not ride on a rail imbedded in the concrete floor but their weight is carried on rails at the side of the tank—one on each side, top and bottom. The bearing surface between the scraper and rail is a thick, flat, detachable manganese steel plate, called a wearing shoe. The single supernatant outlet is 2 ft. below the cover, and like that of the Dorr digester leads to the two rectangular settling tanks. No workable means are provided for operating the two digesters in series and to date both are used as single-stage digesters. Hard scum is no problem in the Link-Belt tank since it can be removed by forking, but occasionally scum becomes too thin for removal and if its depth is over 2 ft., it comes out as supernatant scum and disrupts settling tank operation.

As in the original digester, it is necessary to run the scrapers continuously. If this is not done the loss of gas is very rapid. This continuous operation creates another problem, namely that of rapid wear of the steel shoes bearing on the rails. The results of this wear were presented to us forcefully in July, 1938, when, upon investigating the reason for a broken shear pin at the motor, we found four shoes completely worn through and the scrapers hanging from one side of the rail, one being wedged against the drive shaft. This meant an unplanned draining of the digester and a long wait for the arrival of parts. We proceeded by drawing to an empty settling tank enough seed sludge for later refilling, then dosing all available sludge beds and lastly draining the remaining contents to the effluent brook, which fortunately was swollen by heavy rains so that no nuisance was created. With the draining of the liquid, the heavy scum sank to the bottom and had to be broken up inch by inch with hose pressure. With all eleven manholes and the four gas domes open it was safe for a man to enter the tank and do this work. When the tank was empty we investigated all parts of the mechanism for wear and found that the water-lubricated peak cap bearings were beginning to score the shafts. These were rebabbitted and then grease lines were installed to the bearings. All heating pipes were scraped, all metal parts painted, and after seven weeks the tank was filled again.

The wearing shoes had an original thickness of ¾ in. and were of manganese steel. The first set lasted two years and eight months. The second set lasted only two years and six months, but when this set wore through last February we expected it and our work was planned and materials were on hand. Emptying, reshoeing, and painting required only 3½ weeks. This time we installed shoes of just twice the thickness of the original shoes, or 1½ inches. From these we expect to get at least four years of service.

Pumphouse Layout

The central point for control of primary treatment, other than screening, is called the pumphouse, a building 16 by 21 ft. in plan, with one floor and basement. There the raw and digested sludge pipes, hot water pipes and controls, gas pipes and controls, hot water pumps, sludge pumps, primary unit switchboard, gas fired boiler, office and records, are concentrated, seemingly to the point where one or the other of these most necessary appurtenances goes into a tantrum and protests against its cramped quarters. Raw sludge may be pumped with a Barnes plunger pump or a Chicago screwfeed centrifugal. It may be pumped direct from the settling tanks to either digester or may be run by gravity to a 10,000 gallon wood stave tank in an adjacent building, this tank having been recently equipped for preheating of sludge. Humus sludge is pumped from the final settling tanks, 800 ft. away, to the digesters, by a Carter simplex plunger pump against a 48 ft. static head and a friction head which has at times almost equalled the static head. Only by using a very short stroke can we pump humus sludge without trouble.

Our laboratory equipment and space is very meager and permits only the testing for pH, total alkalinity, settleable solids, chlorine residual, and relative stability. For this reason we have no definite data on the total or volatile solids of sludge. But from the few tests which have been made by the State Bureau of Sanitary Engineering, combined with our quantity measurements, we derive the following pertinent averages for the year ending June 30, 1941:

Sewage Flow	4.01 m.g.d.
Raw Sludge	8,200 gal. per day
Humus Sludge	2,100 gal. per day
Total Volatile Solids	2,700 lb. per day
Gas Collected	17,100 cu. ft. per day

From these figures we can determine that the digesters, whose combined capacity is 68,000 cu. ft., have received a loading of 0.04 lb. volatile solids per day per cu. ft., which is rather low.

Sludge Bed Layout Changes

Three pairs of open beds were originally built for sludge drying, these having irregular dimensions which averaged 50 by 120 ft., the total area being slightly over 36,000 sq. ft. Between each pair of beds there was installed a sludge inlet pipe. The beds were properly underdrained but for some undetermined reason the walls and drying media were installed with a slope of 1 in. in 10 ft. on both the long and short sides of the bed. The plant operator soon found that with this arrangement only one-fourth of each large bed could be used effectively for drying since all the sludge found its way to the low end of the bed. This condition was corrected to some extent by the erection of earthen banks so as to form smaller beds 30 by 50 ft. and by the construction of additional sludge inlets necessary to feed each bed. The situation was later further improved by replacing the earth banks with concrete walls and by regrading the sand to a level surface. We are still unable to draw over 6 in. of sludge in many of the beds because of the slope of the outside walls to a low point. In the last three years we have altered two of the original slow sand filters so that they could be used for sludge drying and have thus added an additional 30,000 sq. ft. of area. The original beds are so laid out that it is almost impossible to use any equipment other than a wheelbarrow for dried sludge removal. Labor costs for maintenance have therefore been high, running to almost $2.00 per cu. yd. removed. This figure includes the cost of hauling fresh sand and grading the beds. All sand comes from nearby city banks.

Digested sludge comes from the tanks with a moisture content of about 90 per cent and a volatile solids content of about 50 per cent. It dries well considering the fact that the sand is very fine and the beds are open. Average drying time has ranged from 30 to 50 days, which includes winter drying.

Because of the frequent, almost to say yearly, necessity of emptying one or the other digester, with the accompanying upset conditions, an average figure for removal of digested sludge from the tanks, and dried sludge from the beds means little. However, these figures have definitely shown a large increase since 1935, especially since the collection of humus sludge began. Digested sludge drawn increased from 12,000 cu. ft. in that year to 78,000 cu. ft. in 1940. Dried sludge removed increased from 8,000 to 28,000 cu. ft. in the same period. Many of the volatile solids are removed from the top of the tanks as scum, the quantity running to roughly 10,000 cu. ft. per year.

Gas Control and Piping System

Apparently at the time of gas system installation in 1931, well designed safety equipment was not available and not much was known about operating requirements or gas action. Gas was led from the collecting dome through a 2 in. pipe to the pumphouse basement, then in a 1½ in. pipe through a sediment trap, and a tin-case gas meter, beyond which the line branched, one side leading to the gas boiler, the other to the waste burner. Flame traps on these lines were nothing more than water strainers set in the line. For pressure relief to the waste burner a gate valve was set in the line and was manually operated. From the pumphouse the gas line pitched to the waste burner on a very flat grade. At least once a year this pipe had to be dug out and cleaned free of scale. Often it froze in winter and gas above the capacity of the boiler had to be bled out at the gas dome. Extensive changes were made three years ago when a new 3 in. c.i. bitumastic lined pipe was installed from the Dorr dome to the pumphouse, and a Sprague ironcase meter, Varec flame traps and pressure relief valve replaced the old equipment. Also, the location of the waste gas burner was changed so that condensate in this line would drain back to the pumphouse for disposal. Other beneficial changes were the installation of unions to facilitate pipe cleaning at the gas domes on both the Dorr and Link-Belt digesters where none were originally installed. Exposed piping at the domes was insulated against freezing and gas dome seals were filled with fuel oil instead of water. This latter safeguard against freezing has however been found far from perfect.

Excepting when grossly upset conditions prevailed, we have always had sufficient gas generated to heat all units connected to the heating system. However, it has been the exception rather than the rule to have perfectly normal conditions prevailing for a period as long as a year. Therefore the average daily gas collection has varied from a low of 6,500 cu. ft. in 1935 to a high of 17,100 cu. ft. in 1940. Through one six-month period of the latter year collection averaged 22,000 cu. ft., or 1 cu. ft. per capita per day. Unfortunately we have but one gas meter and therefore have no record of the gas used for heating or the amount wasted.

Heating System Layout and Problems

Our original Ideal gas boiler of six sections provided sufficient heating capacity for the 600 ft. of 2 in. coil in the Dorr digester and for pumphouse requirements. However, when in 1935 the additional load of the Link-Belt digester coils, and radiators in the adjacent sludge control building were added we could not get enough heat at all points. As the result of damage to this boiler through failure of the gas shut-off valve to operate when the water circulating pump was stopped by a momentary current failure, a larger 10-section boiler was obtained by the city and installed. This boiler was a used one and did not have adequate safety equipment until 1939. Also until that year no water tempering valve was available and the boiler had to be operated at 130 degrees F. so as to prevent caking of sludge around the coils in the digester. The formation of scale and gummy deposit between the boiler sections has always created a problem, and even operation at 160 degrees has not lessened the trouble. Probably the installation of scrubbers to purify the gas would be the only solution.

The impossibility of steadily maintaining near optimum temperatures in our digesters has caused many ups and downs in operation. Two conditions are mainly responsible for this. The location of the boiler in the same room as the pumps and office makes its summer operation intolerable since it raises the temperature to 100 degrees and over in the room. The boiler is therefore shut down during the hottest months and digester temperatures drop to that of the entering sludge, or 68 to 72 degrees. About September 1 boiler operation is resumed and temperatures are soon brought to 85 degrees. In winter there is such a variation of temperatures between bottom sludge and top liquor, especially in the Dorr digester, that operation is upset and the clear top liquor zone disappears. The resultant high solids content of supernatant liquor also upsets settling tank operation. Through the years the temperature variation in the Dorr digester has ranged from 17 degrees up, the maximum occuring last December when the top was at 67 and the bottom at 102 degrees. This did not cause a serious situation until the winter of 1937–38 when digester loadings were considerably increased by humus sludge from final settling tanks.

With little laboratory equipment to aid us we have for the past year tried to keep a check on changing conditions by taking settleable solids tests of supernatant liquor each day in 100 ml. cylinders. Conditions other than temperature being substantially the same, our observations showed readings of 6 to 10 per cent when temperatures were even throughout the tank and near optimum, and readings as high as 48 per cent when temperature variation was at its maximum. The change in readings took place with increasing rapidity from the end of October to the end of December, when the maximum reading was obtained at the time when maximum temperature variation prevailed.

During the past winter the necessary equipment was installed to begin the preheating of sludge. Unfortunately the emptying and reshoeing of the Link-Belt digester in February presented obstacles which prevented us from preheating our sludge consistently. We did however obtain these facts: that at the start of preheating, Dorr bottom temperature was 89 degrees and the top 66; that at that time settleable solids in supernatant were 33 per cent; that five weeks later at the end of March, with temperature variation only 7 degrees, settleable solids had dropped to 20 per cent; that one month later with temperature variation of 2 degrees, settleable solids were down to 12 per cent; and that at the end of June with temperatures at optimum, and equal throughout the tank, settleable solids stood at 8 per cent.

The results obtained in this, our first trial, have led us to believe that we have here the solution of our supernatant liquor problem. It is quite likely that it will give us a more constant gas production. It does not solve the question of digester heat losses but as long as sufficient gas and boiler capacity is available this can be overcome. Undoubtedly the same results would have been obtained by extending our heating coils in the digester near to the roof but this would have necessitated emptying the tank, and much greater expense for coil extension.

Conclusion

This paper, other than presenting a local story, probably has dealt with situations which have many parallels in other plants. Our dearth of controls and laboratory equipment eliminates the possibility of drawing new conclusions or substantiating any theories. The paper points to the fact that if all appurtenances necessary to efficient and economical operation are not installed at the time of plant construction, it is extremely difficult to obtain the items at a later date especially in the smaller plants. It should emphasize the fact that engineers must be cognizant of the operator's problems and must install, if possible, equipment to cope with these problems.

Sewage Research

STUDIES OF SEWAGE PURIFICATION

XVI. DETERMINATION OF DISSOLVED OXYGEN IN ACTIVATED SLUDGE–SEWAGE MIXTURES

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The importance of dissolved oxygen in activated sludge aeration liquors to the successful operation of the process is well known. Only within the past ten years, however, have attempts been made to use dissolved oxygen data as criteria of plant operation. The desire for information concerning the dissolved oxygen content of activated sludge mixed liquors was expressed by Theriault and McNamee (1) in studying bulking problems in 1934. Since then Klassen (2), Anderson (3), Heukelekian (4) and Poindexter (5) have all pointed out the importance of this determination for purposes of activated sludge plant control. While the use of the dissolved oxygen determination on mixed aeration liquors is becoming widespread in activated sludge plant operation, no entirely satisfactory method for its determination has been proposed or developed.

Three primary characteristics of activated sludge make it difficult to determine dissolved oxygen in aeration mixtures. The first and most important is the presence of the zoogleal sludge floc with its adsorbed organic matter. This floc regardless of its condition contains 60 to 90 per cent of organic matter and interferes with the ordinary Winkler or any other similar chemical determination of dissolved oxygen. The second characteristic is the biochemical oxidizing capacity and oxygen demand of the sludge floc, which may use 100 or more mg. of O_2 per liter per hour. The third characteristic which introduces difficulty is the very frequent presence of nitrites in the mixed liquor, which interferes with the ordinary Winkler determination. The ideal method for the determination of dissolved oxygen in sludge liquors, therefore, is one which removes the sludge floc, stops biochemical and chemical oxidation or interference, destroys nitrites and is simple and easy to use. Kuchler (6) designed an apparatus for separating the sludge and supernatant which overcame only the first difficulty, but bulking sludge could hardly be separated quickly enough in the apparatus. However, Kuchler did recommend the use of the azide procedure of Alsterberg to destroy nitrites.

Konstantinowa (7) proposed the use of mercuric chloride to stop biochemical oxidation. After the sludge settled the supernatant was siphoned off and its dissolved oxygen content was determined, using the Rideal Stewart modification to oxidize nitrites and prevent their interference. Theoretically this procedure should be satisfactory, but practical difficulties were observed by Goldthorpe (8) who found that mercuric chloride did not completely arrest absorption of oxygen and tended to disperse the sludge floc and prevent settlement. Watson (9) also used mercuric chloride to stop oxidation and followed this by precipitation of the mercury salt and coagulation of the floc with sodium hydroxide. In view of the increase in rate of chemical oxidation at high pH this practice seems undesirable. The use of mercuric chloride seems unsatisfactory and leads to other difficulties as found by both investigators and consequently will not be further reviewed here.

Theriault and McNamee (1) overcame all difficulties in determining dissolved oxygen in sludge mixtures by developing an apparatus with which the gases in solution were extracted from a sludge sample. The oxygen in the extracted gas was then determined by the Winkler method in a special apparatus. While this procedure is satisfactory for research, it requires special apparatus, decidedly limits the number of samples that can be examined, and has not been adopted in practice.

In their early paper on oxygen demands of activated sludge, Kessler and Nichols (10) used copper sulfate for the prevention of biochemical oxidation. They ascribe the first use of the reagent for this purpose to Palmer and Beck (11). Kessler and Nichols used the short Winkler procedure suggested by Theriault (12) to shorten the period of alkalinization of the supernatant, in the absence of iron and nitrites. However, the effectiveness of copper sulfate in preventing biochemical oxidation has apparently not been thoroughly studied. Goldthorpe, who also adopted copper sulfate as a more satisfactory respiratory inhibitor than mercuric chloride for use with activated sludge, notes that this salt in the concentrations used did not completely arrest oxygen absorption.

Recently it was shown (13) that the sulfuric acid-sodium azide treatment of river and sewage plant effluent samples stopped biochemical oxidation and enabled a delayed dissolved oxygen determination. The use of sodium azide to destroy nitrites previous to and in the Winkler determination has also been carefully studied (13) (14) (15) and found satisfactory for general biochemical oxygen demand work, where ferrous iron is not present. It has also been found (16) that sulfamic acid is effective in destroying nitrites previous to the dissolved oxygen determination in stream pollution and sewage treatment studies. In consideration of these developments a re-investigation of procedures for determining dissolved oxygen in activated sludge mixtures has been made.

Experimental

In the first series of experiments, four duplicate samples were collected in liter bottles from our experimental sludge plant aeration chamber. The first sample was untreated and was immediately centrifuged in special ground-glass stoppered bottles, the dissolved oxygen in the supernatant being determined by the azide modification. The other three samples were collected in bottles to which had been added sulfuric acid, a mixture of sulfuric acid and sodium azide, and copper sulfate solutions respectively. The dissolved oxygen in the supernatant from each sample was determined by the azide modification. The results obtained with three bulking sludges using the above procedure are compared in Table I. These data show that whereas a mean dissolved

TABLE I.—*Comparison of Dissolved Oxygen Found by Various Procedures in Activated Sludge Mixed Liquors*

(All D. O. values are the mean of two determinations)

Sludge	Temp. ° C.	NO_2 P.p.m.	Suspended Solids	Sludge Index	Time in Minutes after Collection and Treatment											
					Initial				30				60			
					A	B	C	D	A	B	C	D	A	B	C	D
1	13	2.0	2528	370	5.40	6.20	6.20	7.36	.08	5.48	5.73	5.42	.09	4.74	5.32	4.22
2	8	2.0	2092	468	8.18	8.15	8.15	9.30	1.57*	7.72	7.80	8.38	.00	7.29	7.52	7.66
3	23	—	1222	704	4.23	4.78	4.78	5.96	.00*	4.41	4.69	4.50	.00	4.25	4.63	4.23
Mean					5.94	6.38	6.38	7.55	.55	5.87	6.07	6.10	.03	5.42	5.82	5.37

* Twenty minutes after collection.

(A) Untreated sample—D. O. by the azide modification

(B) Collection bottle dosed with H_2SO_4, D. O. by azide modification.

(C) Collection bottle dosed with H_2SO_4 and NaN_3, D. O. by azide modification.

(D) Collection bottle dosed with $CuSO_4$, D. O. by Rideal Stewart modification.

oxygen of 5.94 p.p.m. was found in the untreated sample, this rapidly disappeared. The sulfuric acid and sulfuric acid-azide treated samples showed a mean initial dissolved oxygen of 6.38 p.p.m. and this value was slowly reduced in the sulfuric acid treated sample and even more slowly reduced in the sulfuric acid-azide treated sample. The copper sulfate treated sample had a mean initial dissolved oxygen of 7.55 p.p.m. or over 1 p.p.m. higher than the other treated samples. The dissolved oxygen was apparently lost more rapidly than in the sulfuric acid or sulfuric acid-azide treated samples. These experiments indicate that the copper sulfate treatment of sludge is inferior in arresting oxygen absorption but gives higher immediate values.*

In the second series of experiments, eight different treatments were compared to the copper sulfate treatment for determining the dissolved oxygen content immediately after collection. In these experiments 12 gallons of activated sludge mixture were aerated in a conical bottomed aeration vessel in the laboratory. Two parallel siphons were arranged in this vessel so that sludge samples could be siphoned into two bottles simultaneously to ensure duplicate samples. The reagent or reagents to be studied were put into one 1200 ml. glass stoppered bottle and 10 ml.

* It may be supposed that the higher dissolved oxygen values obtained with copper sulfate treatment are due to the reduction of the copper by the potassium iodide in acid solution. Investigation showed that the concentration of potassium iodide used in the dissolved oxygen determination was not sufficient to induce this reaction. If three or four times the usual amount of potassium iodide is used during the dissolved oxygen determination, appreciable amounts of iodine (equivalent to 0.1–0.2 p.p.m. of oxygen) will be released from the iodide by the copper.

of a 10 per cent copper sulfate solution into a similar bottle. The sludge samples were then siphoned into both bottles simultaneously until the bottles were completely filled. The stoppers were inserted, the contents mixed for 5 to 10 seconds, and after settling for 5 to 10 minutes the supernatant was siphoned into 300 ml. dissolved oxygen bottles. The dissolved oxygen in all samples was then determined by the short Winkler technique with sodium azide in the alkaline iodide (12) (13) solution.

The following reagents were employed for floc coagulation and arresting biochemical oxidation in the various tests:

(1) Ten per cent solution of copper sulfate,
(2) Concentrated sulfuric acid,
(3) Two per cent sodium azide solution,
(4) Standard Methods manganous sulfate solution containing 4 per cent sulfamic acid,
(5) Glacial acetic acid,
(6) Dilute acetic acid (1 to 4 dilution of glacial acid),
(7) Two per cent solution of sulfamic acid.

TABLE II.—*Comparison of Treatment Procedures for Coagulation and Prevention of Oxygen Absorption of Activated Sludge in the Determination of Dissolved Oxygen*

Exp. No.	Treatment Used to Compare with $CuSO_4$ — Reagents Added to 1200 ml. Bottle	pH Resulting from Sludge Treatment: Treatment Described at left	pH: $CuSO_4$ only	Dissolved Oxygen, Found in Sample P.p.m.: Treatment Described	Found: $CuSO_4$ only	Deviations: P.p.m.	Deviations: Per Cent
1	10 ml. $CuSO_4$ solution + 2.8 ml. conc. H_2SO_4	1.6	4.8	6.28	6.29	−.01	0.15
2	2.8 ml. conc. H_2SO_4 + 5 ml. NaN_3 solution	1.6	4.7	5.62	6.32	−.70	11.07
3	10 ml. $MnSO_4$—sulfamic acid + 5 ml. NaN_3 sol.	2.9	4.6	6.80	7.00	−.20	2.85
4	3 ml. glacial acetic + 5 ml. NaN_3 solution	3.4	4.4	7.26	7.34	−.08	1.09
5	2 ml. glacial acetic + 5 ml. NaN_3 solution	3.5	4.4	7.16	7.11	+.04	.53
6	4 ml. sulfamic acid sol. + 5 ml. NaN_3 solution	4.8	4.8	2.95	2.99	−.04	1.34
7	8 ml. sulfamic acid sol. + 5 ml. NaN_3 solution	4.4	4.8	4.92	5.00	−.08	1.60
8	1 ml. dilute acetic + 5 ml. NaN_3 solution	4.4	4.6	5.25	5.27	−.02	.37

These reagents were used in the amounts and combinations shown in Table II, and each combination was used in one bottle of a pair, in which the other bottle contained only 10 ml. of copper sulfate. The pair of bottles in each experiment was filled with sludge sample simultaneously as described. The results obtained are shown in Table II.

These data show that the copper sulfate treatment of these sludges reduced the pH to within the range of 4.4 to 4.8 in all experiments. Using other reagents the sludge pH was adjusted to values between 1.6 and 4.8 in the different experiments. Experiment 2 (Table II) which was repeated several times, indicated that when the sludge is treated with sulfuric acid and azide so as to lower its pH to about 1.6, a lower percentage recovery of the dissolved oxygen results than with copper sulfate treatment. However, when the pH is lowered to 1.6 with sulfuric acid in the presence of the copper salt as in Experiment 1, no detrimental effect upon the dissolved oxygen recovery was observed. In Experiment 3 the pH was lowered to 2.9 with a solution of manganous sulfate containing 4 per cent sulfamic acid. In this case the deviation from the dissolved oxygen result obtained with copper sulfate alone was only 2.85 per cent. In the remaining experiments the pH was adjusted between 3.4 and 4.8 with various treatments and the oxygen recovery deviation was always less than 2 per cent. This series of experiments indicated that it was possible to treat and coagulate activated sludge with a number of reagents and obtain dissolved oxygen results practically identical with those obtained with copper sulfate treatment. If the treatment is such that the pH is reduced below about 3.0, oxygen is apt to be lost; while if the pH is 4.8 or above with these reagents, the coagulation is poor so that the time required for settling may be prolonged, especially with a bulking sludge.

The effectiveness of various preliminary treatments in stopping biochemical oxidation was next studied in a series of experiments. The activated sludge was aerated in the conical bottomed vessel and sludge samples were withdrawn over a 4-hour period to study five treatment methods. On the succeeding day the aeration vessel was refilled and samples were withdrawn to complete the experiment with six additional treatment methods. All these experiments were, therefore, conducted using two batches of sludge. While there was no doubt some difference in the oxygen demand of the sludge mixture during the course of these experiments, the range of this variation is not considered sufficient to impair the results obtained.

Each sludge treatment using one or a combination of reagents was studied as follows: The dose of reagents to be studied was introduced into each of 8–500 ml. glass stoppered bottles. These bottles were then filled as rapidly as possible, filling two at a time with the twin siphons. After mixing the contents of all bottles the first and last bottle filled were taken for the initial D.O. determination. As in the previous series the sludge was allowed to settle for five minutes, after which the supernatant was siphoned into dissolved oxygen bottles. The short Winkler technique employing the alkaline iodide reagent containing sodium azide was used on all dissolved oxygen determinations. After final acidification, however, each dissolved oxygen sample was allowed to stand two minutes before titration. The other six bottles of the treated sludge were shaken at two-minute intervals to keep the sludge in contact with the supernatant until the time when the dissolved oxygen in them was to be determined. The dissolved oxygen was determined on two of these after 30 minutes, on another pair after 90 minutes and on the final pair after 180 minutes of this treatment. After the analysis for dissolved oxygen in the 30-minute samples with one treatment combination had been completed, another set of eight bottles was prepared with another combination of reagents and the sludge mixture added in the manner described, followed by identical analytical treatment. This process was repeated until all of the desired reagents or combinations of reagents had been studied. The mean results from the duplicate bottles in each experiment are shown in Table III. The re-

TABLE III.—*Comparison of Treatment Procedures for the Prevention of Oxygen Adsorption in Activated Sludge*

Series 3, Experiment No.	Treatment Used to Stop Biochemical Oxidation (Reagents added to a 500 ml. bottle)	pH Resulting from Treatment	Dissolved Oxygen Present after Indicated Time in Minutes—P.p.m.					Per Cent of D.O. Recovered after the Indicated Time in Minutes			
			0	15	30	90	180	15	30	90	180
1	5 ml. copper sulfate solution	4.6	7.16		5.58	4.10	2.59		77.9	57.3	36.2
2	5 ml. copper nitrate solution (10%)	4.5	7.68		6.55	5.13	3.47		85.3	66.8	45.2
3	1.4 ml. conc. H_2SO_4 + 2.5 ml. sodium azide sol.	<1.6	6.88		6.23	6.17	5.77		90.6	89.7	83.9
4	5 ml. $MnSO_4$ and sulfamic acid + 2.5 sod. azide	3.1	7.28		6.66	6.35	6.05		91.5	87.2	83.1
5	4 ml. sulfamic acid + 2.5 sodium azide	4.4	7.30*		6.81	6.11	5.35		93.3	83.7	73.3
6	0.5 ml. dilute acetic + 2.5 sodium azide	4.5	7.41		6.72	6.16	4.93		90.7	83.1	66.5
7	2.5 ml. copper sulfate + 0.5 ml. dil. acetic + 4 ml. sulfamic	3.4	7.57		6.81	6.12	5.64		90.0	80.8	74.5
8	0.5 ml. dil. acetic + 4 ml. sulfamic	4.0	6.26		5.23	3.59*	2.11*		83.0	57.3	33.7
9	0.5 ml. dilute acetic + 4 ml. sulfamic + 2.5 ml. sodium azide	4.1	6.67*		6.10	5.43	4.72		91.5	81.4	70.8
10	2.5 ml. sodium azide	6.8	5.45*		0.71	0.00	0.00		13.0	0.00	
11	10 ml. sodium azide	6.8	4.99*	4.00	2.64*	0.31†		80.2	52.9	6.2†	
Control	For numbers 1 to 5 untreated	6.8	7.30	2.59				35.5			
"	For numbers 6 to 11 untreated	6.8	7.41	2.92				39.4			

* Determinations in which the duplicates varied more than 0.3 p.p.m.

† Sixty (60) minute observation.

(6) Sludge settled poorly. (8) Excellent settling. (9) Good settling.

sults indicated with an asterisk are those in which the duplicates did not check within 0.3 p.p.m. The control experiments in this table indicated that the untreated sludge absorbed oxygen rapidly, for only 35 to 40 per cent of the initial quantity present remained after 15 minutes. Experiments 10 and 11 showed that sodium azide alone was not effective in stopping biochemical oxidation. In Experiment 11 about ten times the concentration of this reagent ordinarily used to destroy nitrite in the dissolved oxygen determination decreased the oxygen absorption so that 52.9 per cent of the original was recovered after 30 minutes.

The copper salts used were not as effective in stopping oxidation as the combinations of reagents used in later experiments. Copper acetate was also tried and, whereas it gave a good settling sludge, its effectiveness in arresting respiration was of the same order as the sulfate and nitrate. The concentration of copper used in these experiments is undesirable because it prevents the complete destruction of nitrites by the azide treatment. It also prevents one from obtaining an easily recognized sharp end point in the titration using starch as an indicator. As the copper salts are not as effective in stopping oxidation as other reagents, cause poor end points in titrations, and do not permit the effective use of azide for nitrite destruction, their use for preliminary treatment seems undesirable.

The results of Experiment 3 in Table III show again that sulfuric acid and azide treatment, which lowers the sludge pH to 1.6, is very effective in stopping oxygen utilization by the sludge. The initial dissolved oxygen data in this series of experiments are not entirely comparable, because the experiments were performed on two days and there

TABLE IV.—*Comparison of Oxygen Depletion after 30 Minutes in Activated Sludge Mixtures Treated by Promising Methods to Reduce Biochemical Oxidation*

(Temp. of sludge in these tests 25° to 28° C.)

Treatment Used to Stop Biochemical Oxidation (Reagents added to a 500 ml. bottle)	Sample	pH Resulting from Treatment	Dissolved Oxygen—P p.m. Initial	Dissolved Oxygen—P p.m. After 30 Min.	Depletion in 30 Minutes—P.p.m.
4 ml. sulfamic + 0.5 ml. dil. acetic + 2.5 ml. sodium azide	1	4.2	6.11	5.34	0.77
	2	4.1	2.35	1.87	0.48
(This treatment No. 9 from Table III was used as a standard of comparison	3	4.4	5.10	4.39	0.71
	4	4.2	5.81	5.25	0.56
	Mean				0.63
5 ml. of 5 per cent $Cu(C_2H_3O_2)_2$ + 8 ml. sulfamic + 0.5 ml. dilute acetic	1*	2.9	6.42	5.58	0.84
	2	4.2	2.51	2.11	0.40
(This treatment was similar to No. 7 of Table III except that 10 per cent copper acetate solution was substituted for copper sulfate)	2-a	4.2	2.59	2.08	0.51
	3	4.3	5.89	5.18	0.71
	3-a	4.4	5.55	5.03	0.52
	Mean				0.59
8 ml. sulfamic + 0.5 ml. dil. acetic	1	3.0	6.12	5.11	1.01
8 ml. sulfamic + 0.5 ml. dil. acetic	1-a	3.0	6.21	5.24	.97
8 ml. sulfamic + 0.5 ml. dil. acetic	2	2.7	2.40	1.74	.66
8 ml. sulfamic + 0.5 ml. dil. acetic	3	2.6	5.34	4.47	.87
4 ml. sulfamic + 1.0 ml. dil. acetic	4	3.5	5.85	5.20	.65
8 ml. sulfamic + 0.5 ml. dil. acetic	4-a	2.8	5.87	5.21	.66
8 ml. sulfamic + 1.0 ml. dil. acetic	4-b	2.8	5.81	5.15	.66
(Treatment No. 8 of Table III)	Mean				.78

* In this sample $CuSO_4$ was used as in No. 9 of Table III.

was a variation in aeration rate especially in Experiments 6 to 11. However, the results of Experiments 3 indicate again that treatment with sulfuric acid and azide to lower the pH to 1.6 results in a lower initial dissolved oxygen, as it would be expected that the initial dissolved oxygen found here would be between the values found in Experiments 2 and 4.

The most effective combinations in stopping biochemical oxidation in addition to those shown for Experiment 3 were found in Experiments 4, 5, 6 and 9. It will be noticed that in all of these sodium azide was used and the pH of the sludge resulting from the treatment was between

3.1 and 4.5 However, it was found that the introduction of sodium azide in any of these combinations resulted in the generation of some gaseous hydrogen azide, HN_3. The release of this poisonous gas into the atmosphere while the bottles were being filled was sufficient to produce immediate severe headaches in all persons who participated in the experiments.

Although the azide treatment in any of these combinations was very desirable in preventing oxygen absorption, it was considered too hazardous for practical use.

TABLE V.—*Comparison of Supernatant D. O. Results in Sludge Treated with Respiratory Inhibitors after 5 and 30 Minutes of Settling*

(Temperature of sludge in these tests 24° to 25° C.)

Treatment Used to Stop Biochemical Oxidation	Sample No.	pH Resulting from Treatment	Dissolved Oxygen in Supernatant—P.p.m.		Depletion of Supernatant in 30 Minutes P.p.m.
			Initially	After 30 Minutes	
Modification of No. 7 of Table III, acetic and sulfamic as in No. 7					
A. + 2.5 ml. $CuSO_4$	1	2.9	6.84	6.78	.06
	2	3.4	2.64	2.54	.10
B. + 2.5 ml. $Cu(NO_3)_2$	1	3.0	6.82	6.80	.02
	2	3.2	2.66	2.49	.17
C. + 5 ml. 5 per cent $Cu(C_2H_3O_2)_2$	1	4.2	6.80	6.69	.11
	2	3.4	2.68	2.65	.03
No. 8 of Table III					
8 ml. Sulfamic, 0.5 ml. dilute acetic	1	3.0	6.60	6.51	.09
	2	4.4	2.47	2.13	.34
	3	—	6.14	6.14	.00

The result of Experiment 7 showed that a reduction in the amount of copper sulfate to one-half of that used in Experiment 1 with the addition of acetic acid and sulfamic acid was also very effective in reducing oxygen absorption. Upon the basis of dissolved oxygen depletion in 30 minutes this treatment was almost twice as effective as copper sulfate alone. Experiment 8 indicates the possibility of using acetic acid and sulfamic acid together for decreasing oxygen absorption.

A number of experiments were, therefore, carried out using a 30-minute time for reaction with slight variations of the sludge treatment given in Experiments 7 and 8. The dissolved oxygen initially and after 30 minutes was also determined upon similar sludge samples by the method used in Experiment 9 (Table III), employing acetic and sulfamic acids and azide as a standard. The mean results obtained, employing the technique already described on duplicate portions in every case are shown in Table IV. These data indicate that procedures 7 and 9 shown in Table III are about equally effective in preventing biochemical oxidation for a 30-minute period. Treatment with sulfamic acid and acetic acid was not quite as effective as the other two combinations. However, even this treatment is more effective in stopping oxidation than the original copper sulfate treatment. In addition, it destroys any nitrite present in the sludge which copper sulfate, of course, does not do.

In actual practice in determining dissolved oxygen in sludge liquors, the sludge is not kept in contact with the supernatant, as was done in the previous experiments, but is allowed to settle immediately after it is collected and mixed with the respiratory inhibitor. Consequently, a few additional experiments were carried out in this manner, the dissolved

TABLE VI.—*Nitrite Destruction in Activated Sludge Liquors by Respiration Inhibiting Reagents*

Treatment Used on Activated Sludge Sample (Reagents added to a 500 ml. bottle)	Initial NO_2 Added to Activated Sludge P.p.m. N	NO_2 Recovered after Indicated Time in Minutes—P.p.m. N	
		15	30
0.5 ml. dilute acetic + 2.5 ml. sodium azide solution	12	9.0	5.0
	24	22.0	18.0
	36	28.0	28.0
4 ml. sulfamic + 0.5 ml. dilute acetic + 2.5 ml. sodium azide solution	12	4.0	2.0
	24	9.0	5.2
	36	12.0	6.0
8 ml. sulfamic + 0.5 ml. dilute acetic	12	0.2	None
	24	0.8	None
	36	1.2	0.1
2.5 ml. $CuSO_4$ sol. + 8 ml. sulfamic + 0.5 ml. dilute acetic	12	None	None
	24	0.3	None
	36	1.0	.06
5 ml. $CuSO_4$ solution	12	12.0	12.0
	24	24.0	24.0
	36	28.0	28.0

oxygen being determined on the supernatant after 5 minutes of settling and again after a 30-minute period. The data shown in Table V indicate that it is immaterial which copper salt is used with sulfamic and acetic acid. In the six tests made the dissolved oxygen depletion in 30 minutes varied from .02 to .17 p.p.m. With sulfamic and acetic acid together, but no copper salt, a depletion of 0.34 p.p.m. of oxygen was obtained in 30 minutes on one of these samples.

On the basis of the foregoing experiments, it is concluded that a combination of copper sulfate, sulfamic acid and acetic acid is most effective and desirable for arresting respiration in activated sludge when all factors are considered. It is realized that many other combinations of reagents may be used satisfactorily for this purpose, if care is taken to remove and analyze the supernatant as soon as possible after collection and contact with the inhibitors. Any one of the reagents in this combination could even be used alone but this combination of the three is superior to any of the individual reagents or to any pair of reagents for treating activated sludge in determining dissolved oxygen. It has been demonstrated that, when a sludge is collected in contact with those reagents, mixed and allowed to settle for 30 minutes, a higher dissolved oxygen will be obtained than from the same sludge sample from which the solids are removed mechanically as rapidly as possible by centrifuging. This demonstrates that it is extremely important to arrest the respiration instantly with the collection of the sludge sample.

One series of experiments was carried out to determine the effectiveness of the respiration-inhibiting reagents in eliminating nitrites during the sludge treatment. To follow this reaction satisfactorily quantities of nitrite were added to the sludge, after which the sludge was siphoned, in the same manner used previously, into 500 ml. bottles containing the reagents. After mixing the bottles were allowed to stand, the nitrites being determined in the supernatant after 15 and 30 minutes. The results obtained, shown in Table VI, indicate that the acetic acid sodium azide treatment was not very effective in eliminating nitrites in sludge liquors. This confirms the work of Brandt (17). When sulfamic acid was added to the above two reagents, the nitrite destruction reaction rate was increased. Treatment with sulfamic acid and acetic acid, and this combination with copper sulfate, was most effective in destroying nitrites in activated sludge liquors.

Properties of Sulfamic Acid

As sulfamic acid (NH_2SO_2OH) has not been used in sewage analysis heretofore, its properties will be briefly reviewed from Audrieth, *et al* (18). It is a crystalline, non-hygroscopic solid, melting with decomposition at 205° C. Its solubility in 100 grams of water varies from 14.69 at O° C. to 47.08 at 80° C., and is decreased by the presence of sulfuric acid. Sulfamic acid is highly ionized in aqueous solution and is of relatively the same strength as hydrochloric, nitric and sulfuric acids. This acid has been recommended as a primary standard in acidimetry and can be titrated using indicators whose transition points lie within the pH range of 4.5 to 9.0.

Solutions of sulfamic acid are rapidly decomposed by the addition of nitrite:

$$NH_2SO_2OH + NaNO_2 \xrightarrow{H^+} NaHSO_4 + N_2 + H_2O$$

This reaction takes place quantitatively and may, therefore, be used for qualitative or quantitative determination of either sulfamic acid or nitrite. In the reagent suggested for inhibiting respiration in sludge, the sulfamic acid reacts with any nitrite present in accordance with the above reaction with the liberation of nitrogen gas. Neither the sulfamic acid nor the products formed by it interfere in any way with the subsequent determination of dissolved oxygen. Sulfamic acid, however, does react with oxides, hydroxides and carbonates to form sulfamates. As most sulfamates are soluble in water, the formation of copper, manganese or sodium sulfamates in the process of sludge treatment or dissolved oxygen determination does not introduce any difficulty.

The sulfamic acid can, however, be oxidized or hydrolysed and this would make the inhibiting reagent worthless as far as nitrite destruction is concerned. In the cold, chlorine, bromine and chlorates oxidize sulfamic acid to sulfuric acid, but potassium permanganate, chromic acid and ferric chloride exert no oxidizing action. Under the same conditions as those existing during the dissolved oxygen determination, iodine exerts no apparent oxidizing action on sulfamic acid.

Hydrolysis of sulfamic acid (that is conversion from an ammonosulfuric acid into an aquosulfuric acid) takes place in accordance with the following reaction:

$$NH_2SO_2OH + HOH \rightarrow H_2SO_4 + NH_3 \text{ (or } NH_4HSO_4\text{)}$$

This reaction takes place very slowly at ordinary temperatures for according to Audrieth, *et al* (18), no appreciable concentration of sulfate ion could be detected until after several weeks. At higher temperatures the hydrolysis becomes quite rapid, 40 percent of a 10 per cent solution being hydrolyzed in 6 hours at 80° C. according to Cupery (19). In view of this rapid hydrolysis caution in heating to obtain solution of sulfamic acid and copper sulfate in the preparation of the inhibiting reagent is advised. To what extent hydrolysis of the sulfamic acid takes place in this reagent at ordinary temperatures is unknown at present. It has been found that the reagent has maintained its effectiveness in the destruction of nitrites for 45 days after preparation. The mixed reagent's efficiency as a respiratory inhibitor in activated sludge would be but slightly affected, if at all, by hydrolysis of the sulfamic acid due to the continued activity of its other constituents.

Preparation of the Inhibitory Reagent

The inhibitory reagent is prepared in the following manner: Fifty grams of copper sulfate are dissolved in 500 ml. of distilled water. Thirty-two grams of sulfamic acid are then dissolved in 475 ml. of water and the two solutions together with 25 ml. of glacial acetic acid are mixed. Solution of the sulfamic acid may be slow, but can be accomplished by stirring. Heat should not be used to facilitate solution nor should the mixture be exposed to heat at any subsequent time as this hastens the hydrolysis of sulfamic acid. The technical grade sulfamic acid may give a slight turbidity. This turbidity may be disregarded as it does not affect the efficiency of the reagent, or it may be removed by filtration. Five ml. of this reagent correspond to the 2.5 ml. of 10 per cent copper sulfate, 0.5 ml. of 1:4 acetic acid and 8 ml. of 2 per cent sulfamic acid as used in 500 ml. bottles in the experimental work.

In general, one ml. of the inhibitory reagent is used for each 100 ml. portion of sample.

Recommended Procedure for Determining Dissolved Oxygen

In practice, 10 ml. of the inhibitory reagent are added to a one-liter bottle. The sample of mixed liquor is siphoned or allowed to flow into the bottle to overflowing, with reasonable caution to avoid aeration, the stopper inserted and the bottle inverted several times to mix the contents. The sludge is allowed to settle for five or ten minutes, or until the sludge has settled sufficiently to permit siphoning the supernatant into a 300 ml. bottle without obtaining sludge solids. If the sludge is bulking badly a period of 30 to 40 minutes may be allowed for the sludge to settle. There will be no appreciable loss of oxygen within this time provided continuous agitation is avoided. The agitation incidental to transportation of the mixed liquor sample containing the inhibiting reagent from a collection point to a laboratory within easy walking distance should not be detrimental. The dissolved oxygen is determined on the supernatant in the 300 ml. bottle by the short Winkler technique. Two ml. of the standard manganous sulfate and 3 ml. of alkaline iodide containing sodium azide * are added and the sample is shaken for thirty seconds. Two ml. of concentrated sulfuric acid are added and the sample is shaken. If it is desired to titrate 200 ml. of the original sample 203.4 ml. are measured out and titrated with standard N/40 thiosulphate solution.

Summary

An inhibiting reagent composed of sulfamic acid, acetic acid and copper sulfate is proposed. This reagent is about twice as effective as copper sulfate used alone, though it contains only one-half the original concentration of this salt and consequently does not interfere with the end point in the iodine titration. When activated sludge is brought into contact with this reagent, oxygen absorption is stopped, nitrites are destroyed and the sludge is coagulated. The dissolved oxygen may then be determined upon the separated supernatant by the application of the short Winkler procedure employing sodium azide in the alkaline iodide solution. The determination of dissolved oxygen in activated sludge mixtures by this procedure is simple and dependable and has been found especially valuable in actual operating practice.

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THE DETERMINATION OF IRON IN SEWAGE

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The use of iron salts in sewage treatment often makes it desirable to ascertain the iron content of sewage samples. For such determinations use may well be made of the method of Winsor (1). This is a modification of the well-known thiocyanate method, in which the test is made in a medium consisting mostly of methoxy-ethanol (methyl cellosolve of the Carbide and Carbon Chemicals Corporation). The advantages of the modification are greater color intensity and greater color stability.

In applying the method to sewage, it is generally desirable to determine only the iron which dissolves easily in acid, ignoring the iron which may be present in the rock minerals of sand and silt. Hence it is better merely to make the sewage sample strongly acid, rather than to evaporate to dryness and apply extreme measures to bring the last traces of iron into solution.

The following directions indicate the suitable application of the method to sewage.

A. Solution

1. *Test Reagent.*—Distill commercial methoxy-ethanol (methyl cellosolve) in an all-glass distilling apparatus. Dissolve 40 grams of c.p. ammonium thiocyanate in enough of the solvent to make one liter of solution. A faint pink color, due to traces of iron, may be present in the solution. If this is sufficient to interfere with the determination of small amounts of iron, it may be eliminated by storing for a day or more. The reagent should be protected from light; under these conditions it is practically permanent.

2. *Dilute Hydrochloric Acid.*—To 200 ml. of conc. c.p. HCl add enough water to make one liter.

3. *Standard Iron Solution.*—Dissolve 0.112 grams of $Fe(NH_4)_2(SO_4)_2 \cdot 7H_2O$ in 800 ml. of water and make up to one liter with conc. c.p. HCl. This solution should contain 16 mg. of Fe per liter. For maximum accuracy, standardize the solution gravimetrically and adjust to exactly 16 mg. per liter.

4. *Potassium Permanganate Solution.*—Dissolve 3 grams of $KMnO_4$ in a liter of water.

B. Preparation of Sample

To 80 ml. of the sewage sample, which must be representative in respect to suspended solids content, add 20 ml. of conc. c.p. HCl. Clarify by filtering or by allowing to stand for two or three days.

C. Procedure

1. Pipette 10 ml. of the clarified sample into a 50-ml. Nessler tube. Add potassium permanganate solution dropwise until a pink color persists for a minute. Allow the mixture to stand until this color disappears, then make up to the mark with the test reagent. Mix thoroughly by inverting several times.

2. Prepare standards by pipetting varying amounts of the standard iron solution, not exceeding 10 ml., into Nessler tubes, together with enough of the dilute hydrochloric acid to make a total of 10 ml. Each milliliter of the standard iron solution used corresponds to 2 p.p.m. of iron in the unknown. Add potassium permanganate solution and test reagent as in the treatment of the unknown.

3. The unknown may be compared with the standards at once, as the color develops promptly. The colors fade upon standing, more slowly than when methoxy-ethanol is not used, but fast enough so that there should not be a time difference of more than 15 minutes in preparation of unknown and standards. The fading is largely photochemical; hence the tubes should not be exposed unnecessarily to strong illumination.*

If the unknown contains more than 20 p.p.m. of iron, use a smaller amount than 10 ml., making up to 10 ml. with the dilute hydrochloric acid, and multiplying the final reading by the appropriate factor.

The author made several hundred iron determinations in sewage when he served as Research Chemist for the Los Angeles County Sanitation Districts, and found the foregoing procedure much more satisfactory than the simple thiocyanate method which was used formerly.

Summary

The Winsor method for determining iron, which is a methoxy-ethanol modification of the thiocyanate method, is more satisfactory than the simple thiocyanate method for sewage analyses. A detailed procedure is given.

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* The recommendation of Peters, McMasters and French (2) as to the use of hydrogen peroxide for oxidizing the iron, as a means to forestall fading, has not been investigated by the author, but the use of methoxy-ethanol provides sufficient protection against fading, and it would seem that the variable amount of organic matter present in sewage would be oxidized with more certainty with permanganate than with peroxide, without the use of an undue excess of oxidant.

Industrial Wastes

INDUSTRIAL WASTES, THE LAW AND POLLUTION CONTROL PROGRAMS *

By Milton P. Adams

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The present era of accelerating national defense production brings to a close a period of unprecedented building in our field. Tremendous advances have been made in providing facilities for the control of sewage pollution during the past seven years. Judging from our Michigan experience, however, it will still take time to develop complete and dependable, day in and day out pollution control with the facilities heretofore provided.

The problems of many industries and commercial establishments are also being solved. This is particularly true where their wastes through direct connection or after pre-treatment are susceptible of connection to the municipal system.

For the most part, much less has been accomplished in that field frequently mentioned as the "wet" industries. These are dependent for their existence upon relatively large quantities of process water. Most of this used water supply becomes, in turn, a source of industrial waste. The daily operation of these industries creates the largest and most difficult group of problems that remains to be solved. The pollution created is generally responsible for the depletion of normal oxygen in the receiving waters. Adverse effects on private and public rights, on fish and aquatic life and on wild life are one result. This waste occasionally fills in ship channels as well, or taints public water supplies or imparts to them chemical constituents, difficult if not impossible to remove by known and practical methods of water treatment. In any chain of industries along a particular watercourse, the complaint of a downstream operator is frequently lodged against upstream users.

In Michigan, and I believe the same condition exists in other states, some outstanding industrial accomplishments can be mentioned. Others await the completion of experimental and research work now in progress and the passing of the current national defense emergency. But the total problem confronting us is tremendous and goes far beyond the date of anticipated internal industrial plant changes or new waste disposal installations.

A greatly enlarged and continued supervisory and administrative function is introduced if real pollution control is to result in either the municipal or industrial field.

* Presented before the Second Annual Convention, Federation of Sewage Works Association, New York City, October 10, 1941.

I doubt whether any state represented here is today adequately supervising the results of its greatly increased number of operating sewage and waste disposal plants. Nor have we gone sled-length as yet toward getting all the sewage or other wastes to these established plants. And it doesn't take very much marginal pollution to offset the public health value of an operating sewage plant.

It has been our experience that major industrial problems diminish or disappear in proportion to the supervisory staff effort that we can devote to the task. This starts with informal contacts or a Commission notice of failure to control pollution, followed by general plant surveys. Their purpose is to locate, analyze and determine the character and amounts of waste produced. Generally the staff opinion as to waste waters requiring treatment and those which may be separated for direct discharge is accepted by the management and our Commission. If research or experimental pilot plant operation is required at this point, an increasing number of agencies or engineers is available for this purpose. The Engineering Experiment Station of Michigan State College at East Lansing has been called upon most frequently for assistance in the industrial waste field in our state.

The most difficult stage is now reached—how to finance the necessary changes? While this is not the responsibility of the state, a knot can easily be tied by overlooking this factor that may take years to undo. "Piecemeal approach" to the completed solution is frequently necessary, with generally satisfactory although delayed results. Action of our Commission is employed to officially establish pollution restrictions, where necessary, set time limits or officially adjust other matters of difference that may arise. At both official and informal hearings before our Commission, it sits in judgment on our findings and recommendations, as well as the position taken by the polluting agency. Its order or other determinations are then made.

Members of the Commission have been willing as a rule to "take a stand" against pollution when convincing proof of injury has been established. The making of summary orders and their attempted enforcement, however, where ways and means of correction are unknown or currently unattainable, is not sound public policy. Neither is such action likely to be sustained in the courts. Michigan's legislative committees in recent years have viewed more restrictive statutes against pollution with the greatest skepticism. They say we already have enough power. With a few exceptions, I presume state legislative experience with new pollution laws is similar to our own.

Couple this state experience with that of the last six years at Washington in attempting the enactment of federal pollution legislation and I am convinced that more restrictive state or federal statutes are unlikely within the coming decade. Should we not ask ourselves in any event—Are we making the best use of the law which we already possess? Does new legislation necessarily *insure* accelerated progress down the road of improved pollution control? Is the answer to be found in state-instituted litigation to awaken the laggard polluter where he is found? Should such action be coupled with more of the qualified type of technical personnel for contact and field supervisory purposes? Is more research information needed? Are more funds (industrial or federal or both) necessary to accomplish and maintain the changes in waste disposal practice? In the correct answers to these questions lies the solution of our problems.

Currently we appear to have the prospect of operating under one or the other of two federal laws, depending upon which type of bill is enacted. These are H. R. 1110 by Mr. Spence and H. R. 3778 by Mr. Mundt. Both are lodged in the Committee on Rivers and Harbors of the 77th Congress. Neither bill seems likely of consideration at the present time, due to the exigencies of national defense. Yet because these bills represent two divergent conceptions of pollution control administration that have been prevalent for the past several years, they are important.

Unless more progress is made by the states in solving their unyielding industrial problems, we must be prepared to accept federal administration of pollution control in some form. Maybe we will have it anyway.

There is unquestioned need for improvement in statutory law covering procedure and financing and as an aid to the solution of certain state and interstate problems. But these various federal bill drafters hope to make uniform the pollution statutes of all the states, following some national pattern. Have they overlooked the uniformity and protection against pollution and other water abuses, already available? This is inherent in the so-called common or court-made law of the United States and of the several states.

We must take at the outset a broad perspective of the entire matter of water use and controls. Pollution abatement is only one part of a larger problem. The National Resources Planning Board and its predecessor agencies have been attempting to foster this concept for several years past.

Detrimental water pollution to me, is evidence of the abuse of an otherwise perfectly legal use of a state resource. I use the term ''state resource'' advisedly, since with the exception of navigation and certain power installations, our natural waters and their problem are primarily a function of state rather than federal interest and control. Of the fresh water streams and lakes of the United States, only a portion are apparently navigable by either state or federal definition. In addition to the now existing legal and illegal use of public waters for waste disposal purposes, surface waters must provide the means of navigation, power development, public, private and industrial water supplies and irrigation, as well as the medium in which fish and aquatic life live and upon which wildlife depends. Correlated problems created by precipitation and the resultant flow of water are found in flood and soil erosion control.

If we are to make the most of our water resources for the good of unborn generations as well as ourselves, artificial and natural abuses must be checked and corrected. Only in this way can the beneficial uses of this resource be fully developed and utilized. Wise use without abuse is one of the accepted definitions of good conservation. It is also a fair statement of principle to be drawn from the common or court-made law itself. No one use of a water resource can be permitted to prevail at the expense of others without causing trouble and conflict.

If we would but familiarize ourselves with and utilize this declared policy of the so-called common law of waters, we will find sound administrative guides to practically every situation that can conceivably arise. On the other hand, statutes defining rights and establishing limitation on use are strictly construed. Their enactment always trails the problem created. They are frequently inadequate to meet new needs as they arise. They depend upon a sufficiently crystallized majority of legislative opinion for their enactment.

Yet here lies, little used and apparently less appreciated, this potentially valuable implement to our work—the common law of waters of all the states. It presents through its so-called "reasonable use doctrine" uniformity of policy for all users of our water resources to follow.

What then is this common law as it relates to waters? It is an ever increasing compendium of the decisions of the state and federal appellate courts, classified to bear upon definite subjects with related facts. Its original foundation was the English common law. This was accepted conditionally or in its entirety by the states of the Union as they were organized. It also serves as the foundation of jurisprudence of the United States courts. Only to the extent that subsequent statutory enactments have come and gone, and court decisions modified it, has the common law been changed. Hence for any present lack of statutory enactments, the aggrieved party is rarely without a remedy.

To make a geological comparison—it is the sedimentary rock bed ever increasing in thickness and strength as more deposits in the way of current court decisions are laid down. The upper layers of this deposit consisting of the more recent decisions would be given the most judicial consideration presumably, when questions arise for determination. If the facts of a given case are found to fit and the litigation is otherwise properly instituted and free of fatal technicalities or prejudice, the answer will be satisfactory.

Ever changing and generally inadequate statutory law, on the other hand, may be compared to the earth, trees or vegetation which may be found overlaying this rock bed of the common law. It may be brushed off, or completely changed, as time goes on, whereas the rate of change in common law doctrine is exceedingly gradual. It comes about as the result of changing judicial opinion and its weighing of the facts and equities involved. It is this integration of separate but related cases into a stable policy of the law which appeals to me as the only sure foundation upon which pollution control of the future should be based. This is especially the case where existing rights to the use of water are to be curbed. Substantial sums of money must be expended to compensate for the curtailed use of that resource for future waste disposal purposes.

How do we invoke the common law? In Michigan, generally by filing a bill to enjoin detrimental pollution. What we seek is restriction to a "reasonable use" by the polluter obtained through the court's decision. It is heard in a court of equity or chancery as distinguished from a court of law. Equity jurisprudence, so-called, is always open to the complainant, where relief through the law courts is neither adequate nor available.

Relief may be sought by the injured individual as well as by the downstream municipality, if a riparian, or by the state, acting under its police power. The same process by which the pollution offender is compelled to observe the law of the land may be employed by him to obtain his rights to the legal use of the water to which he is entitled. Only the court can define and delineate the limit of reasonable use, beyond which pollution or other abuses are unlawful. But a category of court recognized pollution injuries already exists. They have been heretofore declared as evidences of *unreasonable* use and such practices enjoined. The engineer or pollution control administrator has a good cue, therefore, to the limit to which he may safely go in approving or enforcing pollution control facilities. Those of you in charge of municipal plant operation, and designing engineers as well, will derive much benefit from your attorney's explanation of the relation of the doctrine of the common law to your respective pursuits.

We have tried to follow the declared policy of "reasonable use" in our contacts with industry and municipalities in Michigan. We believe the policy has not only yielded results but has generally meant more effective cooperation toward control in a spirit of good will. The importance of this factor to successful pollution control cannot be overestimated. No state or the federal government can ever employ enough pollution policemen to know about or guard against every occurrence, municipal or industrial, which will cause pollution. Most managements, if convinced that you are fair and reasonable, will respond in like manner. It is obvious one is going to get farther to acknowledge at the outset that the polluter is entitled to a reasonable use of the stream or water for disposal purposes, than to damn him as an outlaw and issue an order for a complete clean-up of *all* pollution from and after a certain day. Moreover, it is my opinion that irrespective of the statutory authority under which one is entitled to proceed, whether state or federal, present or future, "the law" will support you if a reasonable use is conceded, while it may defeat you if it is shown that your requirements are unreasonable or arbitrary or not susceptible of accomplishment.

Through your attorney's counsel is the only way to ascertain the value of seeking a common law solution of your stubborn and resistant pollution problems. Prepare your facts, interpret the test results, list the nature of injuries created and place them in his hands for advice. Armed with his opinion you should be able to prevail upon the head of your department or pollution control board to institute the appropriate litigation.

With your permission, I shall read a few excerpts from paragraphs on the so-called Law of Waters. They are taken from Vol. 67, Corpus Juris, omitting references to the citations to supporting cases. Other authorities, such as "Cyc" (Cyclopedia of Law and Procedure), L. R. A. (Law Reports Annotated) and R. C. L. (Ruling Case Law), are equally available and of interest.

On the subject of the Rights of Riparian Owners to Use of Water (page 690), the following statement of the law is found:

> Subject to any paramount right to the use of the water existing under the general law in some other person, a riparian owner has the right to make any use of the water, beneficial to himself, on the riparian land, which his situation makes possible, so long as he does not inflict any substantial or material injury on those below him, and he may facilitate his use of it by any appropriate means; but all the riparian proprietors have an equal or common right to use the water, and each must exercise his rights in a reasonable manner and to a reasonable extent, so as not to interfere unnecessarily with the corresponding rights of others, . . .

On the subject of Reasonableness of Use, commencing on page 694:

> A riparian owner's rights are not measured by the necessities of his own business, but by the rule that his use of the water must be reasonable when considered with reference to the needs or rights of other riparian proprietors on the stream, and any malicious or wanton use or abuse of his water privileges by a riparian owner is unreasonable and actionable. There is no fixed rule of law for determining what will constitute a reasonable use, but each case depends on its own particular facts, and the reasonableness of a particular use is generally a question of fact for the jury, although the use of the water may be so plainly excessive as to be unreasonable as a matter of law. In determining the reasonableness of a particular use it is proper to consider the character and size of the stream, its location, the nature and condition of the improvements thereon, the uses to which it is subservient, the state of civilization, climatic conditions, the custom and usage of the people in the vicinity and elsewhere in regard to the management of business, the hours of labor, and the use of the water of such streams, the nature of the banks, the volume of water, its fall and velocity, the subject matter of the use, its object and extent, the necessity for it, and the previous usage.

On the subject of Pollution with Respect to the Right to Pure Water, commencing on page 767:

> It is the right of every riparian owner to have the stream continue to flow through or by his premises in its natural condition of purity, and free from any contamination or pollution, such as would render it unfit for domestic purposes, or for manufacturing purposes, or for agricultural purposes, such as irrigation or the watering of stock, or for swimming and bathing purposes, or which would be destructive to the fish therein, or cause it to give off noxious and unhealthful odors. Thus an upper riparian proprietor ordinarily has no right to pollute a stream. If he does so it is wrongful, unless he has some prior or special right to some exclusive or particular enjoyment which permits such pollution. A statute prohibiting the pollution of watercourses occasioned by the inflow of salt water, of oil, and of other substances is a proper exercise of legislative power. . . .

Relative to the Nature of the Right to Pure Water, we find the following:

The right of a riparian owner to have the water flow pure and undefiled is what is termed a natural easement; it is annexed to the soil and is parcel of the land itself, and inheres in the estate entitled ex jure naturae independent of grant or prescription. Such right is not conditioned upon the beneficial user of it, nor can its owner be deprived of it by legislation. An injury to the purity or quality of the water, to the detriment of other riparian owners, constitutes, in legal effect, a wrong and an invasion of private right.

Under Principles Governing Subjection of the Right to Pure Water to the Right of Reasonable Use:

The right to purity of water is subject to the right of each riparian proprietor to use the stream to a reasonable extent, and whether or not a pollution of the waters of a stream is an actionable injury to a lower riparian proprietor depends upon whether it is the result of such a reasonable use of the stream as the upper owner is entitled to make or of an unreasonable use in excess of his rights. The right to purity of water is not one of absolute immunity from all pollution. The upper owner is entitled to use the stream in such a manner as to make it useful to himself even if it somewhat impairs the quality of the water; and so if his use of the stream is a reasonable use, the fact that it incidentally impairs the purity of the water gives no cause of action to a lower riparian owner. However, a riparian owner must not use the water of the stream so that the water is so corrupted and polluted as practically to destroy or greatly impair its value to the lower riparian owners. What is a reasonable use is primarily a question of fact, but whether the undisputed facts, and the necessary inferences therefrom, establish an unreasonable use is a question of law. It is to be determined in view of all the facts and circumstances of the particular case. Every use of a stream which decreases the purity of its waters is not unreasonable. There must be a fair participation in the use of the water between the upper and the lower riparian owners. The reasonableness of the use depends upon the extent of detriment to the riparian proprietors below. If it essentially impairs the use below then it is unreasonable and unlawful unless it is a thing altogether indispensable to any beneficial use at every point of the stream. In some jurisdictions the rule is stricter where the use is for manufacturing or industrial purposes than where it is for ordinary farm or domestic purposes, it being held that the use of the water of a stream for ordinary farm and domestic purposes does not render an upper riparian owner liable to a lower owner even though such use renders the water materially less pure to the lower owner's substantial damage; but the use of the water of a stream for industrial or manufacturing purposes by which it is polluted is quite another matter, and the riparian owner's right is limited to the extent that such use must not materially pollute the water to the substantial damage of the lower riparian owner, and such use and pollution of the water renders the user liable to a lower riparian owner whenever the damage is of a substantial nature.

On the subject of Pollution from Other Sources:

Ordinarily it is no justification or excuse for one who pollutes a watercourse that the stream is already contaminated or that various other persons are contributing to its pollution, or that an extraordinary flood was a contributing cause. The fact that the damage would have been less had the stream been pure when it reached defendant does not reduce his liability for all damages occasioned by his pollution of the stream, nor does the fact that the stream is already partially polluted from other sources permit a riparian owner to increase the pollution thereof to the damage of a lower riparian owner.

Relative to the Necessity to Mitigate or Prevent Injury, the following:

In some jurisdictions if the lower riparian owner by the exercise of ordinary care and at reasonable cost, can minimize the damages it is his duty to do so. In other jurisdictions he is under no duty to mitigate his damages, for although he is bound to exercise reasonable care to protect himself from any damage that he has cause to anticipate, he is not bound to expect that an upper riparian owner will inflict wrongful injuries upon him in the use of the stream, and it is not his duty to take steps to protect himself from unexpected unlawful acts. Thus he is under no duty to protect himself from injury through pollution at his own cost, even though he could protect himself at less expense than would have to be incurred by the wrongdoer causing the pollution for the prevention thereof.

With respect to Refuse from Mills and Factories, commencing on page 774:

A riparian owner has a right to make a reasonable use of the stream for the operation of a mill or factory, and may even cast waste material therein if he does not thereby cause material injury to public or private rights. However, he has no right, by unreasonable use, seriously to impair the rights of a lower riparian owner, . . . It is no excuse or justification for such pollution that the use of the water in the mill or factory is a lawful riparian use; that the business of the mill or factory is conducted skillfully and according to the best modern methods and without malice or negligence . . . or that complainant knew defendant was building large and expensive works and made no objection thereto; or that an act of God in the form of a drought caused the stream to fail to carry off the refuse as it did in normal times. There is no public policy in favor of industrial development which will justify for the sake of a factory or mill the destruction of the rights of other riparian owners by the pollution of the stream. No supposed rule of necessity in order to carry on a business, or on account of its usefulness or necessity, or on account of the amount involved, will authorize the pollution of the waters of a stream. A manufacturer who uses the water from a stream in his plant and returns it into the stream in a condition no more polluted than when he took it out of the stream is not liable for the pollution of the stream.

Under the Effect of Custom, the following:

A long-continued uniform custom of mill owners and manufacturers along a particular stream may make it a reasonable use for them to discharge their waste and refuse into the stream.

Under the subject Occasional Pollution of Stream:

If the riparian owner has employed every means known to the business to prevent a discharge of noxious matters into the stream he is not chargeable with negligence for an occasional unavoidable discharge of such matters with a consequent temporary pollution of the waters of the stream.

Under the subject of Acquisition of the Right to Pollute, as obtained by prescription, we find on page 776:

Although in some jurisdictions the right to pollute a fresh water stream cannot be acquired by prescription or any lapse of time, as a general rule, if the pollution of a watercourse does not constitute a public nuisance, the right to use the water of a stream in such manner as to pollute it to the prejudice of lower riparian proprietors may be acquired by prescription. Such a right cannot arise, however, where it would be injurious to public health, or constitute a public nuisance, or be in opposition to intermediate legislative enactments against it. To acquire a prescriptive right to pollute a stream a riparian proprietor's use of the waters thereof must be injurious to lower riparian proprietors, uninterrupted, adverse, under claim of right, and with the knowledge of the lower riparian proprietors, or with such acts that knowledge will be presumed, and must have continued for the full prescriptive period. Such a prescriptive right can be exercised only in the manner and to the extent to which the pollution was begun and continued in order to acquire the right, but cannot warrant any further or greater pollution.

Relative to Persons Entitled to Relief, the following:

Since he has a right to have the stream flow by or through his place in a pure and undefiled condition, a riparian owner has a cause of action for the pollution of the stream, and a person in possession of reality is, for this purpose, classified as an owner. This right, except where the pollution constitutes a public nuisance or injures the water for a purpose under the regulatory power of the state, is ordinarily confined to the riparian owners below the point on the stream where the pollution takes place; and a nonriparian owner, unless he can show that the pollution of the stream creates a condition which constitutes a nuisance, injurious to him other than the condition of the water itself, has no cause of action therefor. . . .

Other pertinent sections of the law such as that relating to Trial and Relief in Equity, commence on page 789:

Injunction is a proper remedy to prevent a threatened pollution of a watercourse, or to stop the further continuance of a nuisance consisting in such pollution, and this remedy is available, although redress might be had by abatement of the nuisance or an indictment, or by action at law. The granting or refusing of an injunction rests in each case on the sound discretion of the court, exercised according to the recognized principles of equity, and plaintiff must not only show the pollution of the stream, but he must further establish facts entitling him to such relief under the equitable principles generally applicable to injunctions. As a general rule, the use of a stream in such a manner as materially to foul and adulterate its water will be enjoined, provided the injury is a recurring and continuing one, and the stopping of the acts complained of will restore or tend to restore plaintiff to the enjoyment of his rights, and particularly where defendant, before building his plant, gave explicit assurance to plaintiff that he would avoid polluting the stream, or, in the case of pollution by mine water diverted from its natural outlet and by artificial means discharged into a stream which does not form the natural drainage of the mine, where it does not clearly appear that the natural conditions make it impracticable to discharge the water in any other way, or that the expense of doing so would be so great as substantially to deprive the mine owner of the use of his property. Isolated acts of pollution do not constitute a ground for injunction, nor do past acts or resulting injuries unless it appears that the acts or injuries shown will probably continue or recur. Thus an injunction will be denied where, at the time of the suit, defendant has taken steps whereby the pollution is prevented. If a riparian owner's use of the stream is reasonable and does not pollute it to such a degree as to render it unfit for manufacturing, mechanical, or domestic purposes, he will not be enjoined. The court will not, at the instance of the attorney-general, restrain a mill or factory from a use which pollutes a stream somewhat where the lower riparian owners do not complain of such use and most of them are dependent on the operation of the mill or factory for their support.

On the subject of Relative Injury, note the following:

In some jurisdictions the court, in deciding whether to grant or refuse an injunction, cannot consider the balance of convenience, or of advantage or disadvantage, to plaintiff and defendant and the public at large of defendant's use of the stream. In others, in considering whether to enjoin a business enterprise from polluting a stream the courts recognize the importance of business enterprises. They will not overlook the needs of important manufacturing interests nor hamper them for trifling causes. Thus, where such enterprises are established at the only place where it is practicable to operate them, and they are conducted in the only practical manner, their right to operate will not be destroyed for trivial causes or for slight damage resulting to others, and if the damage which will result to defendant from an injunction is much greater than any injury to plaintiff from the pollution such state of facts will warrant a refusal of the application for injunction. However, substantial injury to lower riparian property will not be permitted for the purpose of enabling a new and great industry to flourish. Oil fields will not be abolished and annihilated by an injunction against the pollution of streams by oil wells, it being impossible to abate the pollution and at the same time operate the oil wells.

The subject of Defenses to Action of Abatement is of interest (page 792):

> It is no defense to a suit to enjoin the pollution of a stream that the business engaged in by defendant is a lawful and useful one which is being conducted in a proper and customary manner, or that plaintiff bought the property with knowledge of the existing conditions as to the pollution of the stream. . . . Also, plaintiff's right to an injunction is not affected by the difficulties of complying with it on the part of defendants, provided it is within the limits of physical possibility; nor, it has been held, does the fact that to enjoin the continued discharge of sewage into a stream will cause hardship on the persons enjoined and menace their health and that of others, operate to prevent the issuance of the injunction, but in this connection the right which the courts ordinarily have to refuse an injunction because of the disproportionate injury which would result to the parties must be considered.

You have just heard quoted statements of portions of the court-made law on waters. If unfamiliar with it, are you not impressed by its complete applicability to our work? In all probability you can bring this to bear upon the solution of your delinquent problems. If so, what further need have we for more restrictive statutes against pollution?

It will be noted that the common law of waters is built primarily on riparian owner relationship. State or federal agencies for the control of pollution must therefore establish their eligibility to complain. Where acting in behalf of public health protection, the state's inherent police power would presumably establish this eligibility. Some legislatures have broadened, beyond the limits of public health, the authority of the state to combat pollution. Our attorney general and I presume most state's attorneys, have power to abate public nuisances, however caused.

The purpose of the controversial Section 10 of the Mundt Bill is an attempt to establish the eligibility of complaints by the federal government against pollution. Where the pollution is of a local nature, even though found in navigable waters, it remains to be demonstrated whether or not this bill in Congress, should it become law, will place another unit of government still farther removed than the state in a position to control local pollution. The question is particularly pertinent if, in doing so, state jurisdiction is automatically ousted, as many believe will be the case.

In conclusion then, it would seem entirely unnecessary that any of us in the state pollution control field should be awaiting the enactment of any federal law with the idea that this is necessary to establish uniform national policy. The doctrine and principles of the common law already provide this uniformity. The only safe criterion of water quality in the crossfire of interests in which we find ourselves is that of "reasonable use," interpreted in the light of each differing set of facts and circumstances. Moreover, "reasonable use" will be the criterion where pollution abatement is sought by injunctive process in either state or federal courts. The tests of injury, however, may be expected to be more strict and difficult to prove in federal than in state courts, according to my understanding. All of us cannot wear the same size hat or shoes neither can all pollution problems be equitably solved with the same remedies nor the same degree of treatment.

For those sewage or waste disposal problems that impede or prevent the realization of sound pollution control programs under cooperative compliance policies, we should be getting our facts together, enlisting rather than discouraging the interest and aid of the injured riparian proprietor and giving our own state's attorney the opportunity to help us. By proper steps, the uniformity and fairness of the common law can be brought to bear, with beneficial results.

If such steps are supplemented by inviting Waltonians and other critics of our past methods to give heed to our obstacles as well as the examples of failure of pollution control we will not be constantly "in the middle." We should presently have not only the facilities and plant changes to permit compliance but the staff assistance necessary to the maintenance of satisfactory pollution control for future years.

Acknowledgment

The writer wishes to acknowledge the aid of Mr. Harry W. Jackson, Assistant Attorney General of Michigan, for advice and counsel given in connection with the preparation and review of this paper.

Discussion

By C. R. Hoover

Consultant to the State Water Commission of Connecticut, Member of the Connecticut Flood Control and Water Policy Commission, Wesleyan University, Middletown, Connecticut

Mr. Adams has given us an invigorating, practical and legal justication for the extension and improvement of the control of industrial waste pollution. I agree that further Federal restrictive legislation does not appear likely under present conditions of the National Defense effort, but I am not too confident of continued restraint. Some feel that social and economic changes, not necessary in the present emergency, may be extended as a matter of consistent general policy. I agree that the control of water resources is primarily a State function but unless individual states or groups of states are active in preventing inequalities and injustices across state lines, local as well as Federal pressure for broader control is likely to develop. There has been too much smoke of rumor regarding factory migrations to avoid waste treatment expense to make us confident that there is not some accompanying fire. The military strategy, dictating the wide distribution of defense plants, cannot but locate new sources of pollution in some states which have not been seriously faced with industrial waste problems in the past. These plants become potential competitors of factories required to treat their wastes.

It would appear that if Federal authorities are interested in requiring wide-spread pollution control that they should make provision for industrial waste treatment in plants financed by the National treasury. Moreover, a manufacturer should not be asked to expand his production capacity or sell his product to the Federal Government at a price that will not permit of meeting the cost of waste treatment.

From the stand-point of the manufacturer there are reasons why pre-treatment and waste elimination should be considered at the present time. Full time operation indicates the possibilities of reasonable profits before tax deductions. Sterner competition is certain to be expected in the post-war period. Now is the time to prepare to avoid future expense.

Mr. Adams is undoubtedly correct in his statement that we cannot now expect a continuation of the past extensive public works program, but we can hold our gains. In this connection I feel that one of the basic requirements of the Connecticut State Law, which established the Connecticut State Water Commission, is a good guide at this and all times. This basic requirement is in substance that no objectionable pollution of State waters, by a new industrial source, shall be permitted provided a reasonably feasible and economic method of preventing or eliminating the pollution is known. This law and its justifiable interpretation, would appear to accord with the requirements of the basic common law and the reasonable control policy of Michigan as explained by Mr. Adams.

Technically trained State officials can now, as always, do much to educate and assist industries in understanding their pollution problems. Industrial chemists and engineers need to have more appreciation of sanitary engineering, and the effect of small amounts of toxic substances on biological processes. As one manufacturer once said to me "You want us to reduce our impurities in our waste water to 100 p.p.m.; that is, ten times as pure as the purest product we sell and we think we are doing pretty well to get our impurities down to one-tenth of a per cent or a thousand parts per million."

This is a time when cooperative engineering surveys of industries can be carried out by State and Municipal authorities. Segregation of objectionable wastes and equalization and effective dilution can be encouraged. Economies can be pointed out and recoveries, especially those of strategic materials, emphasized. For example, additional standing rinse tanks in plating rooms, recovery of cutting oils, making cattle feed and fertilizer from food factory wastes, save-alls and closed white water circulation in paper plants. The giving of sound engineering advice, recommendation of well trained outside consultants and the warning to avoid the pitfalls of makeshift treatment expedients are especially needed in these times of peak production.

I would like to emphasize one of the points Mr. Adams mentioned briefly. This is an appropriate time to investigate the full utilization of the large number of new municipal treatment works in connection with industrial wastes that can be admitted to sewerage systems. Proper regulation of the discharge of industrial wastes to sewers, closer pH control, addition of small amounts of regulating chemicals, and many other expedients which modify, but do not seriously alter the operation of a sewage plant, are in order. We have been especially interested in eliminating the effect of copper in separate sludge digestion and hope to report some simple measures to be used in sewages receiving metallurgical wastes. A number of factors affect the amount of copper that can be accepted in a sewage, but owing to the large segregation of copper compounds in settled sludge, we are inclined to agree with Mohlman's original estimate at New Haven that 1 p.p.m. may have retarding effects on sludge digestion. In this connection we are much interested and we feel that all those connected with sludge digestion and all biological processes should also be interested in the proposals being considered by the group of experts preparing to revise the Federal standards for drinking water. Dr. J. K. Hoskins, of the United States Public Health Service, told the American Chemical Society at Atlantic City, on September 8, that the standards being considered involved raising the maximum allowable copper content from .2 p.p.m. to 2. p.p.m. and invited comments from those interested. We find that many so-called potable waters contain more than .2 p.p.m. but we have yet to find one which contains as much as 1. p.p.m.. I am not an authority on the physiological effects of small amounts of copper on humans, but I think I can claim that 2. p.p.m. will be detrimental to other important forms of life of interest to the sanitary engineer.

This situation may be clarified by later proposals but it may serve to indicate my closing point. Cooperation is needed in solving technical problems. Cooperation of Governmental authorities, public health officials, sewage workers, water resource conservators, industrialists, and their varied technical staffs is indicated if the complex problems of water supply and liquid waste disposal are to be solved. By such cooperation we can benefit not only the health of the public but the health of industry as well.

FIRST YEAR'S OPERATION OF THE EFFLUENT TREATMENT PLANT OF THE CALCO CHEMICAL DIVISION, AMERICAN CYANAMID COMPANY, BOUND BROOK, N. J.

By V. L. King, C. H. Bean, and R. E. Lester

A preliminary report on operation of the Calco Effluent Treatment Plant is presented at this time because of the many inquiries that we have received for information. The treatment process is undergoing continuous development on the large scale as we acquire experience with it; as the conditions change in the Raritan River into which the treated effluent is discharged; and as the character of our individual effluents changes by constant addition of new products of manufacture in our plant. Although we speak of having started the treatment plant in November, 1940, attention should be called to the fact that this is only partly correct as there are still several "treatments at the source" to be put into effect and a number of others had been installed prior to that date. For a description of plant and equipment and of the steps leading up to the development of the process, reference is here made to two descriptive articles that appeared in *Chemical Industries* and also in *Chemical and Metallurgical Engineering,* both in March, 1941. This present article gives the first report of operation.

An unprecedented drought occurred in the summer of 1941, with resultant very low flows in the river. Our calculations of minimum river discharge were upset, and we had to improvise means for compensating for this lack of dilution. The need for certain additional treatments at the source was emphasized. Our existing treatments at the source were controlled more strictly, and, in all, the effluent treatment plant gave a creditable account of itself under trying conditions.

The process itself consists of the following general steps:

1. Treatments at the source.
2. Collecting.
3. Compositing.
4. Neutralizing acidity.
5. Settling and clarifying.
6. Aeration.
7. Diffusion and dilution in the river.

The map of the plant and effluent treatment plant layout (Fig. 1) shows the collecting basin at (1). Treatments at the source have been made in various places prior to the delivery of the effluents to this basin. Compositing is effected at (2), neutralization between (2) and (3), clarifying at (3), aeration in the long canal leading to the river and at the diffusion dam.

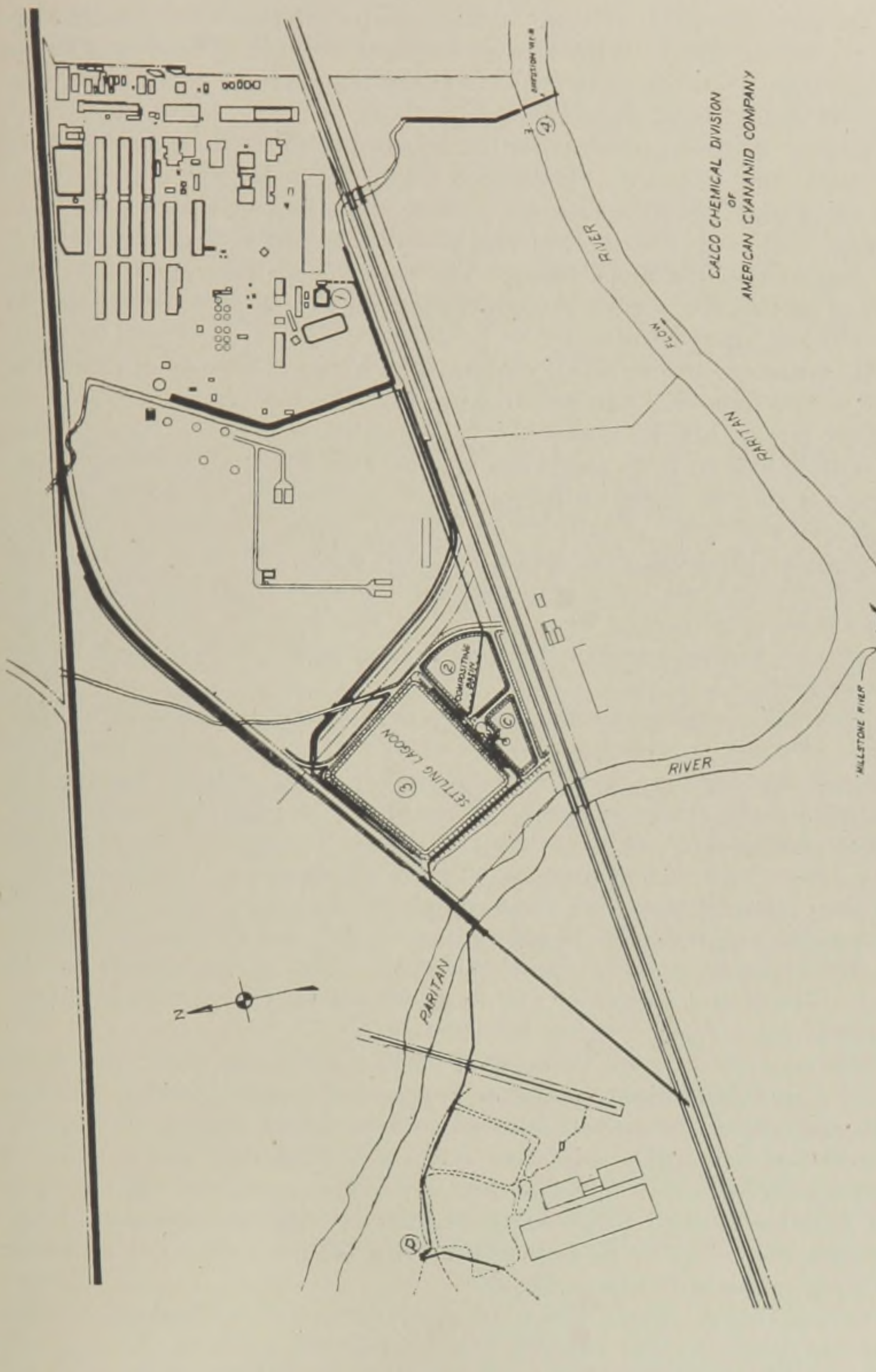

CALCO CHEMICAL DIVISION
OF
AMERICAN CYANAMID COMPANY
RIVER
FLOW
RARITAN
SETTLING LAGOON
RIVER
RARITAN
MILLSTONE RIVER
N

FIG. 1.

Treatment at the Source

Various individual effluents are given specific treatment before they are allowed to flow into the treatment plant proper. These treatments are intended to put them in such condition that the treatment plant may handle them without disturbance.

Earlier methods of clarification by means of settling basins were continued and extended. Thus, iron sludges from aniline manufacture, chrome sludges, and the like, are settled in a series of basins near their sources so that only their clear and nearly colorless supernatant liquors are run to the treatment plant. The overflow from a thickener, containing small percentages but large quantities of sulfites, is included in this class of pretreatment.

Oil traps are being installed at various sources: These are skimming devices for removing surface oils, and settling basins or tanks for removing oils or oil-like materials, both heavier and lighter than water.

Sulfide and sulfhydrate brines are aerated to fix these oxygen-consuming materials as thiosulfates. Sulfur is precipitated, which may be recovered and used. The resulting liquors, containing sulfites and thiosulfates, are treated with waste sulfuric acids and heat to drive off recoverable SO_2 and to precipitate more sulfur which may be reused. The sulfur color brines, when treated in this manner, are almost completely decolorized and their oxygen-consuming power is reduced 98 per cent or more.

The most important reduction in oxygen-consuming power of individual effluents is accomplished at the source by destroying the sulfite brines from the overflow of a Dorr thickener. These liquors are pumped to the tower exits of the contact acid plant where they are further enriched by allowing them to absorb the unconverted SO_2 from the contact sulfuric acid process. The resulting strong bisulfite liquors are then pumped to an SO_2 recovery plant where they are treated with weak waste sulfuric acids to produce crude SO_2 gas and sodium sulfate, the latter being removed in the effluent. This process reduces the oxygen-consuming power of our total effluent by the impressive figure of 120 p.p.m.

The manufacture of fluorescein, eosine, and bromo acids produces waste liquors containing a green fluorescent material which becomes even more fluorescent upon dilution. These waste liquors may be collected and their pH's adjusted to 6.5–7.2. Chlorine gas or sodium hypochlorite, added in sufficient quantity to give a positive starch iodide test and maintained until decolorization is complete, completely decolorizes these liquors in a short time and the color does not reappear on being mixed with other effluents.

Oil emulsions, which are foam-producers, may be broken in some cases by precipitating calcium and magnesium salts in them at pH 5.0–6.0. Such oil adsorbed and entangled in the floc can be settled out thereby.

Neutralization to pH 4.0, at which point the free mineral acidity is destroyed, produces only a little floc.

The metering out, or slow steady discharge of certain highly colored wastes, such as the mother liquors of crystal violet, methyl violet, malachite green, etc., so that the compositing basin may not suffer from "indigestion," is another method of preventing any effect of such wastes upon the final color of the effluent.

These means all serve to reduce the effect upon the river of the final treated effluent by pretreating many of the individual effluents at their sources. The liquors from those treatments are run to the tile sewers along with cooling waters, wash waters, manufacturing or other process liquors and wastes, and the sanitary sewage of about 4,500 employees.

Collection

All effluents, including those treated at the source, are collected in a pumping station sump of 350,000 gallons capacity from which they are pumped continuously to the compositing basin. It was planned to collect everything, including clean water from cooling operations, as well as the sanitary sewage, as the pilot plant work indicated that the resulting composite would not only neutralize the color but also be sufficiently acid to destroy the sewage. Work by the State Department of Health on the river while the plant was being built showed that our effluent, on account of its acid nature, was not only free from *bacterium coli* itself, but when mixed with the river, reduced the *bact. coli* content of the river water to zero as well.

The New Jersey State Department of Health, under the leadership of the Director, and aided by its engineering representatives, have been most helpful throughout this entire endeavor. They have been with us through all of our work and have helped in the solution of many of our problems. It has been a pleasure to work with them and the standard of cooperation between State and industry that has here been established if followed elsewhere cannot fail to greatly expedite the cleaning up of rivers everywhere.

Although the individual effluents are run to the collecting basin by gravity, they must be pumped to the compositing basin through a wooden pipe line 3,000 ft. long. This pumping equipment is made of a special acid bronze which has stood the service with no visible deterioration. This bronze contains 91.3 per cent copper, 8.2 per cent tin, and 0.5 per cent phosphorus. A few cast-iron valves, which were installed because bronze ones were not available at the time, failed after less than a year of service, and were replaced by bronze of the same composition.

Compositing

The compositing basin is the heart of the effluent treatment plant where many different chemical reactions take place and where the effect obtained is so obtained because there is such a great diversity of materials continuously brought together. It is common experience of color makers and users that the thorough blending of many different colors produces absence of color. Similarly, the large number of differently colored effluents thoroughly composited produces a like neutralization of color. The gamut of colors of the many individual effluents disappears and only a tea color of low tinctorial power remains.

This may be demonstrated by mixing individual dye effluents with the river water and comparing the result with that obtained by mixing the same effluents, after compositing with many others, with the river water in the same dilution. At the dilutions usually obtained in the river, the first mixture will color the river water decidedly while the second will not color it at all. This same result has been obtained in the river since November, 1940. It is possible, however, to disturb this process in the compositing basin by a sudden discharge into it of an unusually large amount of some highly tinctorial waste, such as malachite green or crystal violet. Such wastes should be fed in over longer periods of time to give the compositing a chance to work.

The compositing basin had a capacity of 10 million gallons, but the growth of the plant this year made it necessary to increase this capacity by increasing the depth 17 inches to more than 12 million gallons, in order to eliminate short-circuiting and improve the compositing. Here a whole multitude of chemical reaction takes place. Acids meet alkalies, reducers react with oxidizers, stable and complex salts are formed, colors are equalized, precipitates are settled, *bact. coli* is destroyed and the final composited pH reduced to between 2.2 and 2.5.

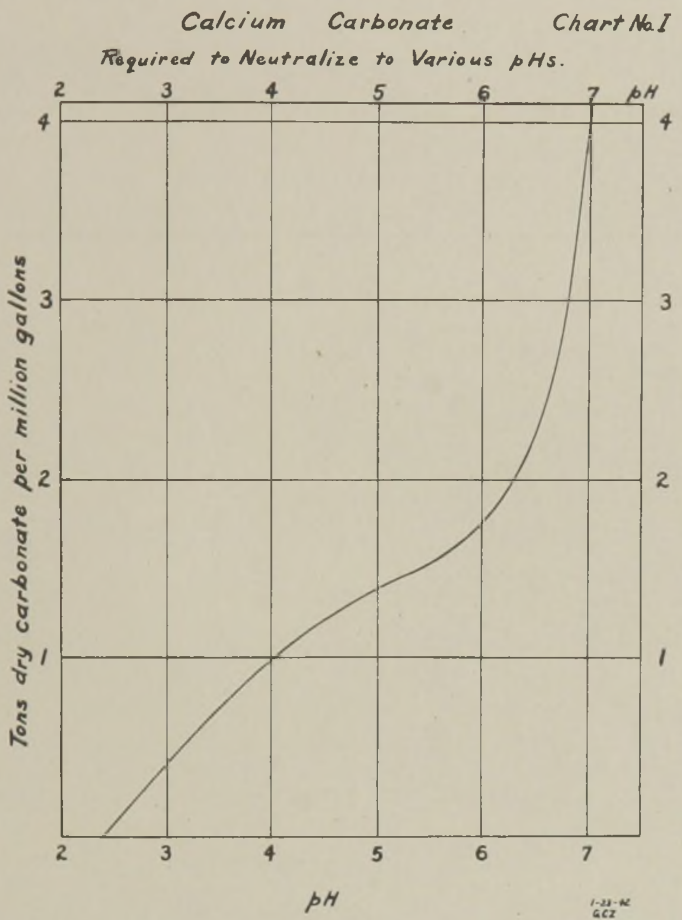
In a year's time, we have accumulated a half-million cubic feet of oily sludge in this basin, that otherwise would have flowed to the river to form sludge banks of unpleasant appearance. This sludge will be pumped out to another basin where it will dry and make fill for low sections of the property.

Neutralization of Acidity

The composited effluent flows through the neutralizer where its pH is adjusted to the end point of the erythrosine indicator, pH 4.0. This is accomplished by the use of a waste carbonate of lime slurry obtained from the Johns-Manville plant nearby.

Our neighbors, the Johns-Manville Company, were extremely helpful to us in promptly giving us their entire output of waste calcium carbonate from their large magnesia manufacturing operations. While it is true that our use of it also disposes of a waste for them, nevertheless, their action is an outstanding example of what cooperation between companies with farsighted management can do. Their readiness to make this valuable and mutually helpful arrangement so quickly with us has enabled us to help the State Department of Health accomplish a decided advance in the improvement of the river. Johns-Manville permitted us to install pumping equipment on their premises and to pump all of their waste directly to our plant. This cooperation resulted also in a better job of recovery from the waste, and reduced plugging of valves and lines in our own equipment and even removed so much of the grit that there remained little for us to remove in our classification of the slurry.

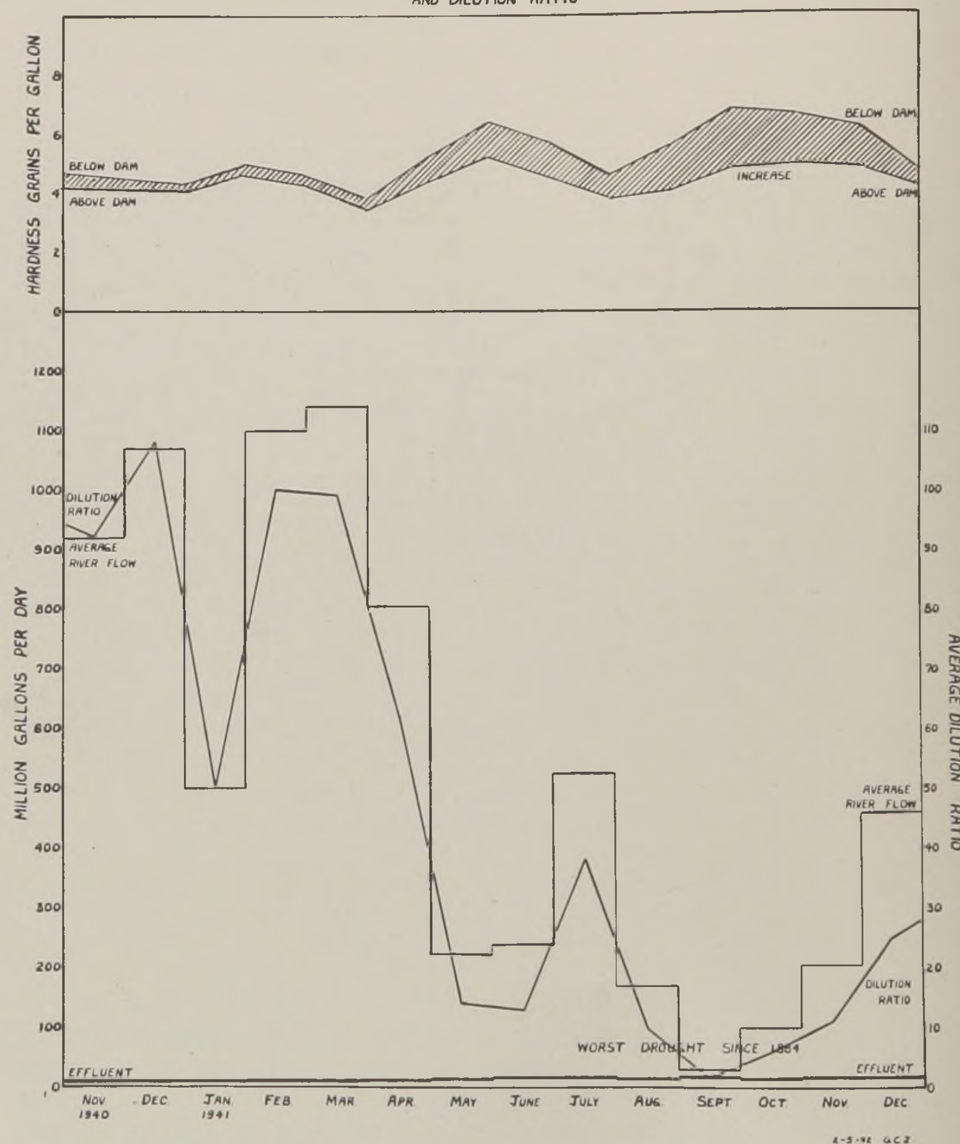
The crude slurry is pumped a mile through 6 inch steel pipe to the effluent treatment plant. The amount required for daily use is delivered directly to a slurry mixer and the excess to a storage basin where it may be accumulated and hydraulically mined from time to time



for use whenever there are interruptions to deliveries. This insures an ample supply at all times so that there will be no interruption in neutralization of the effluent. The slurry is de-gritted by a classifier, thickened to a convenient consistency, about 20 per cent calcium carbonate, and sent to the neutralizer where the quantity applied is controlled automatically by a pneumatically operated valve actuated by a glass-calomel electrode pH control machine. The control valve consists of a large gum-rubber tube slipped through the gate of a diaphragm valve. The gate, in opening and closing, opens or pinches the tube to produce the desired flow, the excess being bypassed back to the thickener. The gum-rubber tube, being smooth, does not allow particles of slurry to build up and close the opening eventually, as was the case when a gate was used alone. A very slight precipitation occurs during this neutralization to pH 4.0 + which destroys the mineral acidity. Some 20 tons of calcium

INCREASE IN HARDNESS, VOLUME OF RIVER FLOW AND DILUTION RATIO

CHART NO II



carbonate, on a dry basis, are used each day to neutralize about 20 million gallons of effluent. In spite of this quantity, the hardness of the river water is raised only a few tenths of a grain per gallon. Chart I shows the quantities of calcium carbonate required to neutralize to various pH values. Chart II shows the increase in hardness, as well as the river flows for the year.

From the neutralizer, the effluent now runs through a flume 1,000 ft. long with nine gates emptying at equal intervals across the south side of the settling lagoon.

Clarification and Settling

This lagoon holds 60 million gallons and has an area of 23 acres. Any inequalities in compositing are smoothed out here, and the effluent becomes a homogeneous liquid of uniform, tea color, thoroughly clarified by the time it empties through four gates into another flume 1,000 ft. along the north side; whence it goes through a mile long canal with several hydraulic stairs to the diffusion dam in the river.

Because of its large surface, considerable aeration takes place in the lagoon, especially in windy weather. Some bleaching takes place because of prolonged exposure to the sun. The dissolved oxygen content usually rises from about zero to 3 p.p.m. in the summer and 7 p.p.m. in the winter time.

Aeration

Aeration is effected by means of the hydraulic stairs and the turbulence of the effluent in the canal leading to the river. Due to the inertness of much of the oxygen-consuming power of the final treated effluent, the effluent always contains a fair percentage of dissolved oxygen when the temperature is 75° F. or lower. This percentage of saturation enables us, most of the time, to discharge the effluent into the river without appreciably lowering the dissolved oxygen content of the latter.

Diffusion into the River

The diffusion dam consists of a 36 inch tile sewer encased in a concrete dam. A center portion, 123 ft. long, has submerged ports which discharge the treated effluent into the river downstream in such a manner as to cause rapid diffusion with the river water, and considerable aeration. The lower the flow in the river, the greater the aeration. This aeration helps to increase the dissolved oxygen content of the river.

Oxygen Consumers

The oxygen-consuming power of an effluent of a chemical type such as ours differs from the oxygen demand of sanitary sewage in that our effluent is sterile and only slowly reactive to dissolved oxygen, whereas the oxygen consumption of sanitary sewage is accomplished by bacteria and is relatively much more rapid. Although our final treated effluent may show what seems to be a high oxygen-consuming power as measured by a hot, strong permanganate test, its activity is very sluggish when blended with river water. On the other hand, a sanitary sewage having an oxygen demand as measured by the same test would be so avid for oxygen, that it would seriously deplete the dissolved oxygen of the river. This inertness of our effluent is reflected by the fact that a

5-day B.O.D. test will show only about 62 per cent of the value of the oxygen-consuming power test.

Some of the more powerful of oxygen-consuming wastes are treated at the source to remove or destroy their oxygen-consuming powers. Thus, effluents containing sulfides and sulfhydrates may be oxidized to thiosulfates and sulfites and then decomposed with waste sulfuric acid to sulfates which have practically no oxygen-consuming power.

Primary effluents, which are treated at the source, are also so treated because of great coloring power, high oxygen-consuming power, or foam-producing properties. A separate chapter has been written on the subject of foams.

As an example of how a brine with both high color and high oxygen-consuming power is treated, the case of the sulfur color brines is presented:

1. The composited brines, collected for the purpose, are aerated for several hours until, by test, all H_2S or sulfides have been oxidized to thiosulfates. These brines are approximately neutral. Sulfur is precipitated.

2. Waste sulfuric acid (about 16 per cent H_2SO_4) is added to lower the pH to about 2.0, and heat in the form of low pressure steam is injected to bring the temperature to 97° C. The sulfuric acid replaces SO_2 which is driven off and absorbed. A considerable amount of sulfur is precipitated and recovered, and the brines are almost completely decolorized. The reduction in oxygen-consuming power, according to permanganate test, is as follows:

Before aeration	126,800 p.p.m.
After aeration	101,200 p.p.m.
After acidification and boiling	2,240 p.p.m.

The resulting liquor is separated from the sulfur through a filter box and runs to the sewer, where it is diluted with much cooling water.

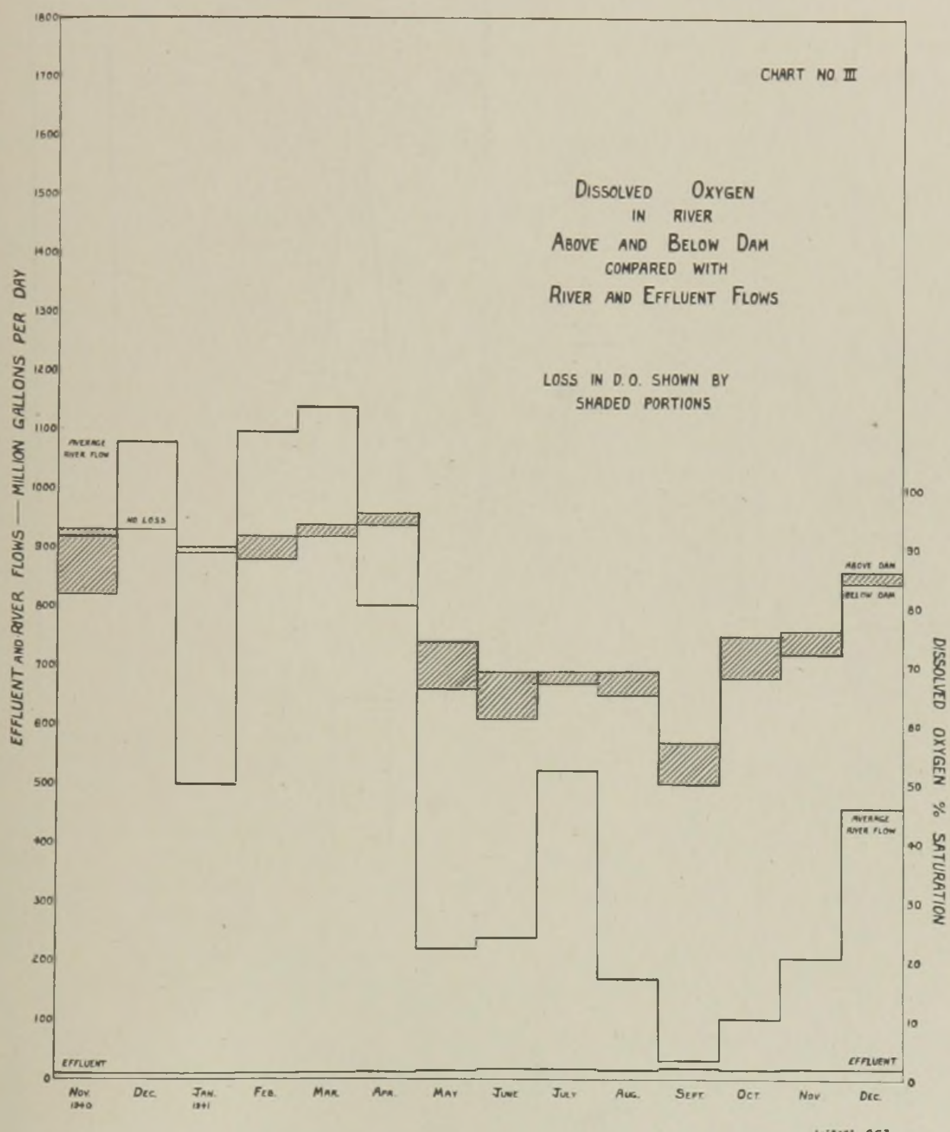
There are other methods for destroying the oxygen-consuming powers of other brines. Those containing oxalic acid may be neutralized and decolored with the same calcium carbonate slurry used for neutralizing at the effluent treatment plant. The scheme for sulfite removal has been sketched briefly. Many other means for destroying undesirable materials are under investigation and we hope for continual improvement.

Effect of Effluent on the River

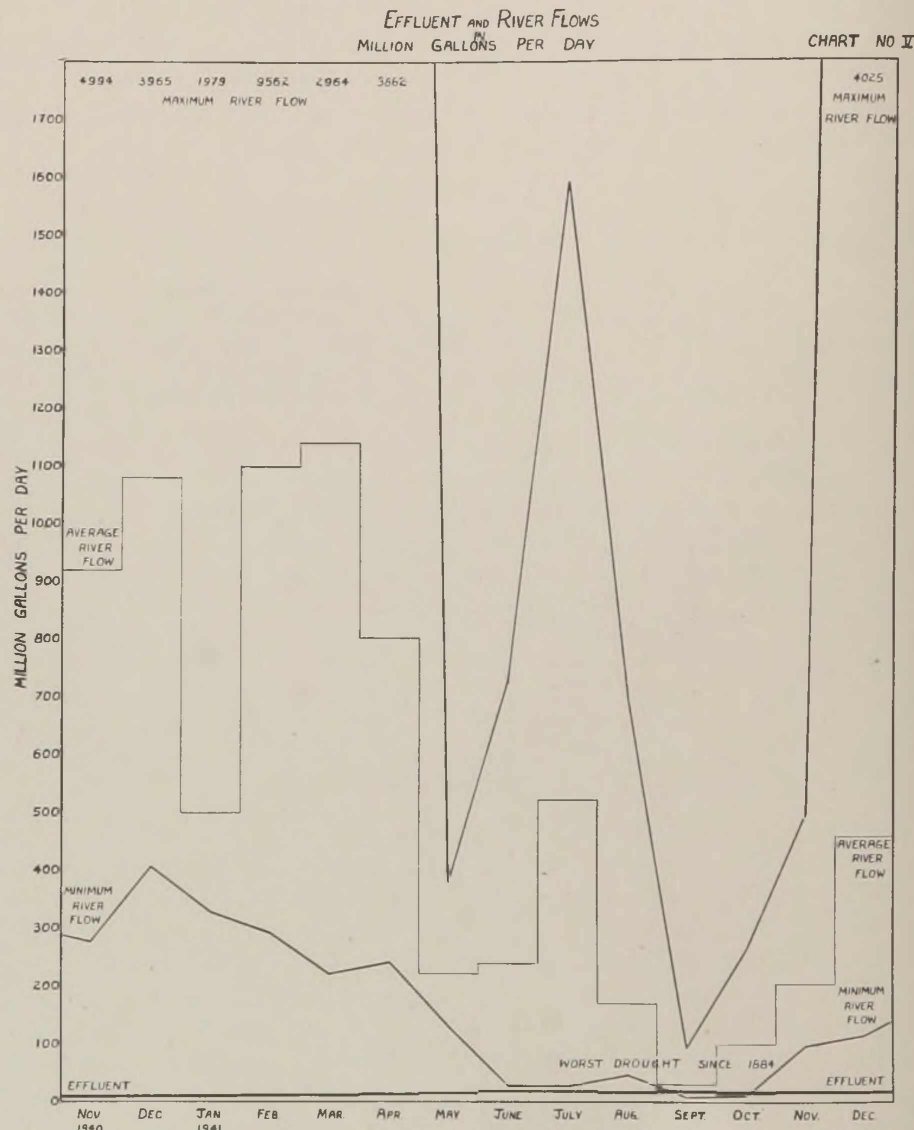
One of the requirements set up by the State Department of Health was that we should not lower the dissolved oxygen of the river below 50 per cent of saturation at a point 1,000 ft. below the point of discharge. It will be noted from Table I and Chart III that during normal flow of the river we lowered the D.O. of the river but slightly through the introduction of our effluent. At times there was no re-

TABLE I.—*Dissolved Oxygen Content of River Water (Monthly Averages—Per Cent Saturation)*

Months	Nov. '40	Dec. '40	Jan. '41	Feb. '41	March '41	April '41	May '41	June '41	July '41	Aug. '41	Sept. '41	Oct. '41	Nov. '41	Dec. '41
River above dam	93	93	90	92	94	96	74	69	69	69	57	75	76	86
River 1,000 ft. below dam	82	93	89	88	92	94	66	61	67	65	50	68	72	84



duction and once in a while we actually added for short periods to the D.O. by aeration over and through our diffusion dam. However, during the almost unprecedented drought of last summer and fall, the river came to us with a very poor percentage of oxygen saturation, possibly due to the exposure of old sanitary sewage sludge beds above us, and we had little to work on. At that, we averaged a bare 50 per cent of saturation in September, our worst month, while the river above us averaged only 57 per cent.

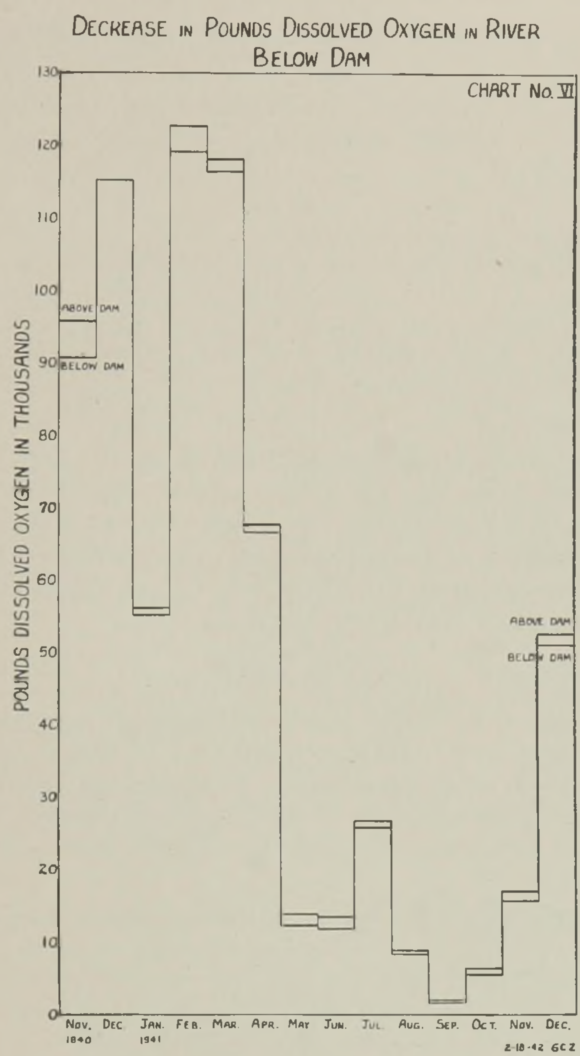


EFFLUENT TO RIVER RATIO 1 TO —

	Nov 1940	Dec	Jan 1941	Feb	Mar.	Apr	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
Average	92	108	50	100	99	62	14	13	38	10	1.7	6	11	25
Maximum	502	398	199	868	268	297	24	39	84	42	5	15	31	195
Minimum	28	41	33	21	19	18	8	1.5	1.5	2.6	0.4	0.6	5.0	5.9

The river flow has varied enormously. Inspection of Chart V reveals that during September and October 1941, there was at times less water in the river than our volume of effluent, after we had taken the water necessary for manufacturing from the river, and before we had discharged our effluent into it. Thus the minimum figures shown on the chart represent the amount of river water available for dilution. Compare this with the peak of over nine billion gallons per day in February, 1940.

So also, has varied the pounds of dissolved oxygen in the river (see Chart VI). It will be observed that this graph follows the general



river flow average. The loss in pounds of dissolved oxygen below the dam as compared with that above the dam decreases partly as the river flow decreases but is tempered favorably by the increased aeration efficiency of the diffusion dam as the river level is lowered. Were it not for the latter, the loss of dissolved oxygen would have been appreciably greater, and we would have been unable to meet, as we did, the State Department of Health's minimum requirement for dissolved oxygen below the dam during the month of September, 1941, when the river flow was at its ebb. This chart is made up of the river flow above the dam before we withdrew our manufacturing water and below the dam after the discharge of the effluent. The volumes above and below the dam are, therefore, equal, and the comparison is absolute.

Control of pH in Effluent

Before compositing, the effluents vary in pH from 1.0 to 8.0. The composited waste is normally acid, varying from pH 2.1 to 2.5. This is neutralized to the end point of the erythrosine indicator, or pH 4.0 +, at which point the mineral acidity is destroyed. Table II shows how this is controlled.

Table II

Months	Nov. '40	Dec. '40	Jan. '41	Feb. '41	March '41	April '41	May '41	June '41	July '41	Aug. '41	Sept. '41	Oct. '41	Nov. '41	Dec. '41
Composited...	2.4	2.3	2.1	2.2	2.2	2.3	2.35	2.5	2.5	2.45	2.5	2.5	2.3	2.3
Neutralized...	4.0	4.2	4.0	4.05	4.2	4.25	4.15	4.6	4.5	5.5	5.2	5.8	5.4	4.5
Final effluent .	4.0	4.25	4.0	4.0	4.1	4.3	4.1	4.6	4.5	6.0	5.9	6.1	5.5	4.2

During the summer and fall of 1941, when the water in the river was so low that there was far from sufficient dilution of the effluent, foams were produced on the river at times. One of the means employed to prevent formation of these foams was raising the pH of neutralization to 6.0. This accounts for the high averages shown in the table for the months August to November, inclusive.

pH of River Water

The pH of the river water is affected more or less according to the dilution of effluent in it. During the period of this study, the volume of effluent has risen from 10 million to 20 million gallons per day. The river has varied from extremes of flood to low water, but at no time has its pH dropped to an unreasonably low figure, as evidenced by Table III.

Table III.—*pH of River Water (Monthly Averages in P.P.M.)*

Months	Nov. '40	Dec. '40	Jan. '41	Feb. '41	March '41	April '41	May '41	June '41	July '41	Aug. '41	Sept. '41	Oct. '41	Nov. '41	Dec. '41
River above dam........	7.3	7.2	7.3	7.2	7.2	7.5	7.5	7.2	7.5	7.4	8.0	7.5	7.8	8.2
River 1,000 ft. below dam...	7.0	7.0	7.0	7.0	7.0	6.9	6.7	6.7	7.2	7.1	6.9	7.1	6.8	7.8

Dissolved Oxygen Content

Temperature has an important effect upon the dissolved oxygen content of the treated effluent as well as in the river. At low temperatures, a fair amount of oxygen is absorbed, although the raw effluent shows only a trace. As the temperature of the effluent approaches 90° F. as it has this summer, the oxygen-consuming power becomes active enough to consume oxygen at about the rate oxygen is absorbed. However, upon cooling in the river water, this activity is decreased so that the river is not affected adversely. Table IV gives the averages.

TABLE IV.—*Dissolved Oxygen in Treated Effluent (Monthly Averages)*

Months	Nov. '40	Dec. '40	Jan. '41	Feb. '41	March '41	April '41	May '41	June '41	July '41	Aug. '41	Sept. '41	Oct. '41	Nov. '41	Dec. '41
P.p.m.	4.2	5.2	7.9	7.4	6.4	4.5	3.5	3.2	3.0	1.7	1.9	4.0	3.6	4.5
Per cent of saturation	37	40	54	50	50	43	36	37	37	22	23	40	32	38

TABLE V.—*Dissolved Oxygen Content of Dilutions—P.P.M.*

No. 1—*1 Effluent in 5 River Water*
Blank = 8.05
Saturation = 9.35 @ 66° F.

	Contact with Air	Sealed from Air
15 minutes	5.75	5.4
1 hour	5.2	4.7
3 hours	6.73	4.5
5½ days	8.05	0

No. 2—*1 Effluent in 10 River Water*
Blank = 8.4
Saturation = 9.4 @ 65° F.

	Contact with Air	Sealed from Air
15 minutes	8.15	—
6 hours	7.9	7.6
5 days	8.7	2.0
8 days	8.8	0.7

No. 3—*1 Effluent in 20 River Water*
Blank = 7.5
Saturation = 9.4 @ 65° F.

	Contact with Air	Sealed from Air
15 minutes	6.6	6.6
2 hours	7.0	6.9
4 hours	7.15	6.7
1 day	8.2	6.1
3 days	8.0	3.4

A dilution of 1:5, effluent to river water, was first established for such comparisons of dissolved oxygen, oxygen-consuming power, and especially color, since 1:5 was the anticipated lowest dilution expected in the river. Actually, the dilution has gone considerably lower during the extremely dry summer and fall. At 1:5, the effluent may sometimes impart a faint amber tinge to the river water, but at 1:10 or 1:20 all suggestion of color is lost.

In the process of compositing in the compositing basin and settling in the settling lagoon, the effluent is exposed to light and air, both of which play a part in bleaching it to the uniform tea color. Some reduction in oxygen-consuming power also takes place as shown in Table VI.

TABLE VI.—*Theoretical Chemical Oxygen-Consuming Power of Effluent (Monthly Averages in P.P.M.)*

Months	Nov. '40	Dec. '40	Jan. '41	Feb. '41	March '41	April '41	May '41	June '41	July '41	Aug. '41	Sept. '41	Oct. '41	Nov. '41	Dec. '41
Composited....	414	401	433	378	284	263	293	306	272	259	285	339	344	392
Neutralized....	410	401	421	376	279	259	288	300	266	256	278	325	336	380
Final effluent ..	391	399	401	371	267	249	270	294	253	245	268	283	325	367

The oxygen-consuming power of the treated effluent is influenced not at all by artificial aeration. Blowing it for periods of as long as a week does not make any reduction in oxygen-consuming power. The effects of the effluent on the river are illustrated in Table VII, which covers periods of highest and lowest dilutions.

TABLE VII.—*Oxygen-Consuming Power of River Water (Monthly Averages in P.P.M.)*

Months	Nov. '40	Dec. '40	Jan. '41	Feb. '41	March '41	April '41	May '41	June '41	July '41	Aug. '41	Sept. '41	Oct. '41	Nov. '41	Dec. '41
River above dam.......	4.3	4.0	4.5	4.7	9.4	7.8	7.6	6.7	6.5	7.1	6.9	4.6	7.3	5.6
River 1,000 ft. below dam .	10.3	11.1	10.6	10.8	10.5	10.2	23.1	20.7	14.2	30.9	49.3	23.2	33.9	36.1

Several ten-day series of treated effluent samples have been run by the Department of Health for pH, chemical oxygen-consuming power and biochemical oxygen demand. The data in Table VIII are typical, although during this period the oxygen-consuming power was lower than the average.

Here, again, the relative inertness of the oxygen-consuming materials in the treated effluent is shown. The 5-day B.O.D. lags behind the

TABLE VIII.—*5-Day B.O.D. vs. Theoretical Chemical Oxygen-Consuming Power of Treated Effluent (in P.P.M.)*

No.	pH	B.O.D.	Oxygen-Consuming Power	Ratio B.O.D. to Ox. Cons. Power, Per Cent
1	4.38	149	208	72
2	4.37	147	210	70
3	4.28	136	202	67
4	4.32	141	200	71
5	4.32	114	200	57
6	4.30	125	204	61
7	4.42	95	198	48
8	4.35	105	198	53
9	4.30	127	197	64
10	4.35	124	199	62
Avg.	4.34	125	201	62

oxygen-consuming power in the proportion of about 62 per cent. This ratio holds true in other series of samples.

Our expectations that there would be no *bact. coli* in the treated effluent when neutralized to 4.0 pH have been realized. The *bact. coli* and the other members of its group, including typhoid, are completely destroyed by the acid liquors in the compositing basin, before reaching the neutralizing area, and any that might escape into the settling lagoon, die there in the liquor neutralized to pH 4.0.

Hardness of River Water

In neutralizing the effluent with calcium carbonate, calcium sulfate is formed, because the principal acidity of the untreated effluent is caused by sulfuric acid. Since calcium sulfate has an appreciable solubility it is not precipitated, but goes to the river dissolved in the treated effluent. This has the effect of increasing the hardness of the river water, but only slightly so, as will be seen from Chart II. Hardness is relatively unimportant, because the Raritan River is not used for potable or domestic water at or below the point where our effluent is discharged into the river. The river water varies in hardness between 3.0 and 6.0 grains per gallon according to the season, rainfall, etc. Up to a few years ago, it ran 5.0 to 9.0 g.p.g. because of the discharge of calcium carbonate wastes into it above our plant. Should the river water below our point of effluent discharge be used for manufacturing, its quality would not be impaired by the very slight rise in hardness. The hardness of the river at its low of 3.0 g.p.g. is increased only fractionally by the $CaSO_4$ in the effluent, since at seasons when the hardness is so low there is a relatively large volume of river water for dilution. As the river water approaches 6.0 g.p.g. hardness, its usual maximum, the flow is low and the increase in hardness may run to 2.0 g.p.g., or slightly more. Therefore, even under the latter condition, the river water containing effluent may be used just as safely for boiler feed water, cooling water, and certain manufacturing processes, as it would be without the addition of our effluent. Chart II shows the relationship between the ratio of dilution of effluent with river and the increase in hardness. The degree of increase is coincident with shortage of water in the river.

Foams

Although it has been our aim to keep the river's surface as clear as possible, early this summer, when the effluent dilution in the river became unusually and unexpectedly low, some foam began to appear at the diffusion dam and sometimes it traveled down the river for quite a distance before disintegrating. The wind would pick it up and concentrate it on a lee shore and magnify its unsatisfactory appearance. The origin of the foams was traced in part to small quantities of emulsified oils which had escaped treatment.

Raising the pH of neutralization to 5, or even 5.5 to 6.0, has been tried over various lengths of time from one day to one week, with the result that this higher pH seems to be quite effective in preventing the formation of any foam at the diffusion dam outlets and, consequently, on the river. The violent agitation at the dam and also at the various hydraulic steps in the canal between the outlet of the settling lagoon and the intake to the dam was designed to provide as much aeration as possible, in the hope of having as much dissolved oxygen in the treated effluent as possible, before it entered the river. This agitation seems to be productive of foam at certain times. In the canal, this foam is skimmed off, but at the dam in the river this is not feasible. For this reason, the higher neutralization was tried and has been found very effective whenever dilution by the river runs low. While it has not yet been definitely established, we think that when the river is so low that the dilution ratio falls below 1 to 10, the pH should be raised to about 5.0 to 6.0. This higher neutralization, however, while very effective in preventing the formation of foam, has certain disadvantages. The clarity of the settled effluent is impaired and the 60 million gallon settling lagoon no longer is able to deliver a bright effluent and it enters the river with a slight turbidity, which is undesirable. Also, we have found at times, on samples examined at the State Department of Health in Trenton, a few *bact. coli* which had escaped the destructive action of the acid in the compositing basin survived the settling lagoon when the liquor was neutralized above pH 4.0. For these reasons, it appears that the longer time under pH 4.0 in the settling lagoon is necessary to complete the destruction of the *bact. coli.* It is our intention to raise the pH above 4.0 only during such low water conditions in the river that there is danger of foam production. Also, it is the wish of the Department of Health that we destroy the *bact. coli* in preference to eliminating foam from the river.

Plans were laid at once to break these emulsions at their sources. In the meanwhile, it was found that foam-breakers, such as Turkey Red Oil, were somewhat effective at times in eliminating the foam when used in dilutions of 1:60,000 of effluent. At 1:10 effluent to river dilution, this meant 1:600,000 in the river, an amount so small that it did not affect the B.O.D. of the river water appreciably.

Identification of Dyestuffs in Foams

Since some dyestuffs have the property of coloring foams which may be formed on the treatment basins or on the river, identifications of the most troublesome of these have been made by means of visual spectrophotometric analysis. Knowing which dyestuffs are responsible for coloring the foams, the discharge of their mother liquors may be controlled or the colors destroyed at the sources.

By means of chromatographic separations, many of the dyestuffs were obtained in a fairly pure state in alcohol solution. The identifications were made with the visual spectrophotometer. It was not possible to identify all of the dyestuffs found, or even a fair percentage of them, possibly because many of the colors were alterations of the original dyestuffs, or even new ones produced through the intricate reactions which occur during compositing. The identification of methyl violet, a dyestuff of intense color, is illustrated in Chart IV.

CA. NO. 13

CHROMATOGRAPHIC ADSORPTION

CHART NO. IV

Title Dried Effluent and River Foams

S. L. Report No. 4878-4879

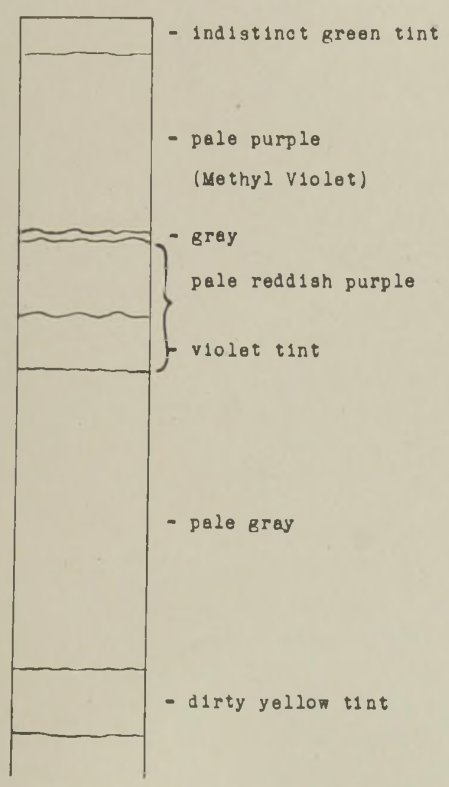
Sample: Dried Effluent Foam

Preparation of Sample: 15 mg dissolved in 10 ml chloroform at boil heat and then filtered.

Adsorbent: E. & A. Talc. Grams per cm: 2.5

Developer: Alcohol

Remarks: Very sharp, vivid, narrow bands from chloroform but developed very well with alcohol.



The chromatographs were prepared in the usual manner. Chloroform, alcohol, tetrachlorethane, and acetone were found to be the most suitable solvents since they extracted most color from the foams.

The vari-colored fractions in each chromatograph were separated mechanically and each fraction extracted with a suitable solvent. Not all of the colored talc fractions lent themselves to easy extraction, so it was not possible to analyze them all. Enough was learned from this work, however, to confirm the results of observation and other means of identification.

Excesses of some other dyestuffs may be identified visually by simply making an extraction by shaking some of the effluent in a bottle with a solvent such as chloroform. Malachite green is identified easily in this manner because the extract shows green by reflected light and its complement, red, by transmitted light. Another dyestuff will show, upon evaporation of the extract, a mass color having the color complement of the dyestuff's undertone.

Conclusion

The foregoing tells briefly of our experiences with this new plant. We had little precedent of any kind to guide us. Now that we have the wastes from 725 different products, we are able to composite them with far better results than might have been possible five or ten years ago when our products were not so numerous. While our effluent treatment is somewhat unique, and the methods used may apply only to our own diversified manufacture, it is our hope that what we have learned will be of some help to others.

CHEMICAL PRECIPITATION OF KIER LIQUOR WASTE ON A PILOT PLANT SCALE AND STUDIES ON THE USE OF RETURN SLUDGE *

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Larger quantities of kier liquor than any other single waste are discharged from cotton mills (1). In spite of the many methods suggested for its disposal, kier liquor remains one of the most difficult wastes to treat (2, 3). It may be treated successfully in combination with domestic sewage under certain conditions. These conditions require that the volume be small, that some type of equalization be provided to distribute the kier liquor in proportion to the flow of sewage and, in some cases, that neutralization of the kier liquor be employed. Whenever the volume of kier waste is large in proportion to the volume of the sewage, separate preliminary treatment or disposal is necessary. A laboratory study (4) was undertaken previously to determine the best methods for the chemical precipitation of this waste. The practicability of any treatment method depends upon the successful application of results obtained by laboratory experimentation. Consequently, this study on a pilot plant scale was undertaken as a means of correlating laboratory data to plant operation. In this study both the continuous and batch methods of operation have been investigated. Also, in connection with the batch method of operation, a study has been made on the use of return sludge as an aid to chemical treatment of kier waste. A previous article (5) is cited which deals with a similar problem of chemical precipitation of concentrated sulfur dye wastes on a pilot plant scale.

Source of Kier Waste

Kier liquor is obtained from the process of kiering cotton in preparation of the cloth for dyeing or bleaching operations that may follow. Treatment of the cloth consists of boiling the material with or without pressure for several hours in a highly alkaline solution containing caustic soda, soda ash, and often accessory chemicals. This process removes the natural fats, waxes, greases, and other substances such as fragments of the boll from the cloth. The waste liquor, which usually has a total alkalinity of approximately one per cent, contains the chemicals of the caustic boil, impurities from the cotton, and materials produced by the partial breakdown of the fiber.

The waste used in this study was obtained from boil-out vats, in which the cloth is treated without pressure, and which require a stronger

* This research project was carried out under joint sponsorship of the University of North Carolina and The Textile Foundation.

bath per pound of goods than that used in the pressure kiers. In order to obtain a waste comparable to the kier liquor previously used for the laboratory experiments, the liquor as discharged from the boil-out vats was diluted by the inclusion of some wash water. During the period of study, the analysis of the waste including the water averaged approximately as follows:

Color: Dark brown, 2750 with platinum-cobalt standards
Total Alkalinity: 14,000 p.p.m. as $CaCO_3$
Phen. Alkalinity: 11,000 p.p.m. as $CaCO_3$
B.O.D.: 2,700 p.p.m. (5-day, 20° C.)

FIG. 1.—Pilot plant used for chemical precipitation of textile wastes on a continuous basis.

APPARATUS

A detailed description of the pilot plant used for precipitation on a continuous basis has already been given in a previous article (5). A picture of the plant is shown in Fig. 1. The plant consisted essentially of the following apparatus:

A 4,000-gal. holding tank used to collect and composite the waste.
A constant-head siphon to permit a regulated discharge of waste.
A floating siphon discharging device to allow regulated chemical dosages.
A mixing chamber containing a mechanical stirrer, with air agitation also available.
A 12-gal. flocculator with a spiro-vortex mixer.
A settling tank having a theoretical capacity of 78 gals. plus 17 gal. sludge capacity within the hopper bottom.
Sand beds for sludge dewatering.

Studies made on a batch basis were carried out in ordinary eleven-gallon metal tanks. Mixing was accomplished by air agitation.

Procedure

The waste kier liquor was pumped from the mill into the holding tank. The material was collected over a period of several days, after which it was thoroughly mixed and stored for use.

Continuous Operation.—The waste was pumped from the holding tank to the constant head siphon box, from which it was discharged at a fixed rate into the mixing chamber. Coagulants in convenient concentrations were dosed into the mixing chamber at rates determined by means of jar tests on a sample of the waste. The mixture of waste and coagulant was then flocculated. In some instances the coagulant dosage was further adjusted according to pH determinations made on samples callected at intervals from the mixing tank and flocculator. Following flocculation, the mixture was settled, the effluent from the settling tank being discharged and the sludge dewatered on the sand drying beds.

Batch Operation.—Laboratory jar tests were made on small samples to determine the required chemical dosage. A 10-gal. volume of the waste was then treated with the proper amount of coagulant and thoroughly mixed for several minutes by air agitation. The pH of the mixture was determined, and, if necessary, adjusted to the optimum range (4) by the addition of more coagulant or adjusting reagent. The mixture was then allowed to settle overnight—a settling period of 16 to 20 hours. At this time, the amount of sludge produced was recorded, and the supernatant liquor was decanted and replaced with fresh kier liquor. The sludge and fresh kier liquor was thoroughly mixed by air. In certain cases, the pH of the sludge-kier mixture was adjusted with concentrated sulfuric acid to the optimum pH range of the coagulant. In no case was more coagulant added. Again the batch was allowed to settle overnight.

Tests.—The following tests were made on the materials indicated:

Kier liquor: pH, alkalinity, B.O.D., color.
Flocculator effluent: pH.
Sludge: pH, suspended solids, total solids, dewatering time.
Effluent: pH, color, B.O.D.

All analyses were performed according to *Standard Methods of Water and Sewage Analysis.* Determinations of pH were made with a Coleman glass electrode electrometer. Sludge dewatering was determined on 100 ml. samples by means of an 11 cm. Buechner funnel, using No. 202 Reeve-Angel rapid filtering paper, and maintained under a suction of 22 inches of mercury.

Results

Continuous Operation.—Previous laboratory results (4) have indicated that alum and copperas are the most economical coagulants for clarification of waste kier liquor. They have also shown that better results are usually obtained by using the coagulants in conjunction with lime. Lime furnishes additional alkalinity, so that more floc can be formed at the proper pH zone, and consequently greater clarification can be obtained.

TABLE I.—*Chemical Treatment of Kier Liquor Waste on a Continuous Basis*

Coagulant		Raw Waste		Coagulated Waste			
Name	Amount,* P.P.M.	B.O.D.	Color	Rate of Flow, G.P.M.	Detention Time (Min.) Flocculator	Detention Time (Min.) Settling	pH
$FeSO_4.7H_2O$	50,000	2,700	2,750	0.585	20.5	133	8.2
$FeSO_4.7H_2O$ and $Ca(OH)_2$	44,600 / 1,000	2,700	2,750	0.594	20.1	131	9.1
$Al_2(SO_4)_3.9H_2O$	29,500	2,700	2,750	0.621	19.3	126	5.6

Coagulant	Effluent					Sludge			
	pH	Color		B.O.D.		pH	Suspended Solids		Dewatering Time for 100 ml. (Bue. Funnel)
		Residual	Per Cent Removal	Residual	Per Cent Removal		P.P.M.	Per Cent Volatile	
$FeSO_4.7H_2O$	5.6	2,500	9.1	—	—	—	—	—	—
$FeSO_4.7H_2O$ and $Ca(OH)_2$	8.7	400	85.5	400	85.2	9.1	—	—	60 sec.
$Al_2(SO_4)_3.9H_2O$	5.6	400	85.5	400	85.2	5.4	15,700	36.3	65 sec.

* Sp. gr. of waste assumed as 1.

In this study, runs were made on a continuous basis using copperas, copperas in conjunction with lime, and filter alum as the coagulants. The results obtained are presented in Table I. As the initial run in the table shows, copperas alone used as the coagulant produced an effluent having a pH of 5.6 and a color of 2500. Since iron is quite soluble at a pH of 5.6, it appeared that the high color of the effluent was due in most part to soluble iron. That such was the case was confirmed by treating a sample of the effluent with lime and thus raising its pH. Upon the addition of lime, an iron-hydroxide floc was formed and the color was reduced to 100. This showed the necessity of maintaining the pH closer to the optimum range. Consequently, a second run was made using copperas together with lime. The effluent of this second run had a pH of 8.7 and a residual color of only 400. The color of 400 compared favorably to the color of 300 which was obtained in the laboratory.

A third run was made on a continuous basis using alum as the coagulant (Table I). The effluent from this run had a pH of 5.6 and a color of 400, which was not so good as the color of 100 obtained in the laboratory. This difference appears to be due to the difficulty of obtaining exact control of chemical dosage under continuous flow operation of the pilot plant.

It was not practicable to operate on a continuous basis with a normal sedimentation period because of the sludge bulking which occurred in the settling tank. The large amount of suspended solids in the coagulated liquor shows that a great deal of settling is not to be expected. In the case of alum precipitation, the amount of suspended solids in the coagulated waste was 15,700 p.p.m., and the sludge index was 64 before settling occurred (S.I. equals volume in ml. occupied by 1 gram). This indicates that the sludge is quite compact without any settling, since with activated sludge an index of 100 or less indicates a satisfactorily settling material (5). It seems advisable when treating kier liquor to eliminate the settling tank and dewater the entire coagulated waste. Dewatering is rapid and no difficulty should arise in disposing of the stable dried sludge.

Batch Operation.—Several factors indicated the desirability of conducting studies on a batch basis, the first of which was the inability with continuous operation of a small pilot plant to control adequately the chemical dosages required to treat such a strong waste as kier liquor. Another factor favoring batch operation was that advantage could be taken of the approximately fifty per cent settling of sludge which occurred during overnight detention. Still further, the large sludge volumes produced in the precipitation of this waste indicated the desirability of studies on the possible re-use of sludge as an aid to coagulation.

The results of the batch operation studies are shown in Tables IIa and IIb. Table IIa shows the results obtained by precipitating kier waste with copperas, calcium chloride, filter alum, and alum in conjunction with lime. Although calcium chloride gave only fair clarification, the other coagulants produced good effluents. As can be seen in the table, control was facilitated by batch operation, since the pH in each case was maintained close to the optimum range. In the runs with copperas and alum a saving in the amount of coagulant over that required when operating on a continuous basis was noted.

Table IIb shows the results obtained by re-using the various sludges. In each case, the sludge settled about 50 per cent overnight, permitting the discharge of about 4 gal. of the supernatant liquor from the 10-gal.

batch. Five gallons of fresh kier liquor was added; the mixture was flocculated without the addition of further chemicals, and allowed to settle. Copperas sludge and calcium chloride sludge clarified the added waste; however, the clarification was considerably less than that obtained originally by the coagulants. The results obtained with alum

TABLE IIa.—*Treatment of Kier Liquor Waste on a Batch Basis with Coagulants*

Coagulant		Volume of Waste, Gals.	% Sludge After Overnight Settling	First Supernatant					
Name	Amount, P.P.M.			pH	Color		B.O.D.		Volume Decanted, Gals.
					Residual	Per Cent Removal	Residual	Per Cent Removal	
$FeSO_4 \cdot 7H_2O$	36,400	10	50	8.78	400	85	640	75	4
$CaCl_2$	17,700	10	50	11.4	800	71	780	69	4
$Al_2(SO_4)_3 \cdot 9H_2O$	24,800	10	50	6.48	450	84	340	87	4
$Al_2(SO_4)_3 \cdot 9H_2O$ and $Ca(OH)_2$	27,300 1,160	10	50	6.38	400	86	390	85	4

TABLE IIb.—*Treatment of Kier Liquor Waste on a Batch Basis with Returned Sludge*

Coagulant	Volume of Fresh Kier Added, Gals.	pH of Sludge-Kier Mixture		Second Supernatant					Sludge			
		After Addition of Kier	After Adjustment with Conc. H_2SO_4	pH	Color		B.O.D.		Total Solids		Suspended Solids	
					Residual	Per Cent Removal	Residual	Per Cent Removal	Per Cent	Per Cent Volatile	P.P.M.	Per Cent Volatile
$FeSO_4 \cdot 7H_2O$	5	11.43	—	11.05	1,950	29	2,000	22	4.31	21.0	27,815	20.7
$CaCl_2$	5	11.40	—	11.40	1,450	47	—	—	—	—	—	—
$Al_2(SO_4)_3 \cdot 9H_2O$	5	10.42	6.5	5.65	550	80	780	70	3.88	27.2	21,565	38.1
$Al_2(SO_4)_3 \cdot 9H_2O$ and $Ca(OH)_2$	5	10.40	6.5	7.10	1,950	29	900	65	—	—	—	—

sludge were negligible unless the pH was adjusted to the proper range, but were quite good after adjustment. When alum and lime sludge was re-used and adjusted so that the supernatant liquor had a pH of 7.1, poor results were obtained because of the high pH. This further illustrates the value of strict pH control.

Use of Returned Sludge.—Further studies were conducted on a laboratory scale on the re-use of sludge because it seemed that the clarifying power of returned sludge might be utilized in conjunction with the coagulants. Sludges obtained by precipitating kier liquor with various coagulants were used in different amounts with various dosages of coagulants to treat fresh kier liquor. Some typical results are presented in Table III.

TABLE III.—*Treatment of Kier Liquor Waste with Coagulants and Returned Sludge*

Coagulant		Return Sludge Added, P.P.M. Suspended Solids	Settling Ratio, Sludge Vol. to Supernatant Liquor		pH	Color	
Name	Amount, P.P.M.		1 Hour	24 Hours		Residual	Per Cent Removal
$FeSO_4 \cdot 7H_2O$	36,200	0	20 to 1	2.2 to 1	7.2	450	84
$FeSO_4 \cdot 7H_2O$	36,200	11,100	11 to 1	1.3 to 1	9.3	350	87
$FeSO_4 \cdot 7H_2O$	36,200	5,500	11 to 1	1.2 to 1	8.7	350	87
$FeSO_4 \cdot 7H_2O$	36,200	1,400	10 to 1	1.2 to 1	8.1	450	84
$FeSO_4 \cdot 7H_2O$	33,400	0	8 to 1	1.3 to 1	9.72	600	78
$FeSO_4 \cdot 7H_2O$	33,400	1,700	8 to 1	1.4 to 1	10.2	450	84
$FeSO_4 \cdot 7H_2O$	22,200	1,700	8 to 1	1.0 to 1.4	11.1	550	80
$FeSO_4 \cdot 7H_2O$	13,900	1,700	1.2 to 1	1.0 to 2.2	11.1	900	67
$CaCl_2$	13,900	0		12 to 1	11.1	750	73
$CaCl_2$	13,900	1,300		11 to 1	11.2	750	73
$CaCl_2$	8,300	1,300		14 to 1	11.2	1,400	49
$CaCl_2$	2,800	1,300		1.4 to 1	11.2	3,000	—
$Al_2(SO_4)_3 \cdot 9H_2O$	25,200	0		5 to 1	7.2*	450	84
$Al_2(SO_4)_3 \cdot 9H_2O$	25,200	8,600		5 to 1	6.9*	450	84
$Al_2(SO_4)_3 \cdot 9H_2O$	8,400	4,300		2 to 1	6.8*	650	76
$Al_2(SO_4)_3 \cdot 9H_2O$	8,400	1,100		1.1 to 1	6.7*	600	78

* pH adjusted with H_2SO_4.

In the case of copperas sludge, it appeared that when a sufficient amount of the coagulant was used, returned sludge offered little or no added clarification. As can be seen in the table, when 36,200 p.p.m. of copperas, approximately the optimum amount, were used without any returned sludge a color of 450 was obtained. Although this was not quite so good as the color obtained by using the same amount of copperas and 5,000 or 10,000 p.p.m. returned sludge, the pH in the case of copperas alone was a little low, and, it seems that better color removal would have been obtained had the pH been higher. With amounts of coagulant smaller than the optimum a distinct improvement was obtained by re-use of sludge. This is evident from the added clarification that returned sludge offered when used with all amounts of copperas smaller than 36,000 p.p.m. However, it appears that the clarification obtained by re-using sludge with amounts of copperas smaller than the optimum was not equivalent to that obtained by using an optimum amount of coagulant alone. Rudolfs and Gehm (6), evaluating returned chemical sludge, state that alum and ferric chloride sludges have definite clarifying value, although the effectiveness of returned sludge decreases as the ferric coagulant dosage increases. This is in accordance with the present study. As is evident from the settling ratios given in Table III for the copperas sludge, in general the re-use of sludge improved settling.

Another feature of the returned-sludge problem investigated with copperas sludge was the limit of effectiveness of the returned sludge; that is, the number of times sludge could be re-used without the addition of coagulant. Copperas was added to a 500 ml. sample of kier liquor, and after mixing the coagulated waste was dewatered by means of a

TABLE IV.—*Treatment of Kier Liquor Waste with Continued Re-Use of Sludge*

Run No.	Volume of Waste, Ml.	Waste Treated with		pH	Color	B.O.D.
		$FeSO_4 . 7H_2O$, P.P.M.	Return Sludge			
		Raw	Kier	11.4	2,750	2,700
1	500	36,200	0	9.85	175	660
2	500	0	Dewatered sludge from Run 1	11.32	500	1,360
3	500	0	Dewatered sludge from Run 2	11.40	1,000	1,320
4	500	0	Dewatered sludge from Run 3	11.40	1,600	1,400
5	500	0	Dewatered sludge from Run 4	11.35	2,000	1,560
6	500	0	Dewatered sludge from Run 5	11.40	3,500	—

Buechner funnel. The sludge obtained was then added to another 500 ml. sample of fresh waste, which also was mixed and dewatered. This procedure was repeated several times. The amount of purification obtained after each precipitation is shown in Table IV. It can be seen that the purification decreased with each additional re-use of sludge, but that some purification was obtained even after the fourth re-use.

In the case of calcium chloride, Table III shows that the use of returned sludge together with coagulant proved of no advantage.

Alum sludge re-used with alum required pH adjustment with sulfuric acid (Table III). The returned sludge offered no added clarification when sufficient coagulant was used. When small amounts of alum sludge were used with small dosages of alum and the pH adjusted with acid, good results were obtained; however, the results were not quite equivalent to those obtained by an optimum amount of alum alone.

This study on the re-use of sludge indicates that, although no added clarification is offered by returned sludge when an optimum amount of coagulant is used, the re-use of sludge with amounts of coagulant slightly less than the optimum gives results which are good and almost equivalent to those obtained by sufficient amount of coagulant alone. It seems, then, that it might be possible with the use of returned sludge to achieve a saving in the amount of coagulant required in the precipitation of strong wastes such as kier liquor.

Discussion

In general, the results of pilot plant operation agreed very closely with the results of laboratory studies. A color of 400 was obtained by treating kier liquor with copperas and lime by the pilot plant whereas a color of 300 was obtained in the laboratory. Results obtained with alum on the pilot plant basis were not so good as those obtained in the laboratory. The reason for the discrepancy in results, evidently, is that the reactions in the pilot plant were not controlled sufficiently close to the optimum. When dealing with strong wastes and concentrated solutions, as is necessary when operating on a pilot plant basis, any variation in the rates of flow of either wastes or solutions will cause the process to vary from the range of maximum efficiency. To achieve maximum clarification, strict pH control is necessary.

Settling of the sludge was poor because of the high content of suspended solids. This, also, agreed with laboratory experiments. Sludge handling presented no difficulties, however, since the sludge dewatered rapidly and appeared very stable. Sludges drawn to a depth of 10 in. on sand filters drained and cracked overnight, and in five days appeared satisfactory for removal.

The batch method appears to be more practical for the treatment of strong wastes. Control is more accurate, and hence results are achieved more economically. Also, this method lends itself more readily to the possibility of using return sludge.

The cost for complete chemical treatment of strong wastes is rather high. Several possibilities of decreasing the cost of treatment, which may show promise in some cases, have been indicated.

Re-use of sludge appears as a practical possibility both for decreasing the cost of chemicals and for increasing settling rates. In instances where complete chemical treatment is unnecessary, the use of small amounts of coagulants together with returned sludge seems to offer considerable possibilities. Of course, when considering the savings that may be realized, it is necessary to consider the cost of handling the returned sludge and the corresponding increase in tank size that would be required.

Another possible method of reducing treatment costs is to treat the waste in two stages. For example, copperas was used to treat a batch of kier liquor and produced an effluent with color of 200. The sludge from this treatment was re-used without the addition of coagulant to precipitate another batch of waste and produced a second effluent having a color of 550. This second effluent was then treated with copperas. A color of 225 was obtained from this second chemical precipitation with a saving in the chemical dosage of greater than 25 per cent over that required in the first precipitation. It seems that two-stage treatment offers possibilities, and further investigations may prove it to be economical for the treatment of certain industrial wastes.

The large dosage of chemical necessary for successfully precipitating kier liquor indicates that recovery of the coagulant by digestion of the sludge would also be feasible. Preliminary work (5) has shown that recovery holds promise as a means of reducing the cost of chemical treatment.

Treatment of the effluent from chemically precipitated kier liquor through filters such as sand beds or activated carbon aids considerably in the reduction of color. A sample of waste was precipitated with copperas and a color of 200 was obtained. The sludge from this treatment was re-used without the addition of coagulant to precipitate another batch of waste and an effluent was obtained this time with a color of 700. Both effluents were filtered through 12 in. of activated carbon. With the chemically precipitated effluent a color of 80 was obtained, and with the sludge-precipitated effluent a color of 250 was obtained.

Another possibility for reducing waste treatment costs lies in the modification of mill practice. Unfortunately, it has been the custom in the past for mill executives to consider liquid wastes as materials to be discharged and forgotten. A more enlightened viewpoint is to consider anything produced by a mill as a product of that process. In this light, waste of a dye house is as much a product of the mill as the finished cloth. Just as an effort is made towards increasing the quantity and quality of salable products, so should an effort be made towards decreasing the quantity and quality of the waste. Both factors tend towards increased profit. The re-use of strong chemical solutions to greater exhaustion offers definite possibilities. Upon suggestions by the authors, one mill has re-used a strong caustic boil-out liquor and thereby effected savings in three distinct ways. The amount of caustic used in the mill has been considerably reduced; and waste treatment costs have been lowered by a decrease in the amount of caustic discharged from the mill, and by a reduction in the amount of chemicals required to treat the waste. There appears to be room for improvement in mill processes so that a lowering of waste treatment costs may be realized from the more efficent use of chemicals and the corresponding decrease in waste products.

Summary and Conclusions

Pilot plant studies on the chemical precipitation of kier liquor were carried out in an effort to correlate laboratory results to plant operation, and to determine efficient methods for treating kier liquor waste.

For the most part, results obtained in pilot plant operation agree with results obtained in the laboratory. However, from the standpoint of color removal, laboratory results may be slightly better than pilot plant results because of more accurate control.

Settling of the precipitated sludge is poor because of the high content of suspended solids. Because of this, when treating a strong waste such as kier liquor on a continuous basis, it seems that the more practical way is to eliminate the settling tank and to dewater the entire coagulated waste by filtration. Sludge from chemically precipitated kier liquor appears to be very stable and can be dewatered rapidly either by sand beds or vacuum filters.

The batch method of operation appears to be more practical than continuous operation when treating strong wastes. Control is more accurate, and hence the method is more economical. Also, the batch method lends itself better to the use of return sludge.

Several methods present themselves as possibilities for decreasing treatment costs. Use of returned sludge shows promise as a means of deçreasing chemical costs and of increasing settling rates.

Two-stage treatment might also be a means of reducing treatment costs. It seems that a saving in the chemical dosage may be obtained by first precipitating the waste with returned sludge and them chemically treating the supernatant.

Another saving lies in the recovery of coagulants used to precipitate strong wastes. Preliminary work indicates that recovery holds promise.

Treatment of the effluent from chemically precipitated kier liquor through filters such as sand beds or activated carbon aids color removal.

A final possibility for the reduction of treatment costs is the modification of mill practice so that savings may be realized from the more efficient use of chemicals and the corresponding decrease in waste products.

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THE OPERATOR'S CORNER

Conducted by W. H. WISELY, Executive Secretary*
Federation of Sewage Works Associations
Box 18 · · Urbana, Illinois

WASTE NOTHING!
PLAN REQUIREMENTS!
BANISH HOARDING!

In these times, it behooves us to analyze this matter of priorities in a sane and sensible manner. Surely, the need for careful control of our supplies of raw materials is obvious, when the demands for mechanical and other equipment by modern warfare are so evident on every side. Our government is to be commended for establishing, as one of its first acts in this emergency, an agency to administer the allocation of important materials to purposes of greatest necessity.

The War Production Board, which has absorbed the earlier Office of Production Management, is a huge machine. It was called upon to build itself and produce results simultaneously. It is not difficult to understand why some confusion and uncertainty accompanied the first meshing of gears and it is gratifying to observe the trend toward "stream-lining" of procedures which has become evident in recent weeks.

We of the sewerage and sewage treatment "industry" should be appreciative of the recognition accorded such public services as being essential to military and civilian protection, proven by the high priority ratings which have been granted. Now, could it be possible that we might reciprocate in some fashion to aid our government in its objectives?

Every care and precaution to prevent waste of operation, maintenance and construction supplies is clearly worthwhile. Planning of future requirements well in advance, is common-sense procedure but placement of large advance orders to build up excessive stores inventories actually defeats the purpose of production control, since heavy instantaneous demands upon producers may require unnecessary tightening of restrictions and react against users in serious need. Long range planning should be employed to enable orders to be placed sufficiently early to allow the manufacturer time to fill them—not as basis for hoarding. Wherever a substitute for a "hard to get" material might be satisfactory, give it a chance! Who knows, the substitute may

* Also Engineer-Manager, Urbana and Champaign Sanitary District.

prove superior in service to the product to which we have become addicted by habit!

Even that Spring house-cleaning may be advantageously adapted to the war effort. All scrap metal or abandoned equipment for which there is no real need should be junked for re-use as raw material.

None of us is too small to help. Winning the war will be the reward!

CALIFORNIA OPERATORS' SYMPOSIUM *

PRESIDENT HAROLD F. GRAY, *California Sewage Works Association:* Now, gentlemen, with your kind permission, we will call the Annual Convention to order. This afternoon we are to have a symposium on various operating problems. This is more or less impromptu. Some of you have been primed but it is going to be an open and general discussion.

All right, it is your party. I am going to turn it over to Wayland Jones, who will be the master of ceremonies, interlocuter, or whatever you want to call him. At any rate, he will conduct the meeting from this point.

WAYLAND JONES, *Stockton:* Fellow operators, I am functioning here in place of Chairman Ralph Sotter who was not able to attend. We have sent cards to some of the members, asking them to be prepared to discuss some of the subjects and would like to hear first from those who have received our cards. We will start with Mr. Allen on the topic "Plant Records."

PLANT RECORDS

W. A. ALLEN, *Pasadena:* I don't know that there is a great deal more to be said on the subject of plant records except to stress the fact that they are of considerable value, mainly to check your past experience when you get into trouble. We have found that we can sometimes find the answer when a difficulty develops by checking the records—not always, because conditions are not always the same.

We keep very complete records for that reason. Records have been of particular value to us when we have sludge bulking. We incline to the belief that the best thing to do with bulked sludge is to get rid of it and start over again. We also have a problem of seasonal variation in flows. Uncertainty and guesswork are unnecessary when you can refer to a complete record of the pumping rates at the various flows.

If you are faced with making additions to your plant and you employ a consulting engineer, good records will save a lot of headaches. This alone will often justify the cost and trouble of record keeping.

Good records also give a good basis of comparison or yardstick in effecting economies in plant operation. Comparing month-to-month records for different years will show if something is costing more than it did previously, so we can find out why and correct it.

* From program of Fall Meeting of California Sewage Works Association held at Sacramento, October 12, 1941.

Do any of you have questions? I would be glad to have you ask them.

Jack Kimball, *Santa Ana:* Mr. Allen, after you have all of this information, how do you review it at the end of the year? Do you make out charts, graphs, or anything like that?

Mr. Allen: We make a monthly report of the chemical analyses, flows and other items and at the end of the year these are compiled into our annual report, giving the averages for the year and also the monthly averages.

H. F. Gray, *Berkeley:* Mr. Allen, I notice that you have a very elaborate cost analysis in your annual report but there is no reference to the capital cost, that is, interest on your bonds, and so on. Why do you omit that? Don't you feel that it is a part of the cost?

Mr. Allen: It is definitely a part of the cost, Mr. Gray, but our report is primarily an operation report, and not a financial report. If we included all of that, it would be more or less superfluous from the Board of Manager's standpoint because they get the Comptroller's Report, which contains all of the financial information. We do show the total historical cost, but no breakdown. Fixed charges are certainly a part of the cost of sewage treatment, there is no question about that.

Chairman Jones: At the Stockton South Plant we use a daily and monthly sheet and have made it a practice to devote a regular time to entering the day's readings and averaging the previous day's report. We have a place on the daily report for every kind of reading that is made in the plant with a space for each operator on duty to record his activities. The original goes to the City Hall and a copy stays at the plant. The monthly report is made up from these daily ones.

We also keep a chart, on which is plotted the daily flows, mounted on a piece of plywood and hung up in the office. Our visitors seem to be very much interested in it. Notice how it shows the effect of the cannery flows.

Question: Do you have a heavy flow in the winter rainy season?

Mr. Jones: Yes, but it lasts only for an hour or two after a heavy storm. Our flow is almost entirely sanitary.

Getting back to records, we make up our annual report from the monthly reports, as is done in Pasadena. This system works very well for us.

Some of you might be interested in these two little gadgets which are useful in connection with record keeping. Very few cities will buy an adding machine for the sewage treatment plant, so I bought this little device myself for $2.50. It is very simple and operates satisfactorily. We use this piece of plyboard for mounting the record which is being filled in. It is very convenient and inexpensive.

I consider records as very important. We are planning some improvements in our plant, and my operation records have been used to great advantage during the last few months. It has been gratifying to me to be able to answer the questions which have been asked.

QUESTION: Mr. Jones, do you include operation and maintenance cost data in your monthly report?

MR. JONES: Yes. It has been interesting to us to compare some of our recent reports to observe the decrease in operation cost. We did have an inefficient pump in our plant, and the power cost has dropped off considerably since it has been replaced.

MR. ALLEN: Gentlemen, I would like to make the same offer I made two or three years ago. I would be glad to exchange annual reports with any operator who wants to do this. We don't send them out to everyone, but I would like to trade with some of you, because I might learn something from yours and you may get some help from ours.

MR. JONES: I will be glad to make the same offer as Mr. Allen. I found it very useful to have record forms used in other plants as a guide in making up my own. It is a good idea to be sure that your record form fits your plant before you have a lot of them printed.

MR. ALLEN: My reason for making this offer is that I feel that a free exchange of our records will result in improvement for all of us. I think every plant should have a complete set of records, and that we can get many good ideas from each other.

METHODS USED IN DISPOSING OF RAGS AND SCREENINGS

CHAIRMAN JONES: Our next topic is "Methods Used in Disposing of Rags and Screenings."

T. M. GWIN, *Folsom State Prison:* I am sure that every operator will agree with me that it is necessary to dispose as quickly as possible of rags and screenings, for the reason that they contain much matter which decomposes and causes odor around the plant. We feel that we have solved this problem at Folsom Prison. Our screens are raked manually, the screenings are dewatered in a press, and from there they go to an incinerator. I would say that our screenings are not in the plant longer than an hour at any time.

At one time, screenings disposal was quite a problem with us. When our plant was built, concrete boxes were provided for storing screenings. We tried to use them, but found that we had to use about 200 pounds of chloride of lime per month to control the odor. We still had flies galore, and so we went to the method described previously.

We have a problem at Folsom Prison that most operators do not have. Our inmates order about two thousand sacks of tobacco per month, as well as the other things they buy through the commissary. Of course, we get a lot of those things in our plant. The men are put in their cells at 4 o'clock in the afternoon, and they stay there until 7:30 in the morning, so that all kinds of waste articles go through the toilet. The item that caused us the most trouble in the beginning was this cellophane paper, which made a dam around the screens, and the water couldn't break through it. We designed this cider press to remove the water from the paper and rags so that they could be hauled away. We felt that it cost quite a bit to get trucks for this hauling, so we built this incinerator to burn up the screenings and save money. We use the gas collected at the plant for fuel. I have some drawings of the screenings press (see *This Journal,* **13**, 6, 1252, November, 1941) and the screenings burner (see Gadget Department, this issue), and any of you who want copies are welcome to them.

H. W. Schuck, *Burlingame:* We dispose of our screenings in about the same way. We have a buggy that catches the screenings and lets the water drain back into the pit. Then they are taken out and burned in a gas burner—which is a homemade affair built like a square box of brick with a grate and gas burner in it.

V. W. Thews, *Terminal Island:* We have a hand-raked bar screen, and we usually try to clean it once an hour, or oftener if need be. The bar screen in the central passage has a ¾ in. clearance between the bars, with a by-pass on either side of it, equipped with a screen having about 1½ in. clearance. The screenings are raked from the screen to a draining bridge and allowed to stand there for about an hour. When the operator comes back to rake the screen the last hour, the rags removed at the previous cleaning are dried, so he pushes them down a chute into a wheelbarrow.

At the end of the shift—that is, eight hours, the rags are burned in the incinerator, with sludge gas as fuel. We dispose of the ashes from the incinerator by filling in low spots around the plant.

On the average we get about 3.0 to 3.5 cu. ft. of screenings per million gallons of sewage treated. In hot weather, we found that it was not a good idea to leave the rags exposed, because flies were attracted. Sea gulls were also attracted, because we are right down on the coast. We arranged to cover these screenings while they were draining, to discourage the flies and gulls.

E. L. Stangaard, *U. S. Naval Station, Alemeda:* I think the answer to this problem is the macerater or comminutor. In my plant, we get a lot of rags, because the sailors throw away their shorts—they call them "skivvies"—when they get soiled. These rags go through the maceraters, but they are completely chopped up, and we do not have any trouble with them.

W. A. Allen, *Pasadena:* We have comminutors too, but we put a screen after the comminutor so that we catch the rags that are chopped up. After the rags are chopped up, they sometimes will accumulate together again and give you trouble in other parts of your plant.

Benjamin Benas, *San Francisco:* We grind our screenings in a shredder which takes care of practically all the material with the exception of some pieces of metal and stones. These are segregated. When we began operating the shredder, we had considerable trouble with odors during the grinding process and we found that these odors could be stopped by adding boiling water to the screenings before grinding.

We have had considerable maintenance on the grinder teeth. They had to be replaced about every 6 to 8 months, and during that time they required 3 or 4 shortenings. We found that the screenings coming into the Sunset sump contained a lot of materials that affected the life of the teeth. We now take the screenings from this source and dispose of them into the incinerator, which is operated by a by-pass from the gas line going to the boilers. The incinerator (Fig. 1) takes about 500 cu. ft. of gas per hour, and so far has been able to handle these screenings. The rest of our screenings, which are practically rags, are handled by the shredder, and the maintenance on it is much less than before.

FIG. 1.—Screenings incinerator at Richmond Sunset Sewage Treatment Works, San Francisco, California.

A. E. GILKEY, *Roseville:* We are fortunate in having a diaphragm pump that pumps almost anything that comes in, so most of the rags which come through our screenings go up into the digester. That, of course, has a tendency to build up a scum layer on top of the digester, but it isn't serious enough to make much difference.

This summer I took off about 3 cu. yd. of float from the top of the digester, consisting of rubber, sticks, blocks of wood, and all kinds of rags, although the rags will digest if there is sufficient time. It takes about 48 hours for the scum from the top of the digester to dry enough so we can burn it. Practically the only odor we get is when we do burn it.

F. W. POST, *Lodi:* We have a bar screen with bars spaced approximately 1½ inches apart. We rake the rags off the bars, and used to dispose of them by burying them in trenches. Later we used drying beds, and when they dried to where they could be handled reasonably well, we would have them hauled away. Still later we arranged with a rancher to haul away our screenings and dispose of them out at his ranch. He built a trailer car that will haul approximately 48 cu. ft. of screenings, and we put an extension on our elevator—raised it up so that it will discharge into this car. He comes once a week and takes away all that we have accumulated.

Chairman Jones: We have a screenings grinder at Stockton, and a new set of teeth is required about every six months. We have trouble especially during the canning season, when a lot of stems and pulp comes in, which makes it necessary to clean the grinder manually every day. Rags are a very serious problem around the plant, especially when we get as many as we had last month—402 cu. ft. Our plant serves the State Hospital, and they send down a lot of rags all the time, because the inmates over there put down sheets, pillow cases, dresses, and things of that nature. Our screenings amounted to 22 cu. ft. per million gallons of sewage last year.

We plan to build a press and incinerator like those Mr. Gwin has up at Folsom. These seem to be very simple.

Mr. Allen: We have bar screens with ¾ inch openings, and the screenings are brought up on a conveyor and discharged into a truck. The truck is left on a slope so that the screenings will drain as they accumulate. We empty the truck once a day and dispose of the screenings by covering them with sand. We have no difficulty with this method.

We get 2.5 to 3.0 cu. ft. of screenings, mostly rags, per million gallons of sewage. Since we have eliminated the fine screens, we have decreased the amount of screenings about 80 per cent. We used to get 5 or 6 truckloads a day; now we get about one load daily.

We have a bar screen ahead of the comminutors and we have replaced the teeth on them, I think, only once in five years because of the protection given by the screen. We also have a screen following the comminutors, and that removes about a bucketful of ordinary rags and papers each day. These are taken with the screenings and burned, and we will probably continue this until the problem gets more serious. It is hardly worthwhile to build an incinerator when we can haul them in our truck just a quarter of a mile and dispose of them so easily. We cover them over each day as we bury them.

Mr. J. H. Van Norman, *Los Angeles:* Burying screenings is one way of disposing of them, if you have plenty of room. Our screenings amount to about 35 tons a day. At the present time a contractor is taking them and using them as an admix with digested sludge for fertilizer—Mr. Kellogg of Garden Grove.

We still burn the rags. The rags take about—of course, we have the advantage of an efficient incinerator—20 to 25 gallons (of oil) per ton of 85 per cent moisture, which I think is very economical. We have never been able to successfully burn rags in any homemade furnace. If you can burn them, I think it is the best method of disposing of them.

Mr. Allen: Are your screenings stored until Kellogg takes them away?

Mr. Van Norman: We had to add several large tanks which hold, I think, about 1200 cu. ft. We can take almost a day's run in two tanks and we keep one tank under air pressure all the time. We have a de-watering press, and the screenings are lifted to it by air pressure, after which they are put through a rotary drier.

Mr. Allen: You actually process them before delivering them to him?

Mr. Van Norman: Yes. The press reduces them to probably 70 per cent moisture content, and the rotary drier reduces the moisture further to about 45 or 50 per cent.

Mr. Allen: Is there any objection to putting the rags in with your screenings, and disposing of them that way?

Mr. Van Norman: Yes. Our bar openings were originally about 2½ inches. We have reduced the space to ¾ inch for the reason that whenever you try to operate any machinery—any moving shafts, gears, or any other thing that rags come in contact with—they will ball up the works in spite of everything, because they will wrap around the shaft or gear. They even throw off the elevator chains in the pits, by getting around the tail pulley or around the top of the gear in the elevator itself, so, if you can keep them away from moving machinery you will be much better off.

Mr. Allen: I meant that perhaps if you added them to the screenings going to your drier.

Mr. Van Norman: Well, I don't think that they would be very good as fertilizer. We agreed with the contractor that we would not put rags in the screenings, and that is the way it stands.

Sewage Sludge as Fertilizer

Chairman Jones: We will now proceed to the next topic. This is a good subject, and we should have plenty of discussion.

K. Fraschina, *San Francisco:* At the Richmond plant, sludge is furnished for fertilization in Golden Gate Park, which has been taking our sludge now for about two years, and they want more than we can produce. It so happens that most of the Park area has a great need for sludge material, so that everything fits in nicely.

Now our sludge happens to have a pretty high nitrogen content—about 3.5 to 4.0 per cent—very high for a digested sludge. It is hard to explain why that should be, except that our raw sludge has a volatile content of about 85 per cent, which is fairly high. Our guess is that this is probably due to the good diet of the people tributary to the plant. The whole area is strictly residential; there is no production waste of any kind, and there is very little ground water infiltration.

Incidentally, the phosphorus content is also quite a bit higher than you would normally expect. The sludge has worked very nicely in the Park, particularly on grass. In some comparative tests with cow manure, the sludge has shown up favorably, producing a very beautiful green grass with strong body and color, which grows very rapidly—about four times as fast as the other grasses. It is applied directly to the top of the ground in a layer 1 inch thick, and in some cases is allowed to dry, and in other cases it is watered immediately, but it does not seem to make much difference. There is no burning of any kind and no weed seeds; it seems to inhibit the growth of wild weeds in the grass itself. Of course, there are a few tomato seeds, but the few plants that come up are killed when cut with the lawn mower.

We are now proposing a series of tests to find out how to use the sludge most productively. We will try to standardize the use of the sludge and propose to try different amounts under controlled conditions with various methods of watering.

The sludge has worked very nicely on shrubs. For example, Mr. McClaren, the Park superintendent, showed us a shrub which he said was going to die, and we put a little sludge around the roots and it came back beautifully. Similarly with rhododendrons. Several collections which seemed to be dying were restored by a little sludge scattered around them.

The only instance where there has been any question at all, is in connection with flowers. Used as a mulch, or top dressing, sludge has been very effective, but there have been some instances where they have dug it into the ground and the ground was not as good as anticipated. We do not know why that is, and expect to include tests on different kinds of flowers in the study we are planning.

It is sometimes hard to believe what it can do. We recall one instance in which a field had a lot of sludge and hadn't been watered for about two weeks. Under these conditions the grass usually gets yellow and may die. The gardener told us that he would water it the next day, which he did, and when we came back the following day, it was surprising to see how the grass came out in that short time.

There is one important thing about using any fertilizer, and that is that you have to use a lot of water with it. If you do you will get fine results. Another advantage of sludge is that it increases the water-holding ability of the soil, so that the total amount of water needed is reduced—some estimates are that only ⅓ to ½ the original amount is needed. This is important in Golden Gate Park because it is so large.

Mr. Allen: Has San Francisco ever considered the possibility of using the sludge in a liquid state, as they are doing in the East? That would save the cost of de-watering the sludge, and would cut down the watering necessary in using it as fertilizer.

Mr. Fraschina: Yes. In our proposed series of tests we will also use sludge in the liquid state, and compare conditions.

All the gardeners have reported that there is no burning or other deleterious effects of any kind, and they are sold on it. The only objection that has been raised is that of odor. There really isn't very much, but it is a heavy odor.

Another problem is the matter of handling the sludge. It is now shoveled by hand, and if it can be spread as it is received, it is much better than handling it from a pile, in which it has been allowed to stay for some time. It seems to compact in the pile, and will stick to the shovel. They are now trying to have enough men available to handle the sludge as it is received.

Mr. Allen: Could they use a mechanical spreader?

Mr. Fraschina: Yes, but one of our difficulties is the lack of funds to get anything like that.

Question: Does the general public know about the sludge, and is there any complaint?

Mr. Fraschina: The only complaint is that they can't get it themselves. They can see that the sludge is very effective, and would like to get it for home use.

Question: Is there any danger in using it?

Mr. Fraschina: The Park uses it only on grass, shrubs, flowers, and trees. It isn't used on vegetables or anything that is eaten, so the danger is quite small, I would say. The digestion period is about 20 days, and you get a great reduction in pathogenic material in that time. Also, the wash water that we use for elutriation is chlorinated. We have never run any bacterial tests on it, but it should be quite low.

Question: Do you know whether there would be any danger to people lying on the grass where sludge had been applied?

Mr. Fraschina: Well, there is plenty of evidence to show that there is some chance for dangerous bacteria to survive in any sludge. It should be used with caution. On the other hand, we have had no difficulty in using it the way we have.

Mr. E. A. Reinke, *Berkeley:* As far as digested sludge is concerned, the evidence that we have had indicated that there is very little danger. Most of the bacteria that stand drying will not live in a digestion tank, although there may be one or two exceptions. So far as I know, nothing has been done on amoebic dysentery; but as far as bacteria are concerned—unless you use raw sludge—the greatest objection we find is what you might call psychological or aesthetic. I am surprised that there has been so little objection in San Francisco, since we have found that most people do not like to use sewage sludge if they know what it is.

H. F. Gray, *Berkeley:* Regarding the question raised by Mr. Reinke, I can't quote the chapter or verse, but I have a recollection of some work in which it had been fairly well determined that spores of amoebic dysentery would pass through digestion tanks with a fair possibility of surviving in an effective form.

As to his troubles with sludge, I got hold of some finely powdered sludge a little while ago and put it on my lawn. None of my neighbors stopped me, my cats weren't shot at, the dog wasn't bothered, and we hardly noticed it either. And the lawn looks a lot greener.

Ask Walter Walker about his tomato plant stunt.

W. J. Walker, *Decoto:* We have four sludge beds, and we draw our sludge about every six weeks. Last June, the tomatoes started to come up by the thousands. A farmer near us told us to let them grow, because tomatoes would be scarce this year. I did, and he disposed of about 21,000 of them for $1.50 a thousand, with the buyers picking them!

T. M. Gwin, *Folsom:* There is a rancher near us who has about 35 acres of ground that he cultivates for garden. We are now furnishing him about 20 per cent of his fertilizer; the rest is from the horse barn and dairy. His method is just to throw the fresh manure or sludge on the ground and plow it under, and he has found that our sludge does not burn as badly as the fresh fertilizer.

In the winter time we have a little difficulty, because our four drying beds do not dry so well. The second winter I was at the plant, I got a tank wagon that holds about 800 gallons, and we filled that directly from the digester and hauled it away. In that way we leave our drying beds alone during the rainy season.

Mr. Allen: We make a really high-class fertilizer. We mechanically dry the sludge, package it, and sell it. We guarantee 6 per cent nitrogen and it usually runs between 6.5 and 7.0 per cent.

Mr. Reinke: I would like to know of your experiences with odors at Stockton, where the Park Department uses the sludge.

Chairman Jones: Yes, they use it and are glad to get it. They use it on the lawns around the City Hall and in the parks. They seem to have better luck with it on the lawns than they do around the shrubs, as someone else here has said. They have also found that the lawn mower takes care of any tomato plants, and that odor hasn't been bad.

Anonymous: We have just started to grind our sludge, and are experimenting with it for use on lawns. We find that the odor is worst in hot weather. If you water it in hot weather you get a pretty strong odor, otherwise it isn't bad.

Beautification of Plants and Grounds

Chairman Jones: We will now move along to the topic "Beautification of Plants and Grounds."

One of the benefits of our San Joaquin County Operators Association is our exchange of plants, shrubs and seeds for beautifying our grounds. It is hard for us to get money from the city for this sort of thing, and dividing up what we have has helped us all. Mr. Hoskinson, will you begin this discussion?

C. N. Hoskinson, *Sacramento:* Since disposal of sewage, though one of the most essential is probably the least attractive function of any political subdivision, it is important that this function be performed not only without offense to any citizen, but everything reasonably possible should be done to insure that this may be accomplished in the most attractive possible setting. This setting should properly be equal, if not superior, to that of other municipal or district functions so that the taxpayer, instead of being offended by the presence of the pumping plant or disposal works, may be proud of its presence in the community and of his part ownership in the plant.

The accomplishment of this ideal is not always easy and may be expensive, but not necessarily so. The need for entire elimination of plant odors must be accepted as a prerequisite; following this, interior finish of a plant need not be in shiny or dull blacks and depressing dark grays, even though some of the less prominent features may be so finished for greater durability of protection. In parts of the interior not subject to gas attack, bright colors such as might be used in most modern bathrooms and kitchens are available in enamels which will be found most durable for plant interiors. Painted floors in motor rooms particularly are desirable, even though more maintenance is necessary, as nothing gives an interior a fresher appearance than a newly painted floor.

For exteriors, light colored walls of buildings, either white or in near white shades, are desirable to maintain the appearance of cleanliness. The plant should, if possible, be surrounded by an expanse of well kept and partially shaded lawn with appropriate trees and shrubs, of which many should be of the evergreen variety, surrounding the main buildings. It is not believed that planting should include too many flowers, as these sometimes require more maintenance than can be given by an operating crew along with their other duties. It is important that a plant should fit into and blend with its surroundings and, if possible, by dignified and simple architecture, blended harmoniously with the neighborhood. We do not believe that the presence of disposal plants should be emphasized by flood lighting, except for protection. Rock gardens, simple pools or electric fountains are desirable features. To identify the plant as a public building an appropriate flag pole should be set firmly in the grounds and the flag of our country should be raised each day and lowered and carefully stored indoors at sunset. The flag should be replaced at proper intervals and never be allowed to become soiled or frayed by the wind.

In short, the plant should present a pleasing and dignified aspect so as to create in each citizen a pride of possession, as it has been found that citizens are much more likely to approve bond issues for needed improvements if they have knowledge of the plant's activities and needs through an appreciative understanding of its functions and first hand approval of its appearance as a public asset.

E. L. Straangard, *U. S. Naval Air Station, Alameda:* I prevailed upon Mr. Emery A. La Vallee, landscape engineer of the Station, to give me a statement concerning soil erosion control. I think some of you will be interested in it, and would like to read it:

> In the building of the U. S. Naval Air Station at Alameda, California, which in general at this time is nearing completion, the U. S. Navy Department has successfully undertaken the development of an Air Base which ranks as the largest of its kind in the Western Hemisphere.
>
> The area embraced in this important arm of the Nation's defense, amounts to approximately 1000 acres of reclaimed land, built up for the most part over tide lands of the San Francisco Bay.

Dredger fill consisting of approximately 20 million cubic yards of sand, silt and clay varying from one to twenty feet in depth, forms the foundation of the site. The southerly and westerly boundary is retained by a rock sea wall, the northerly line being flanked by the Alameda Estuary, and the easterly line forming a juncture with the Alameda mainland.

In the initial proceedings involving determinations to be employed as a basis for a landscape scheme, soil analysis from samples taken from one and two foot depths from specified points, indicated a range of 500 to 40,000 parts of salt per million. Desired leaching was accomplished through the medium of heavy rainfall of last winter. Subsequent analysis showed a reduction of salinity to 100 parts and less per million.

Of the many factors and resultant problems involved therewith in this major development, soil erosion control, of which landscaping is a component part, was recognized as a factor of the highest value and importance.

The scheme envisaged in the treatment of some 500 acres of sand surface was the creation of a naturalistic and at the same time practicable planting throughout the given area.

Framework planting consisting primarily of indigenous trees and shrubs, foundation planting of building structures with occasional tree groupings to bring out a natural park like effect, street trees, flanking roadways, and appropriate planting and lawns for residential quarters, are in brief the keynotes of the scheme outlined and now being put into execution of the first phase of the landscaping program.

The second phase of landscaping, under its function of soil erosion control, by its accomplishment from a practical and utilitarian standpoint merits first consideration.

The introduction of a ground cover over approximately 500 acres of lifeless sand and clay formation required such vegetation that could take root and spread over the surface of this inert mass with a minimum of attention within the shortest space of time, thereby holding in check any sand that might be carried into drifts or suspension by the prevailing, periodically heavy winds.

Ice plant of the variety (*corpobrotus edulis*) commonly known as sea apple, having met the requirements in experiments conducted was first regarded as the solution to the problem, but the element of cost of plants in place temporarily held up its final adoption.

After much speculation as to what to offer as a substitute, an unheralded product from Kenya, South Africa, known as Kikuyu grass (*Pennisetum clandestinum*) was offered for experimental purposes.

Kikuyu grass is a perennial running grass. The original plant and its descendants apparently are functionally female, and while it flowers regularly it does not seed. It has branching leafy stems. The leaves are flat and spreading, and of a vivid green color. Kikuyu is propagated only from stolons taken from roots, runners and rhizomes.

From intensive and exhaustive experiments conducted on the Air Base it has been found that a desirable installation should be made preferably during the winter rains, followed by fertilization consisting of ammonium sulfate and bone meal during the spring period.

As a medium of protection against any undue erosion created by seasonal winds a cover crop of Italian rye and vetch grass introduced between Kikuyu and fertilizer installation serves this function.

In the areas which depend upon rains for irrigation, it is estimated that a Kikuyu ground coverage requires approximately 12 months to complete the desired growth, while the advantages of natural together with artificial irrigation will shorten the growing period by about 6 months. The complete growth of this grass will produce a root matting of from 4 to 5 inches in depth.

The determination to expand and its utter disregard for other forms of ground cover which it gradually chokes out, makes it necessary to limit its movement by providing barriers of ample height and depth, if a check on Kikuyu grass expansion is required.

Kikuyu is primarily a summer grass and will remain green until a severe frost attacks it. The effects indicated by brown spots are superficial and temporary, the root matting being in no way impaired by sub-normal temperature.

The cost of maintenance of Kikuyu ground cover over large expanses is practically nil where soil erosion control is the prime consideration and the factors of color and uncontrolled growth are regarded as secondary. If used as a lawn substitute for finer grasses, irrigation and mowing should be resorted to at least every two weeks during the summer season.

An example of Kikuyu grass performance is demonstrated at the Monterey County Fair Grounds near Monterey, where some two acres of this grass form the body of the grounds and over which the Fair attendance circulates.

The propagation yard near Camp Clayton in Monterey County, consisting of approximately 20 acres of Kikuyu turf, is perhaps the best example of the growing qualities of this grass under more favorable conditions. Complete ground coverage has been attained within a period of five months.

It is estimated that the cost of installing Kikuyu grass over the U. S. Naval Air Station at Alameda will be between 10 and 15 per cent of the cost of any other form of rooted cuttings.

A. B. Shearer, *San Anselmo:* I would like to add a word about a point made by Mr. Hoskinson, relating to the effect on the public and possible bond issues. Some day you may want to float a bond issue, and it will be desirable to have the public think well of you and to know that your plant and department is doing all it can to give them good service.

Some of the communities, besides just operating a sewage treatment plant, are responsible for the maintenance of the sewer system. Keeping your rolling stock and your men and everything else that is on the road as neat and orderly as you do your plant is of equal importance, so far as public relations and friendliness of the public are concerned. It is always hard to get anybody to visit the plant, and they are naturally prejudiced against anything pertaining to sewage. Anything that you can do to improve that opinion by beautifying the plant and keeping your men and equipment presentable, I think, has an important effect.

Chairman Jones: Mr. R. L. Rudolph, who operates the plant at the Sonoma State Home at Eldridge, was unable to come to the meeting, but has sent me a brief statement.

Mr. Rudolph suggests that the natural ground contours should be carefully studied, and that proper drainage should be given consideration in the finished grading. He recommends that flat areas may be made into lawn, but that grass is hard to take care of on slopes and embankments, and suggests small hardy shrubs or vines on such places. Retaining walls of natural stone are also suggested for attractive backgrounds.

Mr. Rudolph also urges careful thought in selecting trees and shrubs and points out that your local nursery man can help in choosing sturdy plants requiring a minimum of care. He cautions against the placing of plants in locations in which they would interfere in any way in carrying on the operations essential to the treatment units.

W. J. Walker, *Decoto:* Our plant is about 400 ft. from the road, and I planted roses and red berries along the driveway. The tanks are surrounded by a flower bed strip about 18 in. wide, in which verbena and coxcomb are grown. The lawn is about 35 ft. by 80 ft.

I placed climbing roses on the outside of the Administration Building. There is a circular turn-around at the end of our driveway at the rear of the building, and in this we have a flower bed in which are about fifteen English holly bushes and different kinds of red berries. We also have gladiolus, iris, marigolds, and dahlias, and I am alternating now by putting in winter stocks.

Except for the grass seed, it doesn't cost us anything for flowers because I trade ground sludge fertilizer for plants.

Many of the people who objected to our plant in the beginning now come down and say, "Why, you have a regular park here," and they ask for some of my cut flowers. It causes us a lot of work, but we think it is worth it.

Mr. Straangard: I think this whole subject was covered pretty thoroughly in the 1939 Short Course at the University of California. They had a whole chapter devoted to the beautification of grounds. However, I would like to say that ice plants, of which there are about 400 different varieties, and 8 or 10 different blooms, are just the thing for terraces and slopes which were referred to in Mr. Rudolph's remarks. This plant covers rapidly and stops erosion, and gives a wonderful blooming mat, like those at the Exposition during the Fair.

J. A. Clark, *Mare Island:* Some time ago I noticed that the second shift man—4 o'clock to midnight—had considerable time at his disposal, after eight o'clock. He would rush through his work and then have nothing left to do but clean the screens. Rearrangement of his duties made it possible for us to utilize the 4–12 shift as a gardening shift. I then found that one of the operators was particularly interested in gardening and was, in fact, operating a nursery in the community.

I have heard since I left this plant and since this man took over the gardening, that it is now more of a park than a sewage works. Even then we were able to keep all the city offices supplied during the summer with fresh flowers. The city of Medford operates its own airport, so if any of you visit the United Airlines station there, you will probably see flowers that came from the sewage plant.

V. W. Thews, *Terminal Island:* Mr. Clark's remarks remind me of two plants: Terminal Island at Los Angeles, and the one at San Fernando. These two cities and plants are very different.

At Terminal Island we have a good sized staff of men; some people say too many. There is about three to three and one-half acres in the site, of which about an acre is in lawn, and we have endeavored to beautify this area. The lawn is made on sand, fertilized with sludge, and grows quite fast, and takes a large portion of one man's time, even though we have a power lawn mower. The trees need pruning, and the flowers have to be cut and cared for. At one time we raised gorgeous zinnias and marigolds, which we would take to the City Engineer's office, and so on.

Recently we had quite a lot of construction work going on, and the grounds have had to be somewhat neglected. That is something that the operator must keep in mind when he starts out to beautify his plant, because he may find, as Mr. Clark has said, that he is going to have to neglect either the plant or the grounds. I would suggest that he use judgment and not start too far-reaching a program.

I have another plan in mind—the one at San Fernando, which is located in the mountains at the northwest corner of Los Angeles. Anyway, this small plant is located out in a wash, nearly a mile from the

FIG. 2.—Tower in Laguna Beach, California, Sewage Treatment Works before planting. R. D. Woodward, Superintendent.

center of town in an area that has mostly cactus and brush. In fact, it is the municipal dump!

The operator is a Mexican chap—very reliable, who spends about five or six hours a day at the plant. The grounds are fenced in, there is very little planting—only a few oleander bushes and pepper trees, and so on—there is no effort to maintain flower beds and lawns, but there isn't a weed inside that fence. And as you drive through this wilderness of cactus and rubbish and look through the fence, you notice that it is just as neat and trim and clean as it can be. The operator should use his head in planning landscaping to meet the needs of his particular surroundings.

R. D. Woodward, *Laguna Beach:* I will pass these pictures around to show you what the planting of vines has done for us (Figs. 2 and 3).

Last year our city acquired about thirty acres across the street from our plant for a park. We already had a good start at our planting, but we are going to have to do more beautifying to keep up with that. One of our biggest problems is to trim the vines on that 48 foot tower,

Fig. 3.—Same tower shown in Fig. 2 after planting with shrubs and vines.

which must be done about twice a year. We use power clippers, with ladders and a long pole, and also have to use planking around the top. It is quite a job.

Chairman Jones: You might tell about having the Rotary Club to luncheon in your grounds, Mr. Woodward.

Is there anyone else on beautifying of plants and grounds? How about the interior of the plant, Mr. Benas?

Benjamin Benas, *San Francisco:* I believe that painting the plant piping various colors depending on their service is quite effective. For instance, water lines can be painted blue, sludge lines brown, chlorine gas pipes yellow, sewage lines black, etc. We now paint our machinery a gray color instead of the old black. Visitors to the building often remark about the color scheme.

We originally had all our railings in black, but found that they were hard to maintain because they got greasy and dirty. I definitely believe in bright colors and variation in colors. Floors, of course, are hard to maintain. We have started some tests on floor paints, but have no conclusions yet. The difficulty with most of these paints is that they must be allowed to dry so long before use. A quick-drying paint that gives a hard finish, is easily cleaned, and has reasonable wearing qualities, is the answer.

Chairman Jones: At Stockton we have trouble getting paint late in the year. The Street Department uses a traffic lacquer which we can get in black and white to mix into a gray, and we get all we want without charging it to the plant. This gray lacquer paint has several advantages to us, in that it dries right away—you can walk on it within five minutes—it is easy to put on, and is very cheap. We use a liquid wax on it to preserve the finish; however, six months is a long time for it to last. At least it keeps the floor clean and neat.

C. N. Hoskinson, *Sacramento:* We have found that the most satisfactory paints are the synthetic enamels. They come in any color you would want and are very effective metal coverings. They dry quite rapidly, and are not very expensive to apply.

Mr. Benas: We had a lot of trouble with our wall paint until we tried enamel. We now find that we can wash the walls with no difficulty.

Mr. J. C. Clark, *Huntington Beach:* For cleaning metal surfaces prior to painting, I have had some success with trisodium phosphate, and would like to know if any of you have had any experience with it. I have found it to be much superior to gasoline for cleaning equipment before painting, and would like to suggest it for your use. It doesn't take much, and it saves a lot of labor.

(*More next issue.*)

THE GADGET DEPARTMENT

Holder for Standard Rain Gage

By Walter A. Sperry

Superintendent, Aurora (Illinois) Sanitary District

A complete description of the standard rain gage in use at the sewage treatment plant of the Aurora Sanitary District was published in the November, 1941, issue of *This Journal* (**13**, 6, 1251). Figure 1 shows construction details of an approved holder for the rain gage.

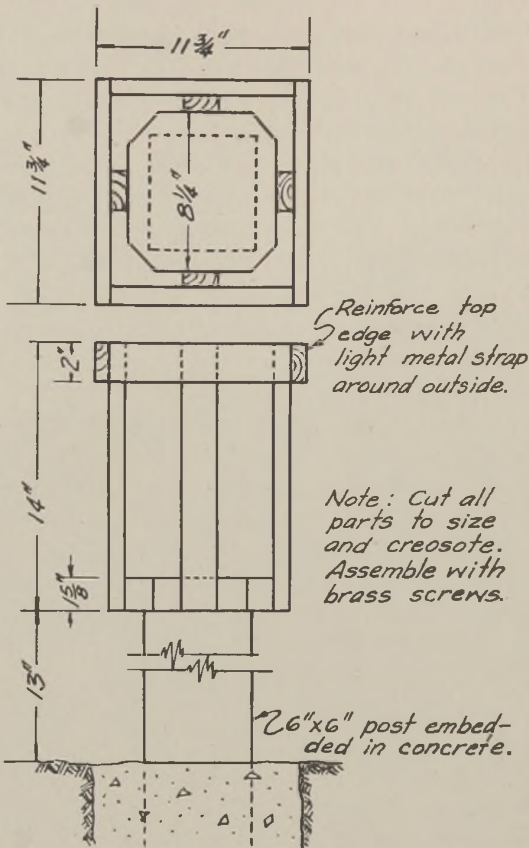


FIG. 1.—Holder for standard rain gage. Designed by Walter A. Sperry, Supt., Aurora, Illinois.

FIG. 2.—General view of rain gage and thermometer "Kiosk," Aurora Sanitary District. Walter A. Sperry, Superintendent.

The gage (with top funnel removed for winter service) and holder are illustrated in Fig. 2. Attention is directed to the maximum and minimum thermometer "kiosk" in the background.

Screenings Incinerator

By Thos. J. Gwin

Superintendent, Sewage Treatment Works, Folsom State Prison, California

In submitting a description of a rag press used for dewatering screenings at the Folsom State Prison, California (see *This Journal*, 13, 6, 1252, November, 1941), reference was made to a "dutch-oven

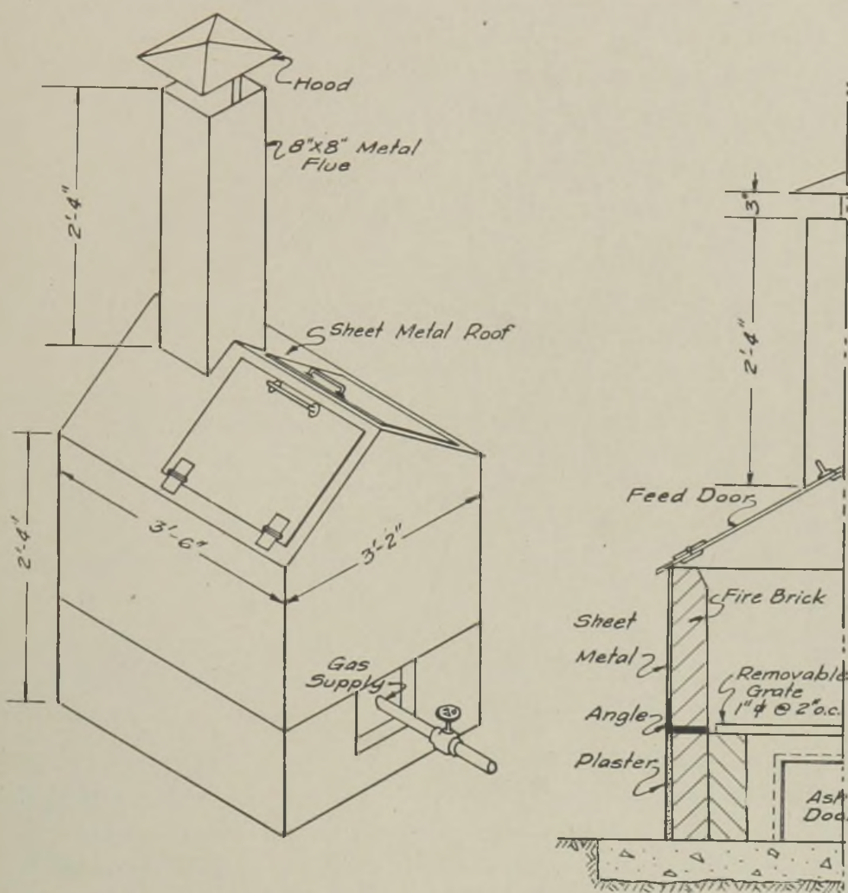


Fig. 3.—Screenings incinerator used at Folsom State Prison, California, Thos. J. Gwin, Supt.

type" incinerator used to effect final disposition of the dewatered screenings.

Details of the incinerator referred to above are shown in Fig. 3. Digester gas is used for fuel. The gas burner or "spud" was made from a piece of ⅜-in. pipe, 8 in. long and with small holes drilled along each side.

Sanitary and Dripless Wash Bottle

By Charles Baugh

Chemist, Los Angeles County Sanitation Districts, California

The sanitary and dripless wash bottle shown in Fig. 4 may be used to good advantage in most laboratories where more than one analyst is employed. Elimination for the need of lip contact to operate the bottle also eliminates the probability of transmission of contagious diseases.

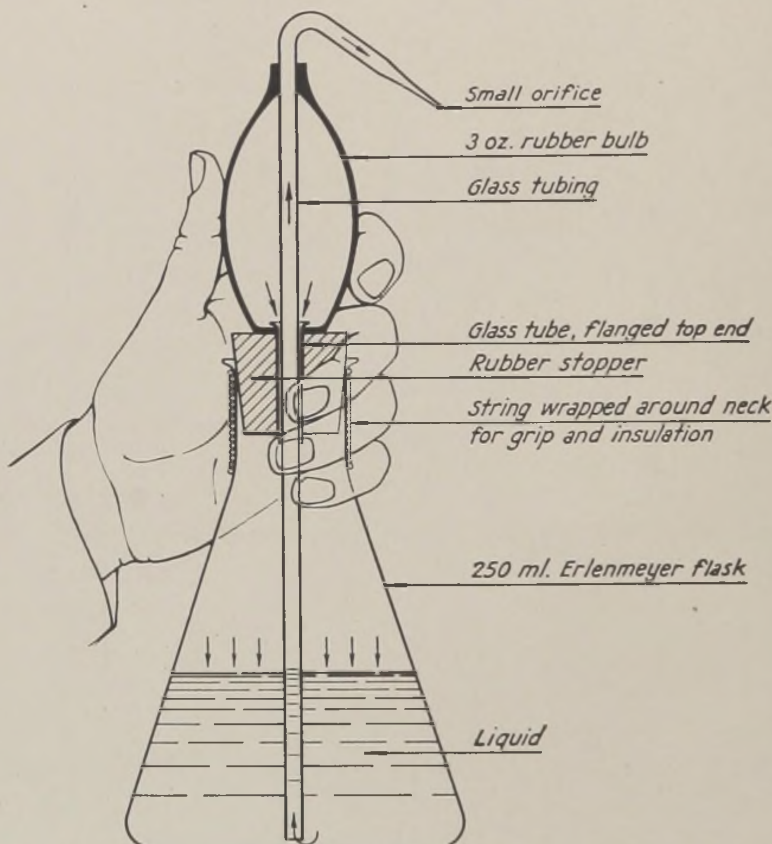


Fig. 4.—Sanitary and dripless wash bottle. Submitted by Charles Baugh, Chemist, Los Angeles County Sanitation Districts.

Particular emphasis may be placed on the use of this simple and inexpensive wash bottle in laboratories in which bacteriological work is performed.

No claim is made as to the originality of the bottle, but some original modifications and improvements have been made to increase its effectiveness and serviceability.

When the rubber bulb is squeezed, air passes through the glass tubes, one of which fits loosely inside the other, and the pressure which is created on the surface of the liquid causes it to spout through the small orifice in a small stream. Upon releasing the bulb, air will be sucked back through the orifice, drawing back excess water and preventing drip. If desired, a check valve similar to that used in inflated rubber balls may be placed in the bulb, directly opposite or in the vicinity of the thumb, thus eliminating the bubbling of air through the water when the bulb is released.

If the contact point between the rubber stopper and the flask is kept absolutely dry, the wash bottle may be picked up by the rubber bulb, but this is not recommended.

DECREASE OF GAS PRODUCTION WITH CESSATION OF FEED TO DIGESTER

By Fred H. Burley

Sewage Plant Supervisor, Detroit, Michigan

The rate at which gas production falls off after the additions of volatile solids to the tank have ceased is of concern to operators who have to take tanks out of service. It also indicates the allowable time interval between the additions of fresh solids without seriously decreasing the gas production.

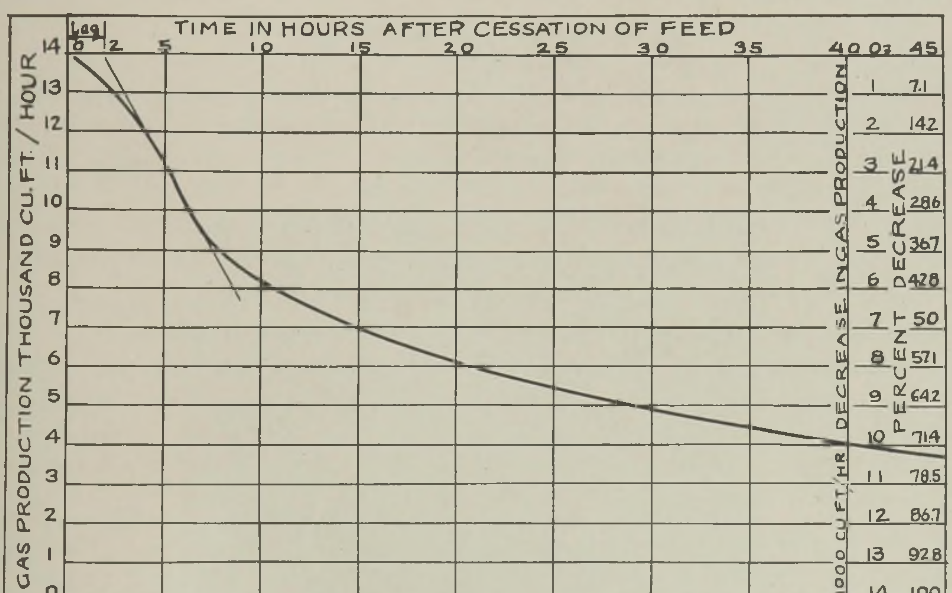


Fig. 1.—Decrease in digester gas production when feed discontinued. Detroit, Michigan.

The digester at Detroit, Michigan, has a volume of 300,000 cu. ft. The normal loading prior to shut down was 45,000 lb. of volatile solids, dry basis, per day. This normally gave a gas production of 384,000 cu. ft. of digester gas per day. A layer of scum about 10 ft. 6 in. deep accumulated early in the fall and decreased gas production to 336,000 cu. ft. per day, decreased the tank capacity by one-third, hampered free action of the cover and was otherwise undesirable. Tank temperature was 93° F. maintained by waste heat received from the gas engine. Under average conditions the sludge solids added were 60 per cent volatile, the volatile matter was reduced from 41 per cent to 43 per cent during digestion, and the digested sludge was about 46 per cent volatile.

Figure 1 is plotted with time as abscissa against gas production in cu. ft. per hour, decrease in gas production and per cent decrease in gas production as ordinates. The curve is of the autocatalytic-unimolecular type described by Fair and Moore in connection with gas production from seeded sludge.* The "X" axis is approached as an asymptote and gas production would evidently continue at some small rate for a very long period. After 400 hours the gas production was still 600 cu. ft. per hr.

The approximate tangent to the reverse or overlapping portion of the curve when extended indicates a "lag" of about two hours. This agrees well with our previous observations that a period of two hours between additions of solids should not be exceeded if gas production is to be sustained.

BARK FROM THE DAILY LOG

March 1—Mu San, professional sanitary engineering fraternity at the University, held an informal initiation ceremony at the plant this evening. Takes us back to our own initiation into the same fraternity in this plant sixteen years ago, when we crashed into the trickling filter wall while running at full speed (blind-folded) to escape a line of paddle wielders. Results—conversion of a "classic Irish" nose into a "pugilistic moderne" type and loss of a front tooth. Those were the days!

March 3—Completed application of water paste paint to the concrete walls of the room beneath the dosing tanks. Because these walls are subject to heavy condensation in winter months and must be hosed down occasionally, a water paste paint recommended for exterior service was used. (After only six months service, this paint began to flake off during hosing of the walls. Our error!)

March 7—While flushing out the dosing tank piping today, one of the operators remarked that this attention was not required nearly so frequently before the quarter-inch mesh trash screens had been placed at the dosing tank inlet weirs to reduce nozzle clogging. The ensuing discussion and observation of operation of the tanks resulted in unanimous approval of the following conclusions:

* *This Journal*, 4, 431 (1932).

1. The fine splashing and turbulence induced by flow through the screens causes greater flotation of grease in the dosing tanks than occurred when the screens were removed (Fig. 1).

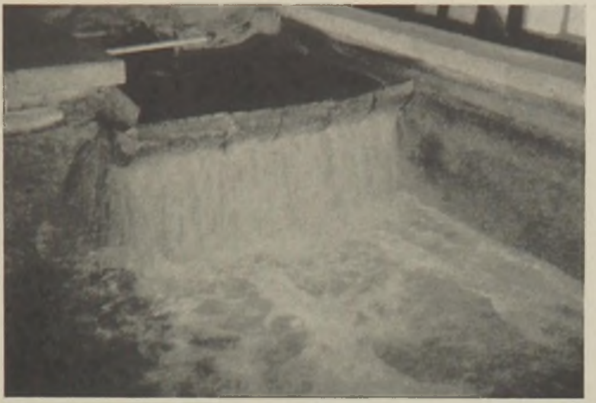


FIG. 1.—Trash screen at dosing tank inlet weir. Note splashing.

2. The weirs over which flow takes place to the starting wells, in which the starting bells and traps are located and where pipe clogging is most troublesome, serve as skimmers, permitting much of the floated grease to have access to the piping.

3. The screens are effective in retaining chewing gum, match sticks and other objects which would obstruct filter nozzles, and should be retained in service.

The most important cause of the pipe clogging being ascertained, a remedy was obvious. Creosoted wood baffles, extending 5 in. below the high water surface, were placed in front of each starting well weir, thus protecting the affected piping (Fig. 2).

FIG. 2.—Baffled starting well weir, preventing skimming of grease into well. Note floating grease.

And so another minor but bothersome condition is improved, because an operator was sufficiently alert and observant to note the change taking place following the installation of the apparently unrelated screens.

March 9—National Youth Administration project terminated today. This venture, in operation since last October, is estimated to have been worth at least $1500 to the District. Work accomplished included removal of 850 cu. yd. of humus from the lagoon, painting of 1600 ft. of woven wire fence, tree trimming, cleaning sludge beds, assistance in office and laboratory, and miscellaneous assistance in repairs and maintenance.

March 12—Imhoff Tank 2 showing considerable floating solids in settling channels. Removed from service to allow to settle down.

Quite a few visitors to-day (as might have been expected with the tanks upset). Operators in attendance at the Illinois Sewage Works Short Course being held at the University came out en masse. "Round Tabled" all through the plant!

March 14—To Lawrence, Kansas, to attend meeting of the Kansas Water and Sewage Works Association. Enjoyed a fine technical program and some typical western hospitality. Thanks Kansas!

March 16—Back from Kansas to find Tank 2 feeling much better. Restored it to service.

March 17—Eight above zero this morning. And we thought Spring was practically here!

March 20—Man from Power Company out today to check power meters. Found master meter recording 2.14 per cent high! Couldn't get them to give us a credit for the overage, or to set the meter to register low for awhile, but they did consent to paint our transformer station in a few weeks!

March 22—The air-lift used for pumping digested sludge to the drying beds is giving trouble. Probably due to accumulated grit in the sump. Serious difficulty with this device is rare, due to its excellent design.

March 24—Made plunger from 50 ft. of ½-in. galvanized pipe to churn up grit accumulations in the sludge air-lift well to expedite removal of such deposits. Cleared the present stoppage in short order. The plunger will be left in the well for future use when needed.

March 28—Began periodic overhaul of switchboard. Job will include tightening of all terminals, with repairs where necessary; checking of insulation on wiring; replacement of bad contacts and dressing of others; lubrication and attention to oil pots of relays; and general cleaning up. The job is not complete until an order is placed to refill the spare parts inventory—and in these days, until they are delivered!

April 1—Taking a tip from "Hap" Hatfield at Decatur, we placed in service today a new cooler for storing composite samples during collection. A used soft drink dispenser with refrigerating unit was purchased for $15.00, the unit being in excellent mechanical condition but the tank having several leaks. Repair of the leaks and application of a little paint was all that was required to give us an efficient cooler holding samples at 7° to 10° C.—a great improvement over the old water-bath cooler that was displaced (see Fig. 3).

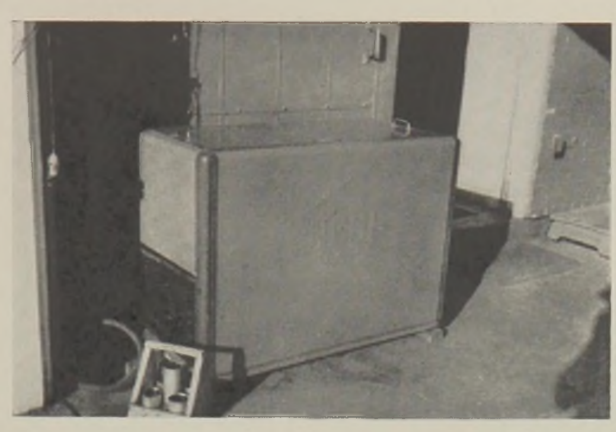


FIG. 3.—Sample storage cooler.

April 3—Steady rain all day today presented opportunity to check the hydraulic gradient in the intercepting sewer system. Quite worth while on this occasion, for we located a partial stoppage in an 18-in. line. Such a stoppage may not be readily noticed in times of low flow but shows up definitely in a check of the gradient during high flows.

April 6—Final clarifier mechanism stopped last night. Located the trouble in the power feed cable which proved to be "shorted" due to failure of the insulation. Because the cable conduit contained considerable water, we are inclined to believe that this trouble is a "hang-over" from the flood of more than two years ago, when this mechanism was inundated.

A new cable was installed after the conduit was dried out by dragging swabs through it.

April 8—A beautiful day! Two certain signs of the advent of Spring were observed: (1) the winter sludge on the drying beds is beginning to crack and (2) the first psychodas of the season came out of hibernation!

April 10—We have been concerned for some time about a section of the 30-in. intercepter which lies along the bank of Boneyard Branch and has been completely exposed on top and on one side by erosion. Today we went over the situation with two local contractors to obtain bids on the construction of a retaining wall about 75 ft. long which will afford protection against serious damage. A wall of heavy broken concrete laid in cement mortar will be constructed as soon as the stream flow recedes to a stabilized dry weather condition.

April 13—Cleaned and oiled up the power mower for its first work-out of the year.

April 14—Imhoff Tank 4 is up to its usual tricks. Located at the end of the raw sewage channel, this unit receives most of the grease and other light solids and does not behave at all similarly to the other three tanks. Soundings in the gas vents today showed no separation between the sludge surface and scum, although the sedimentation channels are in good condition!

April 17—Several days ago, a local machine shop representative estimated the cost of certain repairs to the industrial dump cars used for hauling sludge at $35.00. Today, a very satisfactory repair job was accomplished by one of the regular operators, at a cost of $1.44, exclusive of his time!

April 21—University Hygiene Classes began the usual first semester inspection trips. When the trips are concluded next week, about 1350 students will have been through the plant and will be required to write a report on the trip. These students, upon becoming tax-payers in a few years, will know why and how their sewage treatment dollars are being spent.

April 22—Installed the rebuilt sewage pump (completely new except for the casing) which collapsed last January from old age. A brief test run indicates that it will be very satisfactory.

April 25—For one of the most tedious of all tasks, we nominate that of painting woven wire fence! The fence surrounding our Imhoff tanks, showing definite effects of corrosion, has now been given a coat of aluminum paint after having been thoroughly wire-brushed to remove scale and rust.

As the work was being completed, a paint salesman stopped in and suggested the use of a spray the next time we paint the fence, answering our argument that too much paint would be wasted with a clever suggestion. It seems that one of his industrial customers successfully meets this difficulty by having a man hold a sheet of metal on the side of the fence opposite the spray, the sheet having a trough at the bottom to catch excess paint for re-use.

April 28—Starter of Pump 2 not functioning properly. Unable to find the trouble ourselves, we sought the aid of the local Power Company. They graciously sent out one of their electrical engineers who located a faulty connection in the resistance grid and the difficulty was readily corrected.

April 30—Landscaper set out the new trees and shrubbery replacements ordered last February. Seems a little late for such planting but we are not worried since the work is being done on a "pay if they grow" basis!

INTERESTING EXTRACTS FROM OPERATION REPORTS

THE CORNER *will appreciate copies of annual operation reports from plants of all types and sizes. May we have yours?*

Marion, Indiana (Year Ended August 31, 1941)

By DAVID BACKMEYER, *Superintendent*

Description of Plant.—The Marion, Indiana, sewage treatment plant, designed and constructed under the supervision of the consulting engineering firm of Consoer, Townsend, and Quinlan, was completed in June of 1940, at a total cost of $470,000. The plant is of the activated sludge type with separate sludge digestion. The present designed capacity of the plant is 4.0 million gallons per day. The pumping facilities installed are adequate to handle future peak loads up to 10.0 million gallons per day. Three rectangular shaped primary settling tanks are provided having a total capacity of 300,000 gallons. Secondary treatment consists of four double-pass aeration tanks of 1,150,000 gallons total capacity. Air is supplied through stationary diffuser tubes in the aeration tanks proper, and through plates in the pre-aeration tanks and sewage feed channels. Two final settling tanks having a capacity of 600,000 gallons are equipped with four Tow Bro collectors for removing the settled activated sludge.

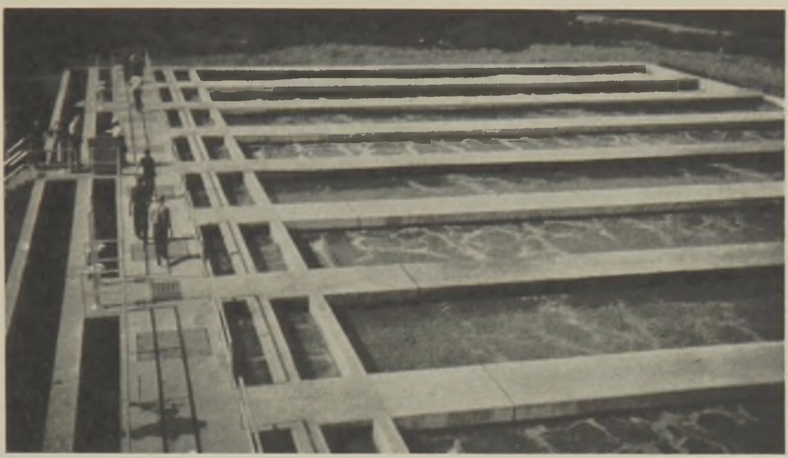


Fig. 1.—Aeration tanks at Marion, Indiana. David Backmeyer, Superintendent.

Two sludge digestion tanks are provided, identical in design, 65 ft. in diameter, with 24 ft. working side wall depth. Both digesters have P.F.T. floating covers with insulated roofs. The capacity of each tank is 83,600 cu. ft., giving a total capacity of 6.25 cu. ft. per capita for the present resident population. Three gas engines having a total capacity of 200 hp. utilize the sewage gas produced. The Marion plant is one of the few plants in the country today designed for dual disposal. Provision has been made for the introduction of ground garbage to the raw sewage wet well beyond the sewage screens. The garbage solids are then pumped with the raw sewage to the grit chambers prior to pre-aeration and settling.

The daily volume of raw sewage averages about 3.0 million gallons giving a per capita volume of 110 gallons per day. Various industrial wastes have added a considerable pollution load to the normal domestic sewage. The waste from the Snider Packing Company is equivalent to the domestic waste of 10,000 persons during the canning season when corn and tomatoes are being packed. Laundries, dairies, meat packing houses, and many other smaller industries contribute waste which brings to the plant an equivalent bio-chemical oxygen demand load of a city of 32,500 population throughout most of the year.

Gas and Garbage.—Perhaps the single outstanding feature of the first year's operation has been the unusual high volume of sewage gas produced by the digestion of the sewage solids. During the year there was produced 19,923,000 cu. ft. of sewage gas. This volume of gas was sufficient to pump all of the raw sewage, drive the blowers for the aeration of the activated sludge process, and heat the sludge digestion tanks

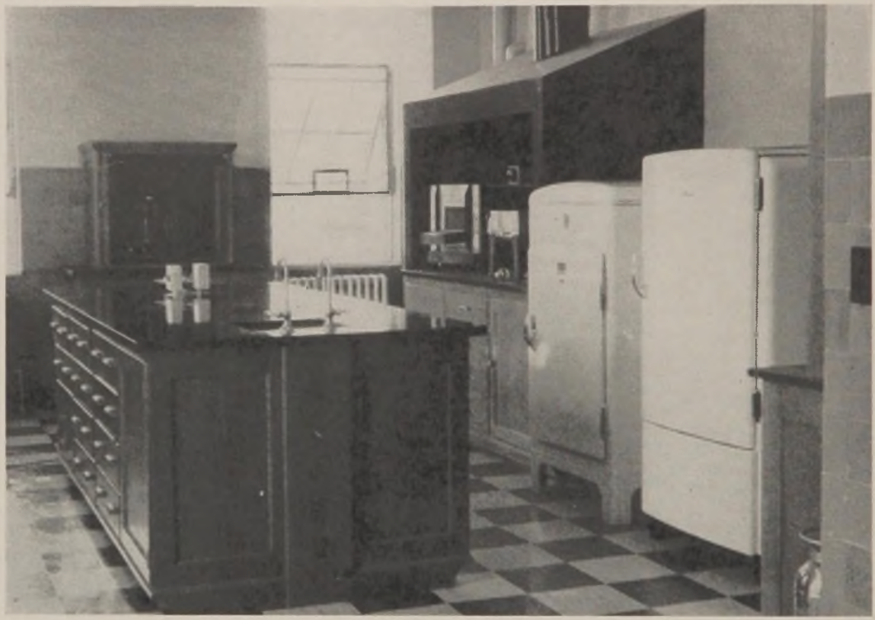


FIG. 2.—Laboratory in Sewage Treatment Works at Marion, Indiana. David Backmeyer, Superintendent.

and plant buildings. The value of the sewage gas at 50 cents per 1000 cu. ft. averages $755.36 per month for the first year. This saving in cost of operation has enabled the plant to operate well within its budget.

During the month of June 1941 the collection and disposal of garbage was transferred to the sanitation department. Although the garbage department operates under a separate budget, and has no financial connection with the sanitation department, the supervision of the collection and disposal of the garbage is now handled at the treatment plant office. The addition of ground garbage to the sewage has resulted in an increase in the volume of sewage gas produced. Several more months of operation will be required, however, before any reliable conclusions can be drawn as to the practicability of this type of garbage disposal.

Economy in Ferric Chloride.—Several projects now underway at the plant should be brought to completion during the coming year. Ferric chloride, an iron salt required for the filtration of the fertilizer sludge, will be purchased next year in the liquid form instead of in the crystalline form. To handle properly the liquid chemical it was necessary to purchase and install a 4500 gallon rubber lined storage tank. As the liquid chemical can be bought at half the cost of the crystalline salt, the cost of the tank will be paid for in a period of four years by the saving made in buying the chemical in this more economical form.

Landscaping Planned.—The grounds surrounding the treatment tanks and plant buildings will be graded and landscaped during the spring and summer months. Part of this work has been completed by the N.Y.A. work experience program recently discontinued because of defense needs. The disposal plant should be one of the beauty spots in the city when completely landscaped. It is hoped that the natural quarry lake between the highway and the plant can be beautified and maintained as part of a City park when the project is completed.

Summary of Operation Data

Item	1940 Average	
Connected population	27,600	
Equivalent population (by sewage analyses)	32,500	
Sewage pumpage—average daily	2.54	m.g.d.
Per capita daily	92	gallons
Activated sludge data:		
Mixed liquor—suspended solids	2,072	p.p.m.
Return sludge—suspended solids	8,351	p.p.m.
Applied air—per gallon sewage	1.26	c.f.
5-Day B.O.D.:		
Raw sewage	245	p.p.m.
Primary effluent	153	p.p.m.
Removal—primary treatment	37	%
Final effluent	15	p.p.m.
Removal—complete treatment	93.6	%
Suspended solids:		
Raw sewage	282	p.p.m.
Primary effluent	131	p.p.m.
Removal—primary treatment	52	%
Final effluent	15	p.p.m.
Removal—complete treatment	94.3	%
Sludge digestion:		
Raw sludge quantity per m.g. sewage	10,520	gallons
Solids content	4.97	%
Volatile content	58.2	%
Digestion temperature—primary unit	96.5	degrees F.
Secondary unit	91.6	degrees F.
Supernatant solids content	1.23	%
Gas production—per capita daily	1.98	c.f.
Portion of total power from gas	80.7	%
Digested sludge quantity per m.g. sewage	3,490	gallons
Solids content	6.1	%
Sludge dewatered (dry solids)	2.36	tons daily
Lime applied (72% CaO)	700	lbs. daily
Ferric chloride applied (anhydrous)	139	lbs. daily
Filter rate—per sq. ft. per hour	7.3	lbs.
Sludge cake solids content	25.8	%
Operation cost—per m.g. treated	$19.57	
Per capita per year	$ 0.67	

Massillon, Ohio (1940)

By R. F. Snyder, *Superintendent of Sewage Treatment*

Industrial Waste Control Needed.—The slow disintegration of pumps, piping, valves and masonry has continued during the year due to acid industrial wastes in the sewage, and as yet recommended legislation for the proper control of all industrial wastes has not been enacted. Although some relief has been obtained in the past two months, adequate and complete control of such wastes at their source is necessary to eliminate this condition. At the present time the city has no authority whatsoever to request or demand that proper pre-treatment of industrial wastes be made. I believe that this condition should be given serious and immediate consideration by the council. With the exception of the conditions mentioned above, the plant otherwise has functioned properly and a good degree of treatment has been obtained at all times.

Sewer Maintenance and Inspection.—Our two laborers have three types of work to perform. They are used for plant upkeep and maintenance, maintenance of the sanitary sewer system, and make all of the sewer inspections where new laterals are connected to the sewer system, both in the city and the Reedurban sewer district. Since April 1, 1940, all of the sewer maintenance and sewer inspection work has been placed under the supervision of the plant superintendent. During this nine month period 181 maintenance calls were handled, and, in addition to this, periodic check-up was made of the sewers in all sections of the city. When found necessary, these sewers were flushed and cleaned.

Under the supervision of the Engineering Department, W.P.A. sewer projects were completed which included the construction of manholes where badly needed for proper sewer maintenance and also local sewers that have helped to reduce our maintenance cost. It is hoped that similar work can be done this coming year because of the condition of some sections of sewers where the inverts in the manholes are completely gone or were never built when first constructed. This condition is especially true of the sewer lines that carry acid wastes. Brick work and masonry in the manholes are completely destroyed and the maintenance costs for these sections are increasing. Additional manholes on the system will also help to reduce maintenance costs.

The Reedurban Sewer District was connected to the City sanitary sewer system in September of this year and property owners immediately began connecting to this sewer system. We inspect each connection to see that it is properly made so no roof or ground water can enter the system. This is done for our own protection and an inspection or permit fee is collected to cover the cost of this work. Since the Reedurban district was placed in operation, a total of 103 connections have been made as of December 31, 1940.

At the beginning of the year all sewer permit fees went into the general fund and inspectors were paid from this fund. In October legislation was passed creating the position of Sewer Inspector in our Division and since then sewer permit fees are turned into the Sewer Rental Fund and inspectors are in turn paid from this fund at the rate of $5.50 per day. No additional help was added to our Division for handling this extra work, but as stated before, the laborers originally on our payroll are paid at inspector's rates only for the actual time they are on inspections. The remainder of their time, when on plant or sewer maintenance, is at a 60 cents per hour rate.

*Summary of Operation Data**

Item	1940 Average	
Sewage flow	2.512	m.g.d.
Sewage temperature	60	degrees F.
Screenings removal	1.18	c.f. per m.g.
Sewage analyses:		
5-Day B.O.D.—raw sewage	151	p.p.m.
Settled effluent	77	p.p.m.
Per cent removal	48.7	
Suspended solids (by filtration)—raw sewage	244	p.p.m.
Settled effluent	86	p.p.m.
Per cent removal	62.5	
Total solids—raw	1,518	p.p.m.
Settled	1,319	p.p.m.
Settleable solids—raw	9.2	ml. per l.
Settled	0.2	ml. per l.
pH—raw	6.3	
Settled	6.3	
Alkalinity—raw	106	p.p.m.
Settled	106	p.p.m.
Total iron as Fe—raw	124	p.p.m.
Settled	112	p.p.m.
Ferrous iron—raw	113	p.p.m.
Settled	101	p.p.m.
Sludge digestion:		
Raw sludge quantity per m.g. sewage	3,900	gallons
Solids content	5.68	%
Volatile content	72.1	%
pH	5.6	
Alkalinity	186	p.p.m.
Digestion temperature	85	degrees F.
Gas production (average daily)	41,714	c.f.
Per lb. volatile matter added	12.9	c.f.
Supernatant liquor quantity	7,010	g.p.d.
Solids content	1.90	%
Volatile content	53.2	%
Digested sludge quantity per m.g. sewage	1,220	gallons
Solids content	5.36	%
Volatile content	50.9	%
pH	7.3	
Alkalinity	2,601	p.p.m.
Operation cost (primary treatment)	$15.65	per m.g.

* Superintendent Snyder directs attention to the fact that accurate sampling is impossible of achievement at Massillon because of the irregular "slug" discharges of acid pickling liquors which are received daily. This may aid in interpreting any inconsistencies in the operation data.

TIPS AND QUIPS

By means of changes in Preference Rating Order P–46 the War Production Board has recently allocated higher priority ratings to certain operation and maintenance activities, expediting prompt deliveries of materials needed in public sewage collection and treatment works. A brief summary of the important revisions are:

1. An A–2 rating is granted to deliveries of material for maintenance, repair and operation of pumping facilities.
2. An A–5 rating is assigned to deliveries of material required to operate and maintain all other facilities included in the scope of the original order.
3. An A–5 rating is assigned to deliveries of material required to extend service to new projects (other than housing projects) bearing a rating of A–5 or better.
4. An A–5 rating is assigned to deliveries of material required for protection against sabotage, if such protection is directed by an authorized federal or state agency.

In order to use the latter two ratings, the War Production Board must be furnished with a description of the project; its relation to military needs, war production, public health or safety; a copy of the customer's rating certificate or order and, for anti-sabotage materials, a copy of order of federal or state agency; whether service can be rendered any other way with use of smaller quantities of critical materials; cost of materials; total cost of project; list of construction materials.

* * *

To develop a market for the sale and disposition of the sludge produced in the new sewage works at Marion, Indiana, a leaflet has been prepared for distribution among potential users to acquaint them with the sludge characteristics, its advantages as a soil conditioner, and the proper methods of application. The charge of fifty cents per cubic yard is adequate to cover the cost of conditioning chemicals, yet it gives the user a fertilizer of about one-half the cost of commercial products on the basis of the relative nitrogen contents.

* * *

The City of Kenosha, Wisconsin, with more than 500 acres of public parks and recreational areas, is its own best customer in utilizing the sludge produced at the municipal sewage treatment works. Chemical industrial wastes contained in the raw sewage have interfered somewhat with sludge digestion, but have been advantageous in primary sedimentation tanks and at the sludge drying beds.

Superintendent H. T. Rudgal has concluded that the disintegration of the dried sludge before application is largely responsible for the excellent results which have been obtained in treating lawns at the city parks and golf courses. A Royer Sludge Disintegrator (Model

NSC–2) has been employed for the past two years in reducing the sludge cake to pea size particles before utilizing it as a soil conditioner. Winter sludge, which has undergone freezing on the drying beds, has been found to disintegrate of its own accord upon thawing and drying, hence grinding of this sludge is unnecessary.

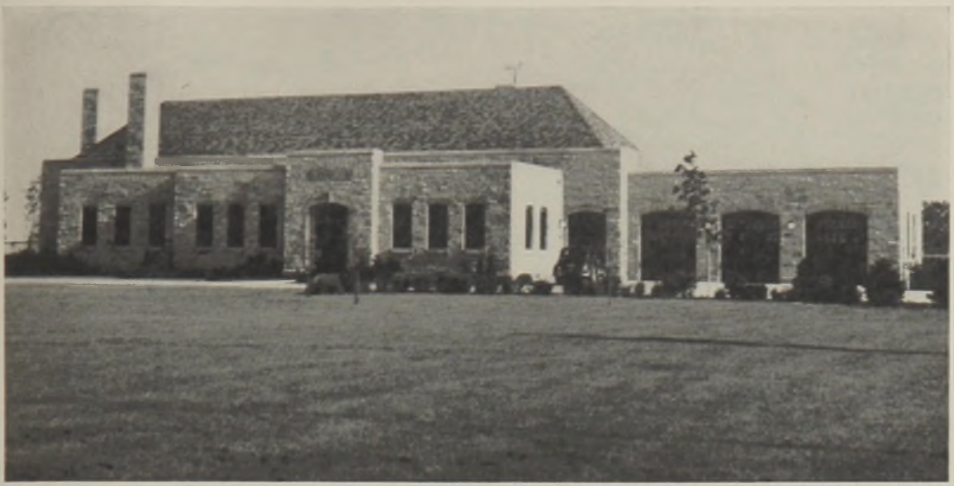


FIG. 1.—Administration building of Sewage Treatment Works at Kenosha, Wisconsin. Note "lawn that sludge built."

Figure 1 shows the fine lawn, developed by generous applications of ground sludge, at the Administration Building of the Kenosha plant.

* * *

Definite restriction in the use of strategic materials in paint manufacture has arrived. Aluminum pigment and paint were placed under complete allocation recently by the War Production Board and tung oil has been ordered withdrawn from many paint specifications. Supplies and availability of other constituents of paints are being considered by the Technical Coatings Advisory Committee.

Ersatz so!

* * *

Some extracts from the Report of the Committee on Safety Standards of the California Sewage Works Association:

Sufficient gas storage should be provided which would prohibit the formation of partial vacuums and the accompanying admission of air into the digestion compartments during sludge withdrawal. . . .

The interpretation of the rules of the Commission (State Industrial Accident Commission) should be modified so as to more carefully determine the classification of the hazardous locations. Definitely, all buildings or rooms of a sewage treatment plant are not hazardous from a gas explosion standpoint. Many plants have been required to install explosion proof switches and motors where the location is no more hazardous than the average home which has gas piping and gas appliances. There are several plants where explosion proof electrical equipment has been required with the switchboard located in a separate outside room, and yet a gas boiler and Bunsen burners are allowed in the so-called hazardous location. . . .

The regulations requiring housing of all belt, chain or gear driven equipment should be carried out to the letter, even though considerable extra inconvenience in operation be caused. . . .

While there is a strong temptation to smooth trowel all concrete floors in order that they may be cleaned more easily, a float finish is much safer from a safety standpoint. . .

Where steel grating is used, care should be taken that the grating lies flat and has sufficient bearing. . . .

Unless absolutely impossible, all plants should be provided with drinking water, a sink, plenty of soap and paper towels. The operator should be required to wash his hands thoroughly after any contact with the sewage, for at least one operator has contracted a severe case of amoebic dysentery from sewage contamination. An operator who chews tobacco or smokes a pipe on the job is really asking for trouble. . . .

Oil spilled on the floor is dangerous, and dirty windows and light globes tend to poor lighting. . . .

No matter how small the plant, there are always some duties which should not be performed by the operator without additional help. They include moving and connection of large chlorine containers and the lifting and moving of any heavy equipment, the cleaning of wet wells, manholes, digestion tanks and other places where sewage or chlorine gas is liable to concentrate. . . .

* * *

Writing to *Science* magazine (March 13, 1942), Mr. Roy Cross of the Kansas City Testing Laboratory suggests ordinary Portland cement as a satisfactory and foolproof substance for extinguishing small fires in oil, metals and other materials. Quoting Mr. Cross:

> In many cases in the writer's experience it (Portland cement) has been highly successful in extinguishing fires where water, carbon tetrachloride, foam and similar substances have been unsuccessful. This very common material, so easily available and so safe to use, should be placed at points where there is danger from fires, either from incendiary bombs or from normal causes.
>
> In our own laboratory, we provide such material easily available in kegs and find it more successful than the usual fire extinguishers. Furthermore, it gives off no injurious gases and is not in itself combustible. . . .

* * *

According to North Dakota's *Official Bulletin,* Superintendent Harley Quam of Lisbon, North Dakota, uses floats made of one-gallon glass jugs at a pumping station in which metal floats were short lived. The jug float is fitted with a rubber stopper and a collar with set-screw is clamped at the top for attachment to the float rod.

* * *

O. P. Rator says, "It will be a lot easier for us to find temporary substitutes for some of the articles and materials we have become accustomed to using, than it would be to develop an *ersatz* 'American way of life'!"

Editorial

A CENSUS OF SEWERAGE SYSTEMS AND SEWAGE TREATMENT PLANTS

The U. S. Public Health Service has just rendered a notable service to sanitarians by publishing a summary of census data on sewerage systems and sewage treatment plants in the United States. The summary is published in *Public Health Report,* Vol. 57, No. 12, for March 20, 1942. This summary is based on voluminous mimeographed tables which contain the detailed information for all towns over 100 population.

The summary data are presented in four tables, which show (1) the totals, by states, for sewer systems and disposal of raw sewage, (2) general data on sewage treatment, together with data on primary treatment, (3) secondary treatment, and (4) chlorination and sludge disposal.

The mimeographed tables include considerably more detailed information, comprising (*a*) rated design of treatment plants, (*b*) design population, (*c*) population equivalents of industrial wastes, where available, (*d*) details concerning methods of treatment followed at individual plants, (*e*) name of watercourse into which raw or treated sewage is discharged by each community, and (*f*) name of the drainage basin in which such watercourse is located. The mimeographed reports will probably be restricted in distribution, because of expense of preparation and bulk of some 10 pounds. They should be made available for state sanitary engineers, engineering offices of selected large cities, consulting engineers, and others who will appreciate their value.

The printed summary gives information that should be widely quoted, as it reflects the status, as of 1940, of sewage disposal in the United States. The tables contain interesting and, at times, curious facts. Who would have thought, for example, that there are 247 privately owned sewer systems in West Virginia and only 157 publicly owned? Or, further, that West Virginia has a total of 387 sewer systems (some of the above 247 plus 157 systems must be partly each type), whereas New York State has only 399 and Illinois 380?

The numbers of privately owned sewer systems in some other states are surprising. Alabama has 33 private and 122 public, Kentucky 35 private and 119 public, New Mexico 67 private and 36 public, Texas 55 private and 391 public and Pennsylvania 105 private and 525 public, whereas Illinois has no private systems, and 380 public, Ohio 4 private and 510 public, New York 37 private and 362 public, and Wisconsin 2 private and 282 public. The total for the U. S. is 747 private and 7,476 public.

Total sewered population is 75,728,000, of which 70,506,000 is estimated connected. Of the latter, a population of 29,889,000 is discharging raw untreated sewage. It is estimated that about 95 per cent of the urban population of the United States is served by sewer systems.

The distributions of separate and combined systems are sometimes surprising. For example, California has 340 separate and 5 combined, New Jersey 210 separate and 12 combined, New York State 311 separate and 38 combined, and Texas 438 separate and 7 combined, whereas Illinois has 206 separate and 169 combined, Indiana 71 separate and 193 combined, Michigan 115 separate and 149 combined, and Ohio 301 separate and 161 combined. Although the number of systems totals 6,444 separate and 1,445 combined, the relative populations are not given. It is probable that the prevalence of combined systems in most larger cities will result in larger populations connected to combined than separate systems, the reverse of the data on number of communities sewered by the two types.

Sewage treatment is reported for 5,085 communities, with a connected population of 40,618,000. Sedimentation is in use for the sewage of 15,097,600 people, of which 4,910,000 is treated in Imhoff tanks, 8,760,000 in separate tanks. There are 1,083 Imhoff tank plants and 405 separate sedimentation, indicating the larger number of Imhoff plants in use in the smaller communities.

Secondary treatment is provided for a population of 22,143,000. The estimated population of 4,012,775 reported connected to chemical plants seems relatively high, but includes such plants as (1) Minneapolis, making up a large part of Minnesota's five chemical plants totalling 956,000, although chemicals have never been used at Minneapolis, (2) Oklahoma, with 18 plants reported at 273,000 population, where chemicals are probably used rarely, (3) Colorado 307,000, mostly Denver, where chemicals have not been used except experimentally, and (4) Georgia, with 286,650 population estimated as having chemical treatment, out of a total of 384,500 connected. The data on chemical treatment in this report, as well as in other recent tabulations, seem to the writer to assign unduly large populations to chemical treatment, since it now appears that practically all chemical-type plants propose to use chemicals infrequently, if at all. Most of these plants should actually be designated as providing only primary treatment.

Activated sludge plants total 302, with 10,480,000 connected population, and trickling filters 1,486 with 8,425,000 connected population. The popularity of trickling filters for medium-sized communities is shown in the table by substantial connected populations in nearly every state in the union. Activated sludge leads, of course, in the larger cities.

Pennsylvania, aside from some of the southern and New England states, stands out as a relatively backward state in sewage treatment. The total sewered population is 6,478,000, of which the sewage of 4,770,000 is discharged untreated. A population of 950,000 is tributary to sedimentation plants, and only 696,000 to secondary treatment. When Philadelphia and Pittsburgh finally come to sewage treatment on an adequate scale, this record will be improved. Massachusetts, with Boston sewage untreated, and Missouri, with St. Louis sewage untreated, also make a poor showing.

There are 1,127 plants, with a connected population of 14,336,000, in which chlorination is provided. These impressive totals reflect the widespread use of chlorine as a guarantee of bacterial efficiency, where needed.

There are many further interesting conclusions that may be drawn from the data in this summary report. The data were checked by the sanitary engineering divisions of the departments of health in the various states listed. Summaries were prepared at the Cincinnati office of the U. S. P. H. S., under the direction of Associate Public Health Engineer Vernon G. McKenzie. The Cincinnati office, long under the supervision of Senior Sanitary Engineer W. L. Hoskins, deserves the thanks of the sanitary engineering profession for this informative and unique accomplishment.

F. W. MOHLMAN

Note. The detailed data are to be published in a number of issues of *Sewage Works Engineering,* beginning in the May, 1942, issue.

Proceedings of Local Associations

CANADIAN INSTITUTE ON SEWAGE AND SANITATION

Eighth Annual Meeting,

Kitchener, Ontario, October 16, 1941

Kitchener, Ontario was the setting for the eighth annual convention of the Canadian Institute on Sewage and Sanitation. The convention opened in the Walper House Hotel on the morning of October 16, 1941. As in previous years, the program was devoted to a number of written papers together with topics which were open to general discussion. This year's meeting proved quite successful and compared favorably with other years. The registration was 152 and the membership of the Institute at the conclusion of the meeting reached the total of 140.

The following papers were read at the convention:

1. *"The Sludge Disposal Problem"*—Dr. W. L. Malcolm, Director, School of Civil Engineering, Cornell University, Ithaca, N. Y.

2. *"Laboratory Control in Sewage Treatment Plant Operation"*—Dr. G. E. Symons, Chief Chemist, Buffalo Sewer Authority, Buffalo, N. Y.

3. *"The Grand River Conservation Project"*—

(*a*) M. Pequegnat, Supt. of Water Commission, Kitchener.
(*b*) A. L. Hanenburg, Sanitary Engineer, City of Kitchener.

4. *"Cleaning and Maintenance of Sewers"*—R. J. Desmarais, City Engineer, Windsor, Ont.

Dr. Malcolm discussed in his paper the various types of sludge resulting from different methods of sewage treatment, and outlined the composition and methods of handling these different sludges. An analysis was made of the average cost of treatment by the different methods.

Dr. Symons, in his paper, placed clearly before the delegates the importance of laboratory control in the operation of sewage treatment plants. He outlined the function of the laboratory and how this can best be adapted to plants of different sizes.

The two papers dealing with the Grand River Conservation project were of interest in that this work is nearing completion and is the first of this type in the Province of Ontario. It is designed to control the flow of water in the Grand River; to prevent floods in the spring and fall and to increase the dry weather flow in the summer. The importance of augmenting the summer flow is a major factor here as the river receives a large quantity of sewage. The inception of this scheme has meant a material saving in the degree of treatment required in the municipalities bordering on this water course.

The final paper of the convention, read by Mr. Desmarais, outlined the various methods of sewer cleaning in the larger cities and towns in Canada. It summarizes the different equipment used and the procedures followed.

A major feature of all recent Institute conventions has been the periods allotted to Guided Discussions. In these, subjects are selected and two persons are asked beforehand to lead in the discussion; others join in. These discussions always prove most instructive to the delegates. This year's subjects were as follows:

1. "*Sewage Treatment by Activated Sludge*"—Chairman, Wm. Storrie, Toronto.
2. "*Refuse Collection and Salvage of Wastes*"—Chairman, R. H. Parsons, Peterborough.
3. "*Sewage Treatment on Sprinkling Filters*"—Chairman, W. B. Redfern, Toronto.
4. "*Municipal Plumbing By-Laws*"—Chairman, H. C. Phillips, Hamilton.

Social activities at this year's meeting were not overlooked. A banquet was held on the evening of the first day. At this, motion pictures were shown of engineering works and discussions were given on matters of interest to the delegates. All this combined to make an enjoyable evening.

The business meeting of the Institute was held on Friday morning at which time the following officers were declared elected: *President*—W. L. McFaul, City Engineer, Hamilton; *Vice-President*—B. F. Lamson, City Engineer, St. Catharines; *Trustees*—H. D. Bradley, Street Commissioner, Toronto, and R. H. Parsons, City Engineer, Peterborough. A. E. Berry of Toronto was elected to the Board of Directors of the Federation of Sewage Works Associations.

An amendment to the Constitution of the Institute was adopted in order to bring the Constitution of the Institute into harmony with the Federation of Sewage Works Associations. No major changes were required with the exception that the type of membership was reduced to three, including honorary, active, and corporate members.

A. E. Berry, *Secretary*

KANSAS WATER AND SEWAGE WORKS ASSOCIATION

Fourteenth Annual Meeting,

Lawrence, Kansas, March 26–28, 1942

Eighty-four members and guests registered for the fourteenth annual meeting of the Kansas Water and Sewage Works Association.

The meeting opened on March 26 at 10:30 A.M. with an introduction by Sol Kunz, president of the Association. The secretary-treasurer's report was read by Lewis A. Young, acting secretary.

The papers dealing with sewage treatment were as follows:

"The Hays Submerged Biological Contact Filter Process of Sewage Treatment" by Clyde C. Hays.

"Sewage Disposal as Applied to Army Camps" by F. M. Veatch.

"Procurement of Chemicals During the War Period" by O. A. Collings.

"Priorities" by Elmer L. Hughes.

Of particular interest to all members were the discussion periods during which numerous questions relating to the wartime operation of municipal utilities were considered.

The papers by O. A. Collings and E. L. Hughes contributed valuable information in this connection.

Thirty-three members and guests went on the inspection trip to Osawatomie. Lunch was provided for the group through the courtesy of city officials.

New officers were elected as follows: W. O. Myers, Ottawa, *President;* J. P. Morris, Council Grove; W. E. Hoagland, Beloit; H. H. Kansteiner, Leavenworth; Wesley Cochran, Winfield, *Vice-presidents.* Lewis A. Young and Paul D. Haney, State Board of Health, Lawrence, continue as secretary-treasurer, and editor, respectively.

PAUL D. HANEY, *Editor*

Reviews and Abstracts

THE DISPOSAL OF WASTE ACIDS

By W. W. Hodge

Wire and Wire Products, January, 1940, p. 30

Methods for disposal of waste pickle liquor from the steel industry are classified as (1) simple disposal methods, (2) methods involving pretreatment but no by-product recovery, (3) processes for treating the waste pickle liquor and recovering by-products.

Under simple disposal methods involving no pretreatment, various concerns have tried running the spent liquors into (1) abandoned mines, (2) exhausted oil or gas wells, (3) evaporation ponds, (4) limestone caves, (5) porous earth or sand sumps near large bodies of dilution water, and (6) deep wells. Disposal into limestone caves and deep wells has not proved satisfactory except in one instance.

The simplest method involving pretreatment but no by-product recovery is that of neutralizing the free acid in the waste pickle liquor with lime or limestone, then pumping to large detention ponds. Where state laws require precipitation of iron as well as neutralization of free acid, the slurry may be pumped directly to detention ponds or the sludge first separated and the supernatant allowed to enter the plant sewers. Sludge is hauled to a dump. Neither method is considered entirely satisfactory by the steel companies. Other methods are the Travers process and one developed by the Dorr Company, both of which involve the use of limestone.

About forty processes involving by-product recovery are available for waste pickle liquor treatment. These vary from treatment for recovery of copperas ($FeSO_4 \cdot 7H_2O$), the most common and oldest method in use, to the manufacture of sulfuric acid and iron oxide. The copperas recovery method involves treatment of the spent liquor with scrap iron for conversion of the free acid to ferrous sulfate. The copperas is recovered from this solution by evaporation and crystallization. Markets for copperas are limited.

Considerable attention has been directed toward the manufacture of ammonium sulfate and iron oxide from pickle liquor and the ammoniacal liquors from by-product coke works.

The more important unit operations in the sulfuric acid-iron oxide recovery systems are (1) neutralization of the pickle liquor with iron oxide, (2) evaporation with recovery of ferrous sulfate monohydrate ($FeSO_4 \cdot 1\frac{1}{2}H_2O$), (3) roasting of the ferrous sulfate together with the proper amount of iron pyrite to form sulfur dioxide, (4) conversion of sulfur dioxide to sulfuric acid. A portion of the iron oxide recovered from the sulfate-pyrite roast is recycled to the process, the remainder being sintered to a form suitable for charging into the blast furnace.

The "Ferron" process involves treatment of the pickle liquor with lime. The products of neutralization are ferrous hydroxide and calcium sulfate. These precipitates are filtered, mixed with a filler such as paper, asbestos or clay, extruded and dried. The resulting product, Ferron, can be sawed and machined into various types of building material.

Polishing rouge and paint pigments may be made from pickle liquor.

In selecting a treatment process factors which have to be considered are: quantity of spent liquor produced; percentages of free acid and iron sulfate; state and local laws regarding atmospheric and stream pollution; possible markets within reasonable shipping distance for the by-products recovered; costs for constructing and operating the plant for treating the waste pickle liquor.

The author's experience has indicated an upward trend in the use of waste pickle liquor and iron salts obtainable therefrom in connection with the purification of water supplies, the treatment of sewage and certain organic industrial wastes. At Kent, Ohio, waste pickle liquor is used as a coagulant at the municipal water purification plant. At the Shades Valley sewage treatment plant, Birmingham, Alabama, chlorinated copperas is employed as a coagulant. The copperas is obtained from a nearby wire mill. The plant flow sheet indicates the use of flash mixing, flocculation, primary and secondary sedimentation, and two-stage digestion units with provision for sludge return to the mixing basins.

Nineteen references. Twenty-three photographs. Three flow sheets. The discussion following the paper is reported in full.

PAUL D. HANEY

NOMOGRAPH FOR THE SOLUBILITY OF CHLORINE IN WATER

BY D. S. DAVIS

Ind. and Eng. Chemistry, 33, 1202 (Sept., 1941)

From recent data on the solubility of chlorine (Whitney and Vivian, *Ind. Eng. Chem.* 33, 741 (1941)) a nomograph was constructed from which solubilities corresponding to any temperature from 10°–25° C. and pressure from .06 to 1.0 atmospheres can be quickly and accurately obtained.

E. HURWITZ

NEW SANITARY SEWAGE FACILITIES FOR SAN DIEGO

BY B. D. PHELPS AND R. C. STOCKMAN

Civil Engineering, 12, 17 (January, 1942)

The conditions in San Diego Bay were made unbearable through the emptying of nine separate outfalls carrying untreated sewage. Thirteen other outfalls empty into the Pacific Ocean through antiquated settling tanks. As a result of an extended bacteriological survey of San Diego Harbor and Bay, a brochure was prepared emphasizing the unsanitary conditions and the proximity of the government naval bases to these hazardous health conditions. Through the cooperation of the Commandant of the Eleventh Naval District, the projects for sewage collection and treatment were put on the W.P.A. National Defense list. Application was immediately made for a sewage treatment plant to handle 15 m.g.d. based on the population of 200,000, together with a new outfall sewer and inceptor. As a result of great expansions in the aircraft industries and army and navy training camps in the vicinity of San Diego, the plans had to be entirely revised during the past year to increase the capacity of the plant to handle a population of 375,000 and a maximum flow of 31.9 m.g.d. The treatment plant will employ chlorination for odor control, comminution of solids, grit removal, aeration and vacuum for removal of scum and grease, combined flocculation and sedimentation, separate digestion of sludge, scum, and grease, elutriation, and thickening of digested sludge, vacuum filtration and flash drying of digested sludge. The novel feature of the plant arises in the method adopted for grease removal. After a brief period of aeration, the sewage passes to two concrete vacuum tanks 35 ft. in diameter with a 10 ft. water depth. A vacuum of about 10 in. mercury is supplied to these tanks to assist in the flotation of scum and grease. Each tank is equipped with a mechanism for skimming off scum and scraping out sludge. The scum will be pumped to the digesters, and the sludge kept in the sewage to pass through the flocculators. Pilot plant tests have indicated that approximately 30 per cent of the suspended solids in the raw sewage may be removed by the vacuators. The sludge filter cake will be dried from a water content of 70 per cent to 10 per cent by intimate mixing with hot air in a flash dryer. All odorous gases will be heated to 1,300° F. to eliminate odors. Heat is to be supplied by the combustion of digester gas. The effluent from the plant will be discharged into San Diego Bay through a concrete pipe 42 in. in diameter in parallel with a vitrified tile pipe 24 in. in diameter. The ends of the outfalls will be 45 ft.

below high water and have three multiple vertical outlets on the 42-in. pipe, and a single outlet on the 24-in. pipe. These pipes will extend 1,200 ft. from the quay wall. Sufficient land had been acquired to more than double the plant in the future. This will permit addition of similar units, or units for additional treatment if ever required, adjacent to the present plant. Since the plant was finally approved, two more large federal housing projects have been announced, the aircraft factories have received larger orders, and it is rumored that some of the naval and military establishments may be enlarged. A total of $4,253,966 has been allocated to date for the control of the sewage collection and treatment problems made so acute by national defense.

Rolf Eliassen

SEWER DESIGN BY APPROXIMATE FLOOD ROUTING AS APPLIED TO AN ARMY CANTONMENT

By R. L. Fraser

Civil Engineering, 12, 102 (February, 1942)

By applying the method of the routing of a "design flood" down rivers and through flood control dams to sewer design at an army cantonment, the author was able to predict with some degree of accuracy the peak flows to be expected at a treatment plant at the end of a long sewer system for an army camp with a population of 20,000. Simplification of the computations of the ordinary flood-routing technique was accomplished by assuming the shape and the quantity of the "design flood" at its origin in the upper reaches of the collection system by taking the hydrograph from a single barracks of 63 men as a basis, or 6.5 gal. per capita reaching the sewers during the early wash-up period to occur in 30 minutes following breakfast. The base flow from the cantonment was also considered as this included infiltration and intermittent discharges throughout the whole day. The author presents computations for determining the base flow from army data. The calculated hydrograph was obtained by superimposing flood discharges on the base flow. These flood discharges occurred during the morning, noon, and evening wash-up periods. This data is useful in the design of pumping stations, treatment plants, and other structures. This method could also be applied to municipal districts, in which cases the hydrograph from individual houses or a combination of houses can be assumed within reasonable accuracy. As the average time of flood discharge into the sewerage system is fairly stable for various districts within a municipality, hydrographs for residential, industrial, and business districts can be used in combination. This method of flood routing is flexible enough to take into account these various factors with few additional calculations.

Rolf Eliassen

BUFFALO SEWAGE WORKS HAS MODERN LABORATORY

By G. E. Symons

Civil Engineering, 12, 95 (Feb., 1942)

The Bird Island Laboratory of the Buffalo Sewer Authority was organized in 1936 to ascertain the extent of pollution of the Buffalo and Niagara Rivers by Buffalo sewage, the purification necessary to meet the standards set for the latter by the International Boundary Commission, and to furnish the designing engineers with information on sewage conditions and strength for use in the design of the treatment works. A temporary laboratory was first constructed and was in operation for 27 months while the treatment plant itself was under construction. The work was divided into 5 classes:

(1) *Boundary Waters.* Studies were conducted on all the streams, rivers, lakes, harbors, and canals in and about the City of Buffalo for the purpose of obtaining information on existing pollution, and on the raw water intake for the City of Niagara Falls.

(2) *Sewage Quantities and Characteristics.* Data was obtained on the volume of sewage, quantity of suspended matter, chlorine demand, and storm effects on all of the larger sewers and sewer districts in the city to aid the engineers in the design of intercepters at treatment plant structures.

(3) *Industrial Wastes.* Fourteen individual industries were studied to obtain data on the volume and character of the wastes, to ascertain any effect of these wastes on sewers and disposal plant structures, and to determine the sludge load of the industrial population.

(4) *Research.* Chlorination studies were made to determine the appropriate chlorine contact time, methods of determining chlorine demand, effect of dilution on chlorinated effluent, and other related problems.

(5) *Special and Miscellaneous Problems.* These included tests on materials which were being used by the contractors in the construction of the plant and other special problems.

The cost of operation of this experimental laboratory for 27 months was $50,000, including construction and equipment, supplies, salaries, and operating expenses.

The permanent laboratory in the new plant was designed by the staff of the laboratory, with the assistance of the consulting engineers and their specialists. This laboratory cost approximately $28,000 for the major equipment and supplies, all of the building's superstructure being included in the plant contract. Separate chemical and bacteriological laboratories are provided, as well as a preparation laboratory, a storage room, and an office. At present, the staff of the laboratory consists of ten persons, including the samplers. The laboratory has been approved by the New York State Department of Health as a water analysis laboratory, in addition to its regular duties in sewage analysis.

Samples from the sewage treatment works are collected from 24 points. These samples include raw sewage, grit-free sewage, settling tank influent, effluent, raw sludge, digested sludge, supernatant liquor, sludge filter cake, ash and others. Analysis of 24-hour composites of these samples are made daily, and bacterial tests are made on fresh samples at six different hours on both raw sewage and chlorinated effluent. In addition to routine chemical and bacteriological testing of sewage, and the analysis of materials purchased on contract, the laboratory has continued monthly surveys of the Buffalo and Niagara Rivers, and has pursued investigations on 60 problems concerning plant operation, stream pollution, research and industrial wastes. The cost of operation of the laboratory has been about $25,000 a year, or about 50¢ per million gallons of sewage treated.

ROLF ELIASSEN

THE GREASE PROBLEM IN SEWAGE TREATMENT

BY A. L. FALES AND S. A. GREELEY

Proceedings, A. S. C. E., 68, 193 (February, 1942)

The authors have surveyed the grease problem of municipalities throughout the United States and have recited data acquired in experimental work in many plants. The main contribution of the article is in the long bibliography and a brief abstract of the pertinent data from each of these articles. Beginning with a definition of grease the material including fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oils, and other non-fat material, and the sources of grease in sewage, the authors describe the characteristics of the component parts of grease, the effect of grease on receiving waterways, and the effect of grease on the sewage treatment plants. Following this introduction the authors describe the tests for determining grease in sewage, including the use of the three common fat solvents, petroleum ether, ethyl ether, and chloroform, and their effect on the extraction of grease. Various techniques of extraction are also discussed. Tables are presented to indicate the quantities of grease present in a number of domestic sewages using the different solvents. These varied from approximately 10 p.p.m. to 500 p.p.m., depending upon the nature of the industrial wastes mixed with the sewage.

A survey of the methods practiced for removing grease from sewage is presented. These include two general methods of grease separation, namely, by the installation of separate tanks or other devices especially designed to retain grease and other floating matters, and by the collection of such materials as they float on the surface of sedimentation tanks or settle to the bottom with sludge. Separate skimming tanks have been installed in a number of plants, while the use of scum-removal equipment on sedimentation tanks is standard practice in modern sewage treatment. The removal of grease in settling tanks has been shown to vary from 8 to 72 per cent as indicated by the data presented by the authors, on raw sewages having grease contents of 43 to 80 p.p.m. From the data it appears that no definite relation exists between detention period and removal of grease at the different plants. The use of aeration prior to skimming is discussed at some length and data are included to indicate that the application of small quantities of air, as low as 0.023 cu. ft. per gal., would remove more of the grease, provided aeration was performed for from 2 to 10 minutes. Various results were obtained, with reductions of from 34 to 75 per cent of the grease in raw sewage containing from 60 to 200 p.p.m. of grease. The results of experiments by other authors using the aero-chlorination method are mentioned. Indications are that removals from 149 per cent to 847 per cent of the removals, when air alone was used, were achieved by the use of chlorine injected into the air pipes serving the grease-removal tank. In some experiments on the recovery of grease from wool-washing wastes, it was found that the fats were in an emulsified state, protected by a gelatinous nitrogenous colloid, and that chlorine destroyed this protective colloid, allowing the liberated grease to be recovered by flotation and skimming. Other methods of grease removal are cited, including the use of grease traps, and the removal of grease from sewage by acid treatment. Mention is made of the disposal of grease by recovery, burial, incineration, or digestion with other sewage solids. The authors conclude that the quantity of grease found in sewage by the present standard method of analysis is largely dependent upon which of the three standard solvents is used for extraction. Differences in the solvents used may lead to confusion when an attempt is made to compare the grease content of sewages of different cities. The following steps appear to be desirable: (1) Agreement upon an answer to the question as to what substances should be included in the term grease; (2) adoption of a standard method which is most suitable for determination of grease in sewage as thus defined; and (3) accumulation of data on grease in sewage, effluents, and sludge, based upon this standard method.

Rolf Eliassen

DISCUSSION OF THE GREASE PROBLEM IN SEWAGE TREATMENT

By A. D. Weston

Proceedings, A. S. C. E., 68, 269 (Feb., 1942)

The need for adequate means of grease removal in the partial treatment of sewage is well illustrated by the discharge into Boston Harbor and its tidal estuaries of some 244 M.G.D. of sewage from a contributing population of about 1,840,000 persons in the Boston Metropolitan area from three different outlets. The sewage was chiefly of domestic origin. Analyses of this sewage were made during the period 1935–1936 and indicated that the suspended solids varied from 119 to 256 p.p.m., the B.O.D. from 119 to 249 p.p.m., and the ether-soluble fats from 34 to 83 p.p.m. Definite nuisances have prevailed in the diluting body of water from bacterial pollutions and from slick or sleek fields. Studies made under the direction of the author showed sleek areas as large as 2,940 acres from the Boston Main Drainage System, 2,050 acres from the North Metropolitan Sewerage System, and 6,820 acres in connection with the South Metropolitan Sewer System. These areas are not only esthetically objectionable because of the use of the harbor waters for yachting and recreation, but the floating solids, consisting of wood, oil, grease, soap, and other debris, have been known to reach shore areas highly developed as summer resorts and bathing beaches and areas normally well-suited for the growing of shellfish.

The author presents considerable data of the use of fine screening, grease removal, and plain sedimentation on the various sewages from Boston. Much of the data do not pertain to grease removal but are on the effect of various detention times on results of plain sedimentation experiments. It appeared that plain sedimentation alone would remove from 30 to 40 per cent of the grease on the basis of two hours detention, and raw sewage grease content of from 40 to 60 p.p.m. The principal experiments of interest from the grease standpoint were conducted on the sewage from Salem and Peabody, Mass., where there are many canneries and other industries having wastes containing considerable quantities of fats. This sewage had a suspended solids content averaging 600 p.p.m. and a grease content averaging 100 p.p.m. Using a detention period of 10 minutes, the removal of grease was 57.9 per cent; applying air for 7 min., followed by quiescent settling for an additional 7 min. the fat removal was only 57.3 per cent, approximately the same as with no air. Tests were made by adding sodium chloride in the amount of 6.75 lb. per 100 gal. of sewage. A removal of 60.9 per cent of grease was accomplished after settling sewage for 7 min. whose fat content was 46 p.p.m. The use of salt plus aeration for a period of 7 min. with 0.18 cu. ft. of air per gal. of sewage, followed by quiescent settling for 7 min. reduced the fat content from 46 to 12 p.p.m., a reduction of 74 per cent. Applying 10 p.p.m. of chlorine to sewage containing 90 p.p.m. of fats, followed by settling for 7 min., reduced the fat content 62.2 per cent. Using the same chlorine dosage, followed by aeration for 7 min. at the rate of 0.18 cu. ft. of air per gallon of sewage, and settling for 7 min., reduced the fat content to 35 p.p.m., or a reduction of 61.6 per cent showing no advantage of the air in this case. The addition of 46.5 p.p.m. of chlorine to a sewage having a fat content of 30 p.p.m., followed by aeration for 7 min. at the above rate of air application, and the 7 min. settling, resulted in a fat removal of 86.7 per cent, the best result achieved thus far, particularly in view of the low grease content of the raw sewage in this case. The results of these analyses confirm the results of the experiments made on sewage discharged into Boston Harbor, in that the additional amount of removal of fats by aeration did not appear to warrant the addition of aeration to plain sedimentation of the sewage without further treatment for removal of grease.

Rolf Eliassen

SLUDGE BOAT "NAVY" DEFIES SUBMARINE MENACE

Engineering News-Record, 128, 165 (Jan. 29, 1942)

The menace of submarines off the Atlantic Coast has interrupted the schedule of the sludge disposal system of the City of New York, Department of Public Works. Ordinarily, three sludge boats carry liquid sludge from the several sewage treatment plants in the City for disposal at sea. Approximately 4,000 wet tons of sludge per day are produced at the treatment plants served by these boats. The vessels were not permitted to leave the harbor by federal authorities and inasmuch as provision for storage of sludge is not available at the treatment plant to any extent, arrangements had to be made for dumping elsewhere. The waters of the Long Island Sound were selected for this purpose for approximately 10 days, after which time the government granted a permit for the ships to dispose at sea again. The dumping of 4,000 tons of sludge per day in Long Island Sound would soon have met with serious objections.

Rolf Eliassen

INTERSTATE SANITATION COMMISSION 1941 ANNUAL REPORT

The policy of the Interstate Sanitation Commission, comprising Connecticut, New York and New Jersey, has been to encourage the building of sewage treatment works rather than issue peremptory orders. During the five years of its existence the Commission has attained its goal without a single court action. Four times as much pollution is removed from the District now as was being removed in 1936. Twenty-seven sewage treatment works are in operation and seven under construction. The most serious barrier to pollution abatement continues to be the problem of financing the construction of treatment works. During the present year Connecticut has joined the Commission. The area added by Connecticut is large and contains important industries and municipalities. Although the number of sewage treatment works placed in operation during this year is not as great as in other years, actually the Commission has consolidated its position.

The protection of public health cannot be diminished during the period of national defense but plays an important role in it. The Army and Navy actually support this health program by the construction of sewage treatment works within the District.

Finance.—During the first six months of the fiscal year the Commission functioned on an annual budget of $24,500. This amount was totally inadequate for the normal duties of the Commission and necessitated the curtailment of necessary functions during this period. During the height of the summer recreational period normal inspections were resumed. Beginning July 1, the appropriations were $15,000 from New York and New Jersey and in October the Connecticut quota of $3,333 became available. Expenditures have been reduced to a minimum and the best use possible is being made of the funds available.

Activities.—In September, 1941 the Tri-State Compact creating the Commission came into full fruition by the joining of Connecticut.

The two important functions of the Commission are: (1) The control of future pollution and (2) the abatement of existing pollution. The laws of New York and New Jersey provide that no new source of pollution shall be created within the District after April, 1935. The law provides that the Commission, after a hearing, may issue orders relating to any pollution which will best serve the public interest. During the past year thirteen cases have been considered.

The request of the City of New York for the construction of sewers in the Borough of Brooklyn, which will be ultimately diverted to the Owl's Head sewage treatment works now under design, was granted. The request of the Navy Department that during the construction of Naval Supply Depot at Bayonne, N. J. it be permitted to discharge sewage, pending the construction of sewage treatment works, was granted.

Investigations by the Commission's staff disclosed that the City of Elizabeth had been discharging all but one million gallons of its sewage daily into the waters tributary to the District without treatment and that the city could avail itself of an existing plant by paying a proportional share of the operation cost. By merely breaking down a small bulkhead seven million gallons of sewage could be treated forthwith. An order was issued to cease the discharge of untreated sewage. The seven million gallons of sewage is now being diverted to the Joint Trunk Sewer.

Other activities consisted of (1) keeping informed on the progress by municipalities to assure adequate funds for the construction of required treatment works, (2) co-operating with various agencies, mainly the State Department of Health, conservation departments, local health departments and municipalities for the abatement of pollution. The plants that cannot be built during the emergency will serve as a Public Works Reserve in the period following the war. In this project the Commission is co-operating with the Federal Agency.

Plant Investigations.—Routine plant investigations were continued from spring to fall for the purpose of determining whether the character of the effluents meets the standards fixed by the Tri-State Compact. Various defects in the operation of the plants were disclosed as a result of these investigations. The most common violation is the failure of the plant to maintain sufficient chlorination to provide adequate sterilization.

Municipal Financing.—The Commission has participated actively in the formulation of ways and means to finance projects for the abatement of pollution. In drafting legislation for the financing of sewage construction works, the Commission does not indorse tax assessment but a sewer rental charge. This scheme, though eminently successful elsewhere, has not found response in the East. The City of Englewood, N. J. in taking over the private sewerage company has continued the charges that the company made as a sewer rental. The result has been successful and is not only maintaining the treatment works but is able to set up a fund from it for improvements and capital expenditures.

Financing of sewage treatment works in New York City by sewer rental is favored by Commissioner Huie of New York City.

Abatement of Pollution.—During the past year several factors have made it difficult to proceed with the construction of sewage treatment plants. Among these are: (1) Decrease of unemployment affecting the supply of labor for W.P.A. projects, and (2) war activities diverting the attention of local authorities and consideration of sewage treatment works as superfluous during the emergency. The Army and Navy have, however, realized the necessity of pollution abatement by investing huge funds in treatment works. The attitude of the Army and Navy regarding this problem should convince municipalities of the necessity of sewage treatment works even during the emergency.

During the past year the following sewage treatment works have been placed in operation: Harmon Shops, Coney Island Extension, Mitchell Field, Bedloe's Island, Republic Aviation Corp. in Nassau Co., and Fort Hancock (N. J.). Construction is now going on at U. S. Naval Ammunition Depot at Iona Island, N. Y., U. S. Naval Supply Depot and Drydock at Bayonne, N. J., and the U. S. Army treatment plant for a portion of Fort Wadsworth, N. Y. Municipal plants under construction include: Freeport, Irvington-on-Hudson and in New York City, Bowery Bay extensions, City Island, 26th Ward and Jamaica.

When all the sewage now being discharged into the Interstate Sanitation District is adequately treated an estimated 495 tons of dry sludge per day will be removed. Of this, 63 tons per day were being removed in 1931. By 1936 the removal had been increased to 69 tons per day and in 1941 to 312 tons.

Types of Plants Put Into Operation

1. *Coney Island Extension:* Sedimentation supplemented by chemical precipitation during the summer months.

2. *Harmon Shops:* Serving a population of 1,300 with a flow of 400,000 gallons. Sewage (10 per cent sanitary and 90 per cent industrial wastes from New York Central Railroad) is treated by prechlorination, settling, mechanical sand filter and open sludge beds. The design capacity of the filter is 500 g.p.m.

3. *Bedloe's Island:* Septic tank—effluent discharging to Class B water requiring no chlorination.

4. *Fort Hancock:* Designed for a population of 5,500. Settling tanks with mechanical cleaning equipment, separate sludge digestion (unheated) post chlorination and open sludge beds.

5. *Fort Wadsworth, Staten Island:* Septic tank for temporary treatment of sewage from dock area.

6. *Mitchell Field, Long Island:* Design population 6,000. Treatment facilities consist of settling tanks with grease separators (air), mechanical sludge removal, heated sludge digesters with floating covers, chlorination, percolation beds and glass covered sludge beds.

7. *Republic Aviation Corp., Long Island:* Design population 10,000 on the basis of 33 gallons per capita per day. Treatment facilities consist of primary settling tanks, prechlorination, dosing tank for six intermittent sand filters and percolation beds.

The plants under the jurisdiction of the Commission were visited once or twice during the season for a period of a day, composite samples being taken from 8 a.m. to 4 p.m. The results of these analyses including pH, suspended solids, settleable solids, B.O.D., residual chlorine and coliform organisms are given. Included in the tables is also a rating for each plant based on whether the effluent came within the Tri-State Compact requirement. Of the 60 sewage plants investigated 38 were found to comply with the provisions of the Compact, both as to removal of suspended solids and effluent disinfection (Group I.) This group includes all ten new plants investigated as well as nine plants that last year failed to meet those standards by a narrow margin. There were five plants in Group II which embraces plants meeting the requirements in earlier investigations but which need some minor extension or improved operation. Seventeen plants have been placed in Group III because of either grossly overloaded conditions or need of major improvements. These include Englewood Cliffs, Freeport, Keansburg, Larchmont, Long Beach, Mamaroneck District, New Rochelle, Dyckman Street plant in Manhattan, Far Rockaway, Piermont, Port Jefferson, Rye, and North and South Yonkers.

H. Heukelekian

THE CONSTRUCTION AND OPERATION OF A SINGLE-STAGE DIGESTION TANK

By W. F. Snook

The Surveyor, 100, 133–134 (October 17, 1941)

The author describes the construction features and operation of a shallow, open digestion tank at the Romford-Hornchurch joint works, which was provided as a temporary expedient in lieu of an expensive permanent sludge digestion installation. Former sludge disposal practice comprised pumping raw sludge and sludge from settled trickling filter effluent onto some 60 acres of farm land and ploughing in the sludge. Aerial nuisance required cessation of this practice.

The tank, 150 by 100 ft. in plan and 11 ft. deep, was excavated in sandy loam. The bottom of the excavation was firm and not concreted. Concrete retaining walls 3 ft. high were placed (in the excavation) and the balance of the walls made of compacted earth excavation. Two separated water (supernatant liquor) manholes were provided with 5 openings at 1 ft. intervals above the bottom.

The cost of the tank construction including inlet and outlet connections is given at £460.

During the period April 1, 1940 to March 31, 1941, a total of 10,994,624 gal. of sludge were pumped to the tank and 4,041,212 gal. of water removed. Raw sludge contained 95.6 per cent moisture, 73.2 per cent volatile matter, 24.6 per cent grease and had a pH of 6.2. Digested sludge samples contained 96.2 to 96.4 per cent moisture; 66.4 to 64.9 per cent volatile matter and 15.1 to 8.39 per cent grease, with a pH of 7.0.

The tank was put into operation in October, 1939, when the sludge had a temperature of 47° and a pH of 6.4 and smelled foul. Lime was added in May, 1940 to raise the pH and by the end of July the temperature stood at 60°. Under these conditions the sludge appeared to digest well. During the winter of 1940 the sludge temperature dropped again to 47° and the pH to 6.8, but the temperature and pH rose again in June, 1941 without the addition of lime and without odor nuisance. Arrangements are provided for mixing fresh sludge with digested sludge within the tank by pumping and recirculation.

K. V. Hill

TODMORDEN SEWAGE DISPOSAL WORKS

By T. S. Wall

The Surveyor, 100, 149–150 (October 31, 1941)

The population of Todmorden is 22,000. The original works were put into operation in 1908 and consisted of screens, detritus tanks, storage tanks, chemical precipitation tanks and primary and secondary contact tanks. Sewage up to 3 times D.W.F. was pumped to the precipitation tanks and storm water in excess of this volume up to 6 times D.W.F. gravitated to storm water tanks.

In 1926, the contact filters becoming sludged up, alterations were made to the plant including installation of mechanically raked screens, mechanical cleaning arrangements for the detritus tanks, construction of percolating filters with rotary distributors, rehabilitation of the contact filters and construction of humus tanks. Sludge was disposed of by filter pressing.

In 1940, the works were again enlarged and rehabilitated so that they now comprise:

Screens: 2 mechanically raked 6 ft. wide with ½-inch openings.
Detritus Tanks: 2, each with capacity for one hour's D.W.F. (50,000 gallons) grit is removed by a travelling Stott's dredger.
Storm Water Tanks: 2, each 100 ft. × 38 ft. × 5.5 ft. with total capacity of 4 hours D.W.F.
Sedimentation Tanks: 8, each 96 ft. × 42 ft. × 7 ft. providing total detention period for one day's D.W.F.
Filters: Varying sizes 153 ft. to 39 ft. in diameter, total area 2.06 acres, 4 ft. deep.
Humus Tanks: 3, each 117 ft. × 24.5 ft. × 4.5 ft. providing 5 hours detention of D.W.F.
Sludge Beds: 4,500 square yards.
Sludge Digestion Tanks: 3, each 150 ft. × 90 ft. × 4.75 ft. unheated and with no provision for stirring.

The digestion tanks have capacity equivalent to 2 years' detention. This liberal capacity was provided to allow the sludge to become thoroughly digested at atmospheric temperature and because of the lack of available space at the works for storage of sludge. The sludge drying beds are not used unless there is a demand for dried sludge.

K. V. Hill

SEWAGE SLUDGE AS A MANURE

An Editorial

The Surveyor, 100, 161 (November 14, 1941)

The editor discusses information presented in a paper by H. T. Cranfield, Advisory Chemist to the Midland Agricultural College, on "Manurial Value of Sludge." The editor indicates two points regarding fertilizers: (1) for good crop production, organic matter is necessary, and (2) sewage sludge is a valuable source of this organic matter.

Cranfield expressed the opinion that sewage sludge from drying beds has about two-thirds to three-quarters the value of farmyard dung, weight for weight. The editor computes the value of sludge from a sewered population of 30,000,000 people as equivalent to over 1,500,000 tons of farmyard dung per annum, and states that under present conditions the use of this material should be pushed. He decries the lack of publicity to urge the use of sludge as fertilizer and cites various cases where it could be used to great advantage. Failures with sewage sludge are due, in his opinion, to poor farming and injudicious use of the sludge.

K. V. Hill

POST WAR LABORATORY PLANNING AND EQUIPMENT FOR SEWAGE PURIFICATION WORKS

By Reginald W. Covill

The Surveyor, 101, 75–76 (February 27, 1942)

The article is accompanied in its original form by five photographs and one sketch showing details of the arrangements and general dimensions, respectively. The laboratory described was installed at the Carlisle sewage works in 1937.

The laboratory was planned and equipped for chemical, biological and bacteriological work. The inside dimensions of the laboratory are 34 ft. by 17 ft.; the northeast corner is partitioned off for a balance room about 7 ft. by 6 ft. in plan and contains one window. Wall benches 3 ft. wide occupy the north and south sides of the room. Walls, ceilings and doors are painted a cream color.

The north wall bench was allocated to determinations utilizing "fixed" pieces of apparatus, including still-oven, air-oven, gas-heated furnace, distillation apparatus and distilled water apparatus. This bench contained also a large all-purpose sink. Another section of the bench was allocated to colorimetric estimation of ammonical and albuminoid nitrogen.

The south wall bench was devoted to biological and bacteriological work and was fitted with a sink and fume hood.

A center bench, 15 ft. long by 5 ft. wide was provided and fitted with a 2-tier reagent stand and sink at one end. The north side of the bench was for routine sewage analyses of oxygen absorbed and B.O.D. The south side of the bench was for research work and was fitted with a centrifuge and Soxhlet fat extraction apparatus.

Forty-five cabinets were provided in the benches in addition to a separate apparatus case.

K. V. Hill

HIGH RATE DOSING OF GRAVEL BEDS

By John T. Thompson

The Surveyor, 101, 85–87 (March 6, 1942)

The author describes experimental work with high rate dosing of trickling filters at Leeds. There are 36 acres of trickling filters at Leeds 6 ft. deep: except for 2 acres the filters are of water worn gravel 1 to 3 in. in size. Experience at Leeds indicates that the natural gravel is very permanent, that it provides somewhat less purification due to its smoothness than clinkers or coke, and that filters constructed of natural gravel are less likely to pond. Long experience with these filters indicates two things: (1) that the percentage purification measured by 4 hours' oxygen absorbed is about 60 per cent and (2) that this same percentage purification would obtain were the load to be considerably increased.

Experiments were undertaken to determine the reserve capacity of the filters and to find out the effect of high rate dosing upon their performance. The period of the experiments was approximately 2½ years.

The two experimental filters used were 8 ft. in diameter and contained 6 ft. of gravel 1 to 4 in. in size and were dosed with 2-arm rotary distributors. A 3 months' period of tuning up (May to August) at a rate of application of 200 gal. per cu. yd. was required before nitrates appeared in the effluent.

One filter (Bed. No. 1) was then dosed at 250 gal. per cu. yd. and its performance observed under various seasonal temperature changes and rest periods. Cold weather caused the organisms to withdraw into the bed and ponding resulted. A light wooden cover was placed over the bed and this encouraged the growth of certain worms (which are photofugic) which help to clean the filter material. The author's conclusion was that with a filter media of the size in this filter (1 to 4 in.) the maximum dosing rate to avoid ponding in cold weather was 140 gal. per cubic yard.

The second filter (Bed. No. 2) was operated for 5 periods at rates varying from 200 to 750 gal. per cu. yd. with various clogging conditions taking place. The filter media was then removed and regraded to 2 to 4 in. and the distributor converted to a 4-arm machine. The filter was then operated for 3 six-months' periods at 750, 900, and 1,200 gal. per cu. yd. with much less ponding than occurred in the first filter or in this unit with the finer media.

Analytical data included with the article indicate nitrates always present in the effluent of Bed No. 1 which was dosed at 250 gal. per cubic yard. Nitrates disappeared from the effluent of Bed. No. 2 when the dosage rate reached and exceeded 750 gal. per cubic yard. The work done by Bed. No. 1 as measured by the pounds of oxygen absorbed removed per cu. yd. appeared to be about 1.2 lb. per cubic yard. The pounds of oxygen absorbed removed per cu. yd. in Bed No. 2 varied with the rate of dosing as follows:

Lb. Oxygen Absorbed per Cu. Yd.	Average Dosing Rate Cu. Yd. per Day
0.96	186
1.43	327
1.72	464
1.61	286
2.28	536
2.49*	536
2.73	643
3.91	857

* Size of filter media increased.

K. V. Hill

HAS THE USE OF THE ACTIVATED SLUDGE SYSTEM BEEN JUSTIFIED?

By A. E. Berry

The Canadian Engineer (*Water and Sewage*), 80, 17 (Feb., 1942)

There are numerous methods available for sewage treatment, there having been less standardization in this field than in the case of water treatment. The choice of treatment for Canadian plants has been influenced by both British and United States practices. In recent years the relationship between American and Canadian design has been more pronounced. The dual influence has resulted in treatment works of all kinds being installed in this country.

Despite advances made over a period of years there are many old works that are still functioning and producing satisfactory effluents. Basic principles of treatment have not changed so rapidly as have the equipment and technique needed to utilize these established procedures most readily.

Two attitudes as to the degree of treatment necessary are found, both somewhat extreme. One is the view that all surface streams should be protected against use for the disposal of sewage or other wastes; the other is that full use should be made of surface waters to deposit and oxidize these wastes. An appreciation of the need for the conservation of the purity of public waters is concomitant with complete methods of sewage treatment rather than with partial processes. Into this situation fit the activated sludge process and sewage filtration.

Of the total of about 130 sewage treatment works in Canada, 47 are of the activated sludge type, while 45 of the others are for primary treatment only. This tendency towards complete treatment may be taken as evidence of difficult conditions in the streams or as an indication of a desire to keep public waters in a sanitary condition.

An analysis of the conditions prevailing in the municipalities that were the first to adopt the activated sludge process reveals some of the reasons for this choice even though the information then available on this method was quite meagre. These may be listed as:

(1) The early plants were built to replace partial-treatment works which had been found inadequate to meet the sanitary requirements of the localities.

(2) It was possible to adapt parts of the older plants to activated sludge plants with a minimum of expenditure.

(3) The use of sprinkling filters would require so much greater head that pumping would be necessary.

(4) The process gave promise of a good quality effluent.

Some of the objectives in the adoption of activated sludge treatment in this country have been fairly apparent. Have the hopes of the designers and the municipalities been realized over the period of years in which these works have operated? Mistakes in the early works were expected. Knowledge concerning the activated sludge process has accumulated over a period of years. Some of the earlier aspirations and hopes were adversely affected by inadequate knowledge concerning the sludge problem, the selection of personnel, and the many idiosyncrasies of this method.

The use of the method in a very small plant has not proved satisfactory. For such places as hospitals, two factors are especially difficult. The flow of sewage is variable in quantity and composition, and the type of operating personnel available is such that only inferior results can be expected. Instances are found, of course, where good results are obtained, but in general the risk involved here is altogether too great to justify such a selection in preference to trickling filters or other methods.

Municipal plants of the activated sludge type have been difficult to control at times. Industrial wastes, fluctuations in loading and certain other conditions have given concern to the operators.

Sludge handling facilities of the early plants were quite inadequate in most instances. The sludge problem has proved to be one of the most complex of those associated with the activated sludge plants.

While there might be some question about the adaptability of this method to a Canadian climate, this does not seem to have been a serious problem. Most aeration tanks are uncovered, but those in the north, such as at Timmins and Cochrane, are completely enclosed. Winter weather has added to the cost of these plants, and it has increased the cost of operation, but aside from this, little adverse effect has been seen.

In not a few cases a lower degree of treatment might be used for cold weather. The activated sludge process is not well suited for intermittent operation. Inconvenience is experienced in re-starting the system, and there is also a tendency to leave it out of service for too long a period.

The activated sludge process, during the period from 1918 when the first plant was constructed to the present, has passed through many changes. The developments that have taken place seem to have justified the selection of this process for Canadian municipalities, where there is need for an effluent low in solids and biochemical oxygen demand. It may be expected to be improved, and to continue to serve efficiently.

T. L. Herrick

THE OXIDIZED SLUDGE AND REGENERATIVE DIGESTION TREATMENT PLANT AT ZEELAND, MICHIGAN

By E. F. Eldridge

Bull. 94, Mich. Eng. Expt. Sta., East Lansing, Mich. (Rec'd. Apr. 27, 1942)

The Mead-Johnson Company manufactures a variety of food products from milk. Two types of casein precipitation are employed, one using acetic acid and the other calcium chloride. The whey from these processes is discharged as a very concentrated waste. Other less concentrated wastes are produced by washing cans, equipment and floors. The maximum flow of whey per day was estimated at 3,500 gallons and the 5-day B.O.D. at 52,000 p.p.m., representing a load of 1,520 pounds per day. The total flow was 60,000 and the B.O.D. load 3,000 lb. per 24 hours. Distribution of design loading was as follows:

Waste	Flow, Gal. per 24 Hr.	B.O.D., Lb.	Per Cent of B.O.D.
Whey	4,400	1,900	63.3
Curd Washings	16,000	565	18.9
General Waste	39,600	535	17.8
Total	60,000	3,000	100.0

Various plans for disposal of wastes were considered. It was decided to install a plant according to plans submitted by Mr. E. B. Mallory of the Lancaster, Pa., Iron Works Research Laboratory, comprising the "regenerative digestion process" and the "oxidized sludge process."

(In the Foreword, Mr. Eldridge states:

"The conventional activated sludge process has always been considered a truly biological reaction or series of reactions caused by the activity of organisms or their secretions. Mallory has demonstrated that the oxidation of sterile organic material may be accomplished by this same process and has concluded that the reaction is primarily chemical oxidation enhanced perhaps by the presence of certain catalyzers in the oxidized solids.")

The "regenerative digestion process" comprises a concentric set of digestion chambers, the central one being heated, and the surrounding annular ring being provided with air lifts to re-circulate sludge back to the center compartment. The outer annular ring serves as a settling tank.

The primary process consists of a circular tank 73 ft. 8 in. in diameter and 13 ft. 6 in. deep. The center ring is 27 ft. in diameter and has a capacity of 53,100 gallons. It is heated by a circular steel tank 9 ft. in diameter, around a 3 ft. central column. The tank is filled with fresh water, heated by low-pressure steam from the factory. The condensed steam overflows into the 27 ft. center compartment, which is heated to 90 to 100 deg. F.

The annular ring surrounding the central tank is approximately 50 ft. in diameter and holds 153,000 gallons. The temperature in this zone is held between 80 and 90 deg. F. The supernatant liquor overflows from this tank into the outer annular chamber 76 ft. in diameter, with a capacity of 195,000 gallons. The solids settle in this compartment and the overflow goes to the secondary process.

Sludge is discharged to the drying beds from the final chamber (three radial chambers in series) of the sludge compartment. Chemical sludge from the secondary process may be mixed with the digested sludge as it goes to the beds.

The secondary process consists of a circular steel tank, with concrete base, 52 ft. in diameter, in which two rectangular settling tanks are constructed, each about 34 ft. long and 17 ft. wide. One is designated as an "oxidized-sludge clarifier," with a capacity of 38,000 gallons, and the other as a "chemical-clarifier," with a capacity of 33,000 gallons. Outside of these tanks, and occupying the space between their walls and the peripheral wall, is the aeration chamber, 11 ft. deep, with a capacity of 79,800 gallons.

The aeration compartment is supplied with about 4,600 air-diffusion nozzles. Each of the settling tanks contains eight steel inverted-pyramidal hoppers, with air-lifts to the bottom of each hopper, for recirculation of sludge.

Two chemical feeders are located at the inlet end of the chemical clarifier. Alum is applied preceding the application of lime. Chemicals are used only when the effluent from the first clarifier is turbid.

There are three Connersville blowers, each having a capacity of 600 cu. ft. per min. at 6 lb. pressure, rated at 21.5 hp. per unit. One will have ample capacity for average conditions (supplying 864,000 cu. ft. per day at 6 lb. pressure). The second will be required for maximum flows at peak production periods, and the third is a stand-by.

A pumping station, two grit chambers, and a sludge-drying bed are provided. The sand bed is 50 ft. in diameter, with an area of 1960 sq. ft.

The plant was started in operation July 9, 1941. At first whey was not treated, but during the official test, from Aug. 11 to Sept. 6, 1941, some whey was treated in the aeration unit. The digestion tank was used for the reduction of excess and chemical sludge solids.

During the 23-day test, operating and control tests were made by the Lancaster Iron Works engineers, and the Mead-Johnson Co. personnel. All chemical tests were made by a representative of the Michigan Engineering Expt. Station. Samples were obtained by compositing hourly samples over the entire factory operating period.

Whey and washings were contained in the general wastes, except on Aug. 13 and 14, when concentrated wastes were added at the plant. Excess oxidized and chemical sludges were added to the digester during the test.

The general factory wastes varied from 15,500 to 69,800 gallons per day, averaging 40,700 g.p.d. The suspended solids varied from 190 to 962 p.p.m., volatile (total) solids from 712 to 4,230, pH from 4.4 to 9.2, and B.O.D. from 405 to 2,940 p.p.m.

The volume of digester supernatant liquor varied from 1,310 to 17,545 gal. per day, with suspended solids varying from 20 to 214 p.p.m. and B.O.D. from 24 to 598 p.p.m. (No whey added, only excess oxidized and chemical sludge.)

The oxidized sludge secondary process treated from 17,400 to 75,800 gal. per day, averaging 47,650. (The capacity of the aeration tank is 79,800 gallons.) Design estimates had indicated a sludge return rate of 50 per cent for an indicated loading of 100,000 gal. per day, giving an aeration period of 12.8 hours. Actually, during the test, the sludge return rate was 600,000 gal. per day, added to the influent of 47,650 g.p.d. On this basis, the computed aeration periods are reported to vary from 2.62 to 3.12 hours. (Mr. Eldridge states: "Actually the aerator detention period is much greater than this calculation indicates since the return of sludge at the rate used amounts to recirculation of the waste through the aerator unit.")

The settling periods were estimated, in design, to provide 9.1 hours for the first clarifier and 7.95 hours for the second, with flows of 100,000 g.p.d. and 50,000 sludge return. Actually, during the test, the clarifier detention time is reported as 1.35 to 1.47 hours, based on 47,650 g.p.d. average flow of wastes, plus 600,000 g.p.d. return sludge.

The analyses of influents and effluents of the aerator-clarifier, flows, and loadings during the test were as follows (Table 9 in Report):

TABLE 9.—*Aerator-Clarifier Loadings and Reductions*

Date	Total Flow, G.p.d.	B.O.D. Load, Lb./day	Influent B.O.D., P.p.m.	Effluent B.O.D., P.p.m.	Reduction, Per Cent
Aug. 11	43,660	149	410	1	99.7
12	75,800	515	812	4	99.5
13	63,400	1,219	2,800	2	99.9
14	73,350	1,453	2,380	12	99.2
15	64,285	393	743	3	99.5
16	35,300	199	676	2	99.7
18	54,750	758	1,660	8	99.5
19	62,700	582	1,114	2	99.8
20	24,220	197	975	2	99.8
21	34,030	190	668	4	99.4
22	63,040	796	1,510	3	99.8
23	38,110	183	575	2	99.6
25	31,850	158	595	2	99.6
26	62,305	733	1,410	7	99.5
27	71,110	903	1,522	5	99.7
28	43,410	149	412	3	99.3
29	24,125	145	720	3	99.5
30	25,120	117	558	1	99.8
Sept. 2	55,800	206	442	26	94.2
3	47,400	345	873	15	98.3
4	39,720	375	1,130	3	99.7
5	44,930	234	623	6	99.1
6	17,400	134	922	3	99.7

Later operation, with heavier loadings, gave results as follows (Table 11):

TABLE 11 (*Excerpts*).—*Subsequent Results of the Operation of the Oxidized Sludge Unit*

Date	Volume General Wastes, G.d.	Final Effluent	
		Suspended Solids, P.p.m.	B.O.D., P.p.m.
Sept. 29	31,385	36	11
Oct. 1	25,200	28	8
2	37,800	—	—
3	40,800	34	8
4	48,200	—	—
6	42,600	18	4.5
7	48,700	—	—
8	33,900	9	5
10	44,700	9	9
11	38,000	—	—
13	55,000	8	9
20	70,300	11	0.7
21	57,600	—	—
22	69,300	12	2.7
23	53,700	—	—
24	67,500	7	3.6

The data on which the plant was designed contemplated a flow of 60,000 gal. per day with a B.O.D. of 3,000 lb. per day, giving a population equivalent of 18,000. The primary process was designed for a flow of 14,000 gal. and a load of 2,000 lb. B.O.D. per day. The secondary process was designed for a flow of 100,000 gallons and a load of 1,000 lb. B.O.D. per day. During the test the aerator influent B.O.D. loading varied from 117 to 1,453 lb. per day averaging 440 lb. per day. During the later operation shown in Table 11, it was estimated that the loadings were in excess of 1,100 lb. per day, not including digester supernatant, on Oct. 21, 22 and 24. The data show that application of acid whey and curd washings has little, if any, effect on the effluent.

Pages 29 to 31 of the Report deal with later operation of the digester, which received increasing quantities of whey and curd washings, up to an estimated load of 1,423 lb. volatile solids per day. The design rating was 2,500 lb. per day, including all excess sludge. The digester took a heavy load of wastes on November 24, without adverse effect.

The author states that "a long period has been required to build up the solids concentration of the digester contents. Apparently these solids are converted to gas and liquid form almost as rapidly as they are added. Unless the chemical stage is used to a great extent, there will be very little sludge delivered to the drying beds from this digester. In fact, it is doubtful if any sludge will be drawn during 1942."

Abstractor's Note.—Mr. Eldridge's report does not include any data on chemicals used for clarification of the aerated effluent, prior to settling in the chemical clarifier. This information has been requested by letter and the reply will be added to this abstract if received in time.

The remainder of the Report deals with estimates of the cost of evaporation, and the equations and control tests used by Mr. Mallory. Further description of these equations and tests is given by Mr. Mallory in *Water Works and Sewerage* for April, 1942. The cost of the Zeeland plant is there given as \$3.50 per capita (presumably based on pop. equiv. of 18,000, giving \$63,000) or \$22 per lb. of B.O.D. capacity (design loading 3,000 lb., giving \$66,000).

F. W. MOHLMAN

Note.—The following letter was received from Mr. Eldridge May 5:

"The chemical treament facility at the Zeeland plant was added to safeguard the plant effluent from any emergency loadings beyond the plant capacity. Actually this facility has been needed but for a total period of about one week since the plant was put into operation. Strangely enough, it was required for an underload rather than an overload. In order to compensate for the extreme variations in loadings, it is necessary to keep the sludge in a condition of over-oxidation. On the two occasions mentioned, whey was not produced in the factory for a period of about five days. After about three days of extremely low loadings, a portion of the sludge became colloidal and the first-clarifier effluent had the appearance of muddy water. A small quantity of lime and alum was necessary to flocculate this colloidal material and prevent its discharge in the final effluent.

" Chemicals were added during a portion of the test period referred to in the *Bulletin*. However, they were not needed and caused little if any additional removal of either solids or B.O.D.

" The only period during which chemicals were added was the week of August 25 to 30. The applications consisted of 30 p.p.m. each of lime and alum. The reference to chemical sludge being added to the digester is misleading. The term should read chemical-clarifier sludge and in most cases refers to the additional settling of activated sludge in the second clarifier."

BOOK REVIEW

Industrial Waste Treatment Practice. By E. F. Eldridge. McGraw-Hill Book Co., Inc. 1942. Price, $5.00.

This is a book of 401 pages, divided into an introduction of 5 pp. and 17 chapters, as follows:

Title of Chapter	Pages
Stream Pollution	15
Characteristics of Industrial Wastes	17
Standard Treatment Methods, Structures and Equipment	45
Wastes from the Beet-Sugar Industry	27
Milk Products Factory Wastes	32
Canning Factory Wastes	26
Tannery Wastes	26
Pulp and Paper Mill Wastes	37
Textile Wastes	29
Meat Packing and Slaughterhouse Wastes	18
Laundry Wastes	5
Wastes from the Metal Industries	12
Gas and Coke Plant Wastes and Other Phenolic Wastes	18
Wastes from Fermentation Industries	25
Wastes from Oil Fields and Refineries	18
Treatment of Combined Industrial Waste and Domestic Sewage	19
Methods of Analysis for Industrial Wastes	22

The author is well known for the Bulletins prepared by him or under his direction at the Engineering Experiment Station of Michigan State College. Out of this experience has been evolved a record of his contacts and problems. As such it will prove useful as a reference book to practitioners. As a text book for students, it seems unsuited, because the book is so largely a record of facts and specific instructions, whereas a student needs to learn fundamental principles.

The book is somewhat unbalanced in the allotment of space to various industries. No reference is made to the Corn Products Industry. Occasionally the author takes up a topic, such as the use of chlorine in treating packinghouse waste and designates it as valuable, whereas apparently it has proved a failure. His references to literature are few and not particularly well selected. No mention is made of the research of Hodge and his associates on handling spent acid pickling waste. Minor errors appear, such as misspelled proper names (i.e., Homman for Hommon and Bushwell for Buswell), which can be eliminated by more careful proof reading.

As a first approach to an American treatise on industrial wastes, this book is welcome, in the hope that the author will broaden out the chapters on industrial waste and condense or eliminate those general chapters which are best handled in the excellent standard books on sewage disposal now available.

Langdon Pearse

LOCAL ASSOCIATION MEETINGS IN 1942

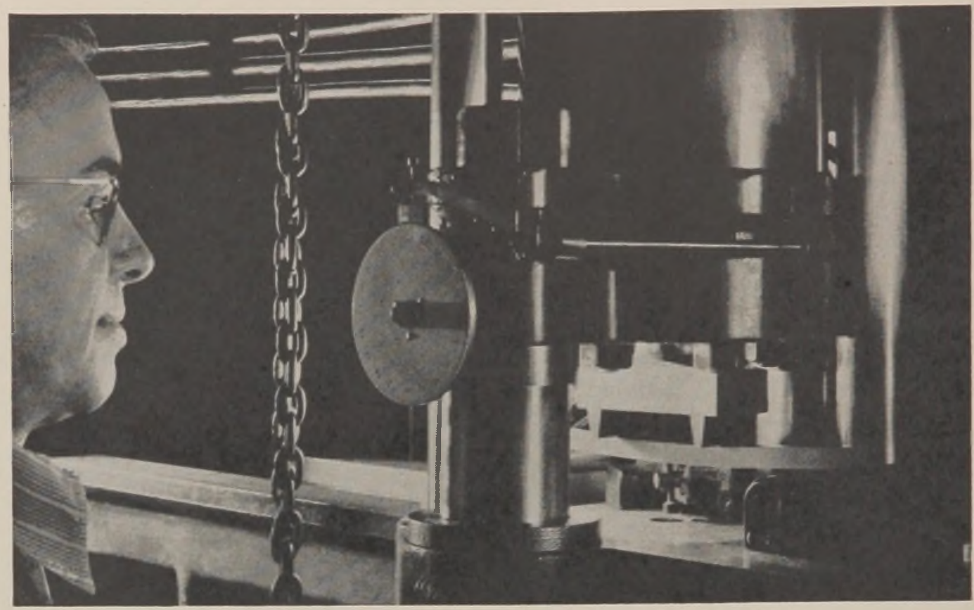
Association	*Place*	*Date*
Canadian Institute of Sewage and Sanitation	Toronto, Ontario (Royal York Hotel)	Oct. 22–23
Central States Sewage Works Association	Minneapolis, Minn. (Nicollet Hotel)	June 18–19
Florida Sewage Works Association	Gainesville, Fla. (Univ. of Florida)	May 27–30*
North Dakota Sewage Works Conference	Williston, N. D.	Oct., 1942
Maryland-Delaware Water and Sewerage Association	Hagerstown, Md. (Alexander Hotel)	May 7–8
Missouri Water and Sewerage Conference	Hannibal, Mo.	Sept. or Oct.
New England Sewage Works Association	Boston, Mass. (Bradford Hotel)	May 27–28
New York State Sewage Works Association	Albany, New York (Hotel Ten Eyck)	June 5–6
North Carolina Sewage Works Association	Durham, N. C. (Washington Duke Hotel)	Nov. 2–4
Ohio Sewage Works Conference	Cleveland, Ohio (Statler Hotel)	Oct. 15–17
Pacific Northwest Sewage Works Association	Corvallis, Ore. (Marcus Whitman Hotel)	May 7–9
Pennsylvania Sewage Works Association	State College, Pa.	Aug. 24–26

* Changed date from that previously announced.

FEDERATION OF SEWAGE WORKS ASSOCIATIONS

Third Annual Meeting, Cleveland, Ohio

October 15–17, 1942



Change Sludge into "Folding Money"!

Many cities are doing it with a Royer!

IT sounds like magic, but it is the plain truth! Sewage treatment plant engineers all over the United States bear this out. They say the Royer Sludge Disintegrator saves them time and money from the moment it goes on the job; and, by preparing sewage sludge for marketing as a fertilizer, it taps a continuous flow of revenue.

A Royer NSD–P owned by the Charlotte, North Carolina, sewage plant is shown here performing two essential operations simultaneously—shredding the thick sludge cake into pea-sized particles and loading it onto a truck for delivery where desired.

Notice that the sludge fertilizer is thoroughly clean when it passes through the Royer for sticks, stones and trash are completely removed. The sludge comes out ready for top dressing or fertilizer, or as a base for a high strength fertilizer. Enrichening chemicals, when indicated, are thoroughly mixed with the sludge by the Royer.

Find out today how you, too, can make a generous profit from sludge. A Royer saves you the expensive operations of burying or burning, and translates sludge into cash by sales to parks, schools, golf courses, nurseries, florists, cemeteries, private homes, truck farms and others interested in greater soil fertility.

THE ROYER

No matter what the size of your plant, there is a Royer exactly suited to your needs. Merely the saving of time and labor at the plant makes it a wonderful buy. Many plant superintendents declare, "It's the most valuable piece of equipment we own."

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Return empty chlorine cylinders promptly
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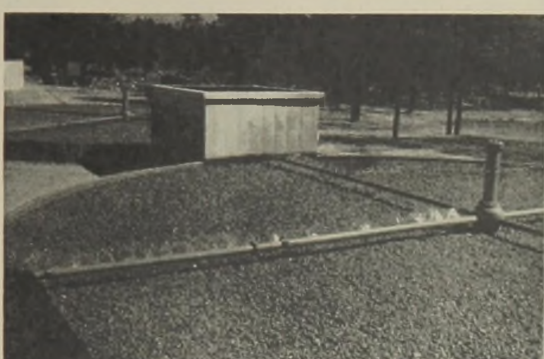

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