A STUDY OF THE EFFICIENCY OF OPERATION

of

THE VIRGINIA POLYTECHNIC INSTITUTE SEWAGE DISPOSAL PLANT

by

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REVIEW OF LITERATURE

I. Characteristics of Sewage

Sewage is the spent water supply of a community, together with those human and industrial wastes which are removed by water carriage, supplemented in some instances by sheet washings and industrial wastes. Ordinarily it contains more than 99.9 per cent of water. The remaining constituents, usually much less than 0.1 per cent, include the objectionable substances which are offensive in character and behavior or dangerous to public health.

Physically, sewage contains matter in suspension and matter in solution. Some of the suspended matter will settle out when the carrying power of the sewage is reduced by decreasing the velocity of flow; however, a large part of the solids are colloidal and dissolved and will not settle out even when the sewage is held quiecent for a period. Part of the solids in sewage comes from the water which is its principal constituent. If the water is hard or highly mineralized, it will contribute a large proportion of the solids. The other solids come from kitchens, laundries, bathrooms, hotels and office buildings and are mostly feces, urine, grease, soaps, and paper. Industrial wastes, where there are industries, contribute considerable solids too. Naturally, the concentrations of such constituents vary with the rate of consumption of water, and the habits of the community. This varies from day to to day and fluctuates enormously from hour to hour.

Chemically, sewage contains substances of animal, vegetable and mineral origin. Those substances of animal and vegetable origin are called organic matter and are largely offensive in character and behavior. They are a combination of the elements carbon, hydrogen, and oxygen together with nitrogen in some cases, and in a few instances sulphur and phosphorus may also be present. Organic matter as found in sewage is principally in the form of proteins, carbohydrates and fats and their products of decomposition all break down more or less readily through the activity of bacteria and other living organisms. Proteins are the principal constituents of the animal organisms and have the rather distinctive characteristic of containing a fairly high and constant proportion of nitrogen in addition to carbon, hydrogen and oxygen. In many cases sulphur, phosphorus and iron are also found in protein. These and the proteins are the chief sources of the nitrogen in sewage. The carbohydrates contain carbon, hydrogen and oxygen in certain, definite proportions, and as found in sewage, are principally sugars, starches, cellulose and wood fibre. Fats are combination of fatty acids with glycerine. Soaps are the mineral salts of fatty acids. Fats and soaps are relatively simple in chemical structure and are among the more stable of organic compounds. The fats contain carbon, oxygen and hydrogen and the soaps, as found in sewage, include in addition the more common alkali or alkaline earth metals, such as sodium, potassium, calcium and magnesium. The decomposition of organic matter results in a rapid depletion of the oxygen present in water, after which foul-smelling compounds are formed. For this reason the organic contents of sewage constituents are some of the principal problems of sewage treatment and disposal.

Mineral matter composes approximately 50 per cent of the solids and is made up of inert matter principally of mineral origin. A large amount of the mineral matter is contributed by the water in the sewage. The inert matter has little if any objectionable properties and is not a very important problem in the treatment and disposal of sewage.

Biologically, sewage contains vast numbers of living organisms, among which bacteria predominate. Most of these organisms are harmless to humans and are largely responsible for converting the complex organic constituents of sewage into simpler more stable, organic compounds. In addition sewage contains large numbers of disease producing organisms given off by people with water borne diseases such as typhoid fever and dysentery. These diseases producing all pathogenic organisms constitute the danger to public health.

The non-disease producing organisms are of three distinct types; namely, aerobic, anaerobic, and facultative, each of which plays a distinctive part in the treatment of sewage. Aerobic bacteria require oxygen for their existence and are only found where free oxygen is present. Anaerobic bacteria obtain their oxygen from the oxygen radicals of organic compounds or such mineral compounds as nitrites, nitrates and sulphates, and exist only where there is an absence of free oxygen. The facultative organisms are more capable at adapting themselves to surrounding conditions and manage to live and multiply under both aerobic and anaerobic conditions. Some bacteria are enemies to others and will tend to kill each other until, in the end, the predominating bacteria will be those best adapted to living in conditions similar to those that prevail. It is, therefore, desirable to keep the pH and temperature of sewage and sludge at the optimum for the organism which aid in the treatment of sewage.

The decomposition of sewage is essentially the breaking down of complex chemical substances by a biological and to a lesser degree, chemical action into other simpler and more stable compounds. Decomposition is primarily of two distinct types (1) anaerobic decomposition or putrefaction, and (2) aerobic decomposition or oxidation. Putrefaction is the first stage and oxidation the second. The organic nitrogenous substances are broken down under anaerobic condition into ammonia, and such end products as methane, hydrogen, hydrogen sulphide, and carbon dioxide are given off. Area is converted into ammonia by a special group of bacteria. The ammonia is then converted by oxidation into nitrites and subsequently nitrates. Nitrates are relatively stable and serve as plant food. It is desirable then to have a treatment plant that furnishes an effluent that contains a large amount of nitrates and very little of the more complex and objectionable nitrogen compounds.

II. Treatment of Sewage

Sewage treatment is essentially a combination of three processes; namely, the separation of the solid sewage from the liquid sewage, the treatment of the solid matters, and treatment of the liquid sewage.

1. <u>Separation of the Solid Sewage From the Liquid Sewage</u>

Solids are characterized as suspended collodial and dissolved solids. Part of these suspended solids will settle out when the transporting power of the sewage is decreased by a reduction in the velocity of the sewage. Some, however, are light enough to float and will not settle. Those lighter solids are mostly feces, matches, rags, hair, paper, and similar wastes which tend to clog up the filters of a treatment plant and impose an unnecessary burden on the plant as a hold. It is then desirable to remove the floating matter before the sewage reaches the treatment plant. A screen is usually provided for this purpose and is essentially a device with openings, generally of uniform size, used to retain the coarse sewage solids. Some of the smaller plants, however, are not equipped with a screening device. They merely have a baffle near the influent to the sedimentation chamber that serves as a skimming device and retains the floating matter in a restricted portion of the tank.

Floating matter is usually unsightly and if allowed to accumulate will tend to putrify and give off obnoxious odors. Usually it is advisable to remove such matter at least once a day and more often if screens tend to clog and either bury it or dispose of it by inceneration.

A large portion of the settleable solids are heavy mineral solids or grit which readily settle out when there is only a small decrease in the velocity of the sewage. These are not offensive in character or behavior and as they are not readily decomposed by bacteriological and chemical action, it is advantageous to remove them before the sewage reaches the sedimentation chamber. The grit chamber is employed to remove the heavy mineral solids. It is merely an enlarged channel or long basin in which the cross-section is increased to reduce the velocity of the flowing sewage just enough to allow the deposition of heavy solids such as sand, grit, and gravel. Such chambers are usually omitted when the sewage system is a separate one, that is, when only human household and industrial waters are allowed to enter the sewer.

Screens a nd grit chambers remove the larger floating solids and grit, but do not rid the sewage of the finer suspended mineral and organic solids which are just as undesirable and even more offensive when they begin to putrify. The removal of such suspended matter is, therefore, an important function of sewage treatment works. It is accomplished by sedimentation. The transporting power of sewage varies as the sixth power of the velocity, and when its velocity is reduced the suspended matter will subside and be deposited by gravity. Coagulating chemicals may also be employed to bring the fine suspended and colloidal solids together to form larger masses which will settle more readily. If coagulating chemicals are not added to the sewage, the structures in which the process of settling takes place are known as plain sedimentation tanks. If chemicals are used, the structures are called chemical precipitation tanks.

Plain sedimentation tanks are of two types, (1) horizontal flow tanks and (2) vertical flow tanks. Horizontal flow tanks are employed extnesively where clarification precedes oxidation processes and are, therefore, of more interest to this reviewer.

2. Sludge Digestion

An integral part of sewage treatment is the storage and subsequent decomposition of the solids which settle out. These solids, or sludge, may be allowed to digest in two different ways, (1) while remaining in contact with the flowing sewage as in single-story septic tanks, or (2) after separation from the flowing sewage as in two-story septic tanks and separate sludge digestion tanks.

Single-story septic tanks have not proved efficient for preliminary treatment and are used chiefly as final sedimentation tanks or humus tanks.

Two-story septic tanks are used rather extensively in this contry and abroad, the most common type being the Imhoff tank. In Imhoff tanks the sewage flows through the sedimentation chambers only. Here settleable solids are allowed to subside to the inclined surfaces of the lower portion of the sedimentation chamber where they slide through slots into the sludge chamber directly below. The slots are trapped so that no gases from the sludge chamber can rise into the sedimentation chamber. The sludge in the sludge chamber is allowed to undergo septic decomposition. The gases given off by this decomposition rise through the chamber to gas vents and are either allowed to escape to the atmosphere or captured and utilized for heating purposes.

Separate sludge digestion tanks are growing in popularity and are being used in numerous treatment plants. They differ from the two-story septic tanks in that the sludge digestion unit is not below the sedimentation unit. Instead, the sludge is pumped from the bottom of the sedimentation chamber to a digestion chamber some distance away. Separate sludge digestion facilitates the use of mechanical clarifiers in the sedimentation tanks and enables operators to execute a greater degree of control over the digestion of the sludge.

No matter which of the above-mentioned methods is used, the principles of digestion are the same. Sludge digestion is an anaerobic process. Under the optimum condition of pH and temperature, anaerobic bacteria attack the sludge and break down the more complex organic or nitrogenous compounds into simpler substances. The carbohydrates and soluble nitrogenous compounds are first attacked, and through their decomposition, gases are given off and acid carbonates are formed. This tends to acidify the sludge and lower pH to a marked extent. The organic acids thus formed and the nitrogenous compounds are attacked by another type of bacteria and are broken down into such end products as ammonia compounds andorganic acids. As this process takes place, there is acid regression and a resulting rise in pH. By this time the bacteria have succeeded in liquefying the proteins and other more resistant materials and proceed to break them down into ammonia, organic acids, and gases such as methane, carbon dioxide and nitrogen.

All of these stages are operative at the same time and will, under proper conditions, establish a physical, chemical, and biological balance such that digestion progresses rapidly and without the production of offensive conditions.

Sludge that has undergone complete septic decomposition is usually rendered inoffensive and may be drawn off and pumped to sludge drying beds where it is de-watered and dried to facilitate its use as a fertilizer.

3. <u>Treatment of Liquid Sewage</u>

Only about a third of the putrescible solids are removed from the liquid sewage by sedimentation; and it is, therefore, necessary for the sewage to undergo further treatment before it is rendered stable enough to be discharged into a water course. The further treatment is an oxidation process in which the living organism, aerobic, in the sewage convert the organic matter into a more stable form or into mineral matter. It is accomplished most frequently by filtration.

The most common filtration units are contact beds and trickling filters. A contact bed is a bed of coarse material, such as broken stones or clinkers in a water tight basin which is operated in cycles of filling with sewage, standing full, being emptied, and resting empty. A trickling filter is a bed of coarse material, simpler to that used in contact beds, over which sewage is distributed intermittently and through which it trickles to under-drains.

The removal of the colloidal and dissolved organic matter which takes place during filtration is neither due to straining nor sedimentation as might be expected. Instead a slimy, gelatinous growth of bacteria (zooglea) and other organisms form on the surface of the filter medium which tend to concentrate the colloidal and dissolved organic solids at the jelly surface and adsorb the substances thus concentrated. Then, in the presence of oxygen, the living organisms and their enzymes found in the gelatinous films covering the control surfaces attack the adsorbed substances and decompose the organic matter into such products as carbon dioxide, nitrate, and a humus-like residue. The gas escapes from the filter, the nitrates are dissolved in the sewage and pass out with it, and the humus matter washes out as suspended matter in the sewage.

The suspended humus matter is readily settleable and is removed by passing the effluent from the filter through a final sedimentation tank or humus tank. This tank is of the single-story septic tank type. The humus is collected and stored in the bottom of the tank where partial septic decomposition takes place.

INTRODUCTION

Shortly after the sewage treatment for the Virginia Polytechnic Institute and the Town of Blacksburg, Virginia, was put into operation, Mr. James Marvin Cultice made a study to determine the operating efficiency of the various treatment units and of the plant as a whole. Experiments were completed in June 1932 and the results were presented as a thesis, "A Study of the Sewage Disposal Plant for Virginia Polytechnic Institute."

The purpose of this study was to determine the present efficiency of treatment accomplished by each part of the plant, and to ascertain the degree of purification of sewage now being accomplished. It was of major interest, however, to compare these results with the results of the similar study made by Mr. Cultice seven years previous and determine any inconsistencies in the performance of the plant.

Beginning August 17, 1938, and continuing until May 10, 1939, samples were taken weekly at several key points in the plant and the ordinary routine tests for plant control were made in accordance with "Standard Methods of Sewage Analysis of American Public Health Association." It is believed that the nine months' period covered by the present tests offers a reasonably accurate check on the performance of the plant.

THE VIRGINIA POLYTECHNIC INSTITUTE SEWAGE DISPOSAL PLANT

The Virginia Polytechnic Institute sewage disposal plant was placed in operation in August 1928. It handles the sewage from both the Town of Blacksburg and the College and was designed to accommodate a polulation of 5,000. The plant consists of a single Imhoff tank, four contact beds, three final settling tanks, usually used in rotation, and three sludge drying beds under a single glass cover. The final effluent of the disposal plant is discharged into Struble's Creek, a small stream which flows through the center of the Town of Blacksburg and thence by the V. P. I. disposal plant.

Resume of V. P. I. and Blacksburg, Va.
Sewage Disposal Plant Design

by

C. B. Williamson

General Conditions: - The sewage from the town of Blacksburg and the Virginia Polytechnic Institute is handled in a separate system and a recent survey shows that practically all storm water is excluded. Disposal is now effected through an Imhoff tank and contact beds which are in excess of 100% overloaded, having been designed for 150,000 gallons daily capacity. Measurements show the present flow to be an average of 350,000 gallons from approximately 3,500 people. Sewage is very fresh and as the water supply is very hard, soap is a considerable element.

Due to poor condition of the collecting system and its location, considerable ground water enters the system rendering sewage relatively weak. The main sources of grease; namely, the Mess Hall and Power Plant at the Institute have been trapped.

Line to New Plant. The sewer line to the new plant has been designed to conserve head rather than on the basis of capacity with a 2' velocity. n = .013.

Imhoff Tank. The entire plant is designed on the basis of 500,000 gallons daily flow from 5,000 people. Average hourly rate 20,833.33 gallons or 2,765 c.f. or 46.08 c.f. per minute, cross-section area 122 square feet, length 41 feet, volume 4,902 c.f., detention period 1.76 hrs. Flowing through velocity is .38 feet per minute. At 200% rate .76 feet per minute. Side slopes of basin, 1.4:1. Digestion space figured on a plain 18" below slot level is 9,300 c.f. or 1.86 c.f. per capita. Scum space figured above level of slots, 7,342 c.f. or 1.47 c.f. per capita. Side slopes of digestion space min. .485 to 1. Two-inch lead pressure line is provided around hoppers. Gas collector area is 1.41% of tank area. Flow reversal provided. Sludge pipe discharge 5.5' head. Sludge ports opposite each gas vent under 4.5' head. All sludge and scum are handled in pipe lines min. fall 1' in 20'.

Contact Beds. This unit will provide 36,000 sq. ft. of area with minimum depth of contact material 4'. Rate is 150,000 gallons per foot of depth per acre daily of 600,000 gallons per acre daily. Automatic control is provided through Miller Adams 8" x 18" feeds and 10" timed siphons of the P.F.T. Co. The total area is distributed over four beds. Minimum resting period at maximum rates if approximately 60% of time the cycle being 1376 minutes or 22 hours and 55 minutes and max. rates and beds dirty. Vertical drop (maximum) when emptying .0415 inch per minute. Under drains are 8" split tile radiating from central collector each draining a maximum area of 375 sq. ft. Approximate velocity (maximum) .35 feet per second. Distributors are laid below stone surface to prevent exposure of sewage to view. Stone passes 2½" ring and is retained on 1" ring.

Final or Humus Tank. - This unit is divided into three compartments, each a straight flow unit. Each compartment is 10 x 40 with minimum flow line depth of 6' and maximum 8'-6" with volume 3,000 c.f. Total vol. is 9,000 c.f. and detention period at average rates 3¼ hours and at maximum rates 2-1/5 hours. Slope of bottom is 1' in 20 and entire basin is covered with concrete cover. Sludge from this unit can be pumped to Imhoff or drying beds.

Sludge Pump. Diaphram type. Handles sludge and scum from preliminary and final tanks to drying beds or water under pressure to flushing pipes in Imhoff tank hoppers.

Sludge Drying Beds. Based on .48 sq. ft. per person or 2,400 sq. ft. and is provided with greenhouse cover, sand bed, drainage system, distributing pipes and handling tracks.

Hydraulic Gradient. Invert manhole 498.11. Flow line of Imhoff 497.58. F. L. in round tile (top) 496.47. Elev. of floor at corner (contact beds)

492.47. Elev. floor at entrance to distributor 491.97. Elev. of top of outlet pipe (12") 491.87. F. L. in final tank (approx.) 491.8.

Actual Design (as constructed) Figures

There exist throughout the plant several discrepancies between the designer's figures and the actual design (as constructed) figures which make the actual plant capacity considerably less than that shown by the designer's figures.

The Imhoff tank was originally designed to have a capacity of 500,000 gallons per day, but actually it is much less. The sedimentation chamber, as constructed, has a total cross-sectional area of 107.88 sq. ft. and is 41 ft. in length. The volume, therefore, equals 4,420 cu. ft. instead of 4,902 cu. ft. as shown as the designer's figures. Assuming the same detention period, 1.76 hrs., and a flowing through velocity, 0.38 ft. per minute, to prevail, the actual capacity of the Imhoff tank is only 450,000 gallons per day ($500,000 \times \frac{4420}{4902}$). Because of operational difficulties due to insufficient gas area, (properly designed plants have approximately 20% gas area instead of 1.41% as prevails at the V.P.I. Plant) a quantity of 400,000 gallons per day or less would be a good maximum capacity for this tank.

According to the designer's figures, each contact bed is supposed to take 125,000 gallons per day. Actually the average depth of filter is about 4'-6", the area 95.5 sq. ft., and the 100 per cent void capacity 41,000 cu. ft. (95.5 x 95.5 x 4.5) or 306,000 gallons. Professor F. H. Fish determined by experiments that the per cent of voids is about

46 per cent. Capacity them is 140,000 gallons per bed (306,000 x 46%). Due to outlet elevation being above the floor of the contact bed approximately 18 inches useable space is reduced. Professor P. H. McGauhey and Mr. H. P. C. Vandenberg obtained a draw down of 13 inches at the center of the contact bed when the siphon well was pumped dry. This indicates an unused volume of 29,000 gallons,

$$(95.5 \times 95.5 \ \frac{7}{12} \ \frac{1}{3} \times \frac{6}{12} \times 0.46 \times 7.5)$$

in each bed. The actual capacity of each contact bed is, therefore, only 111,000 gallons (140,000 - 29,000) and total capacity of the contact beds is 440,000 gallons (111,000 x 4).

The sludge drying beds were cleaned during the month of March and elevations of several points on the floor of the beds were determined. It was found that the outlet end of the floor was several inches higher than any other point on the floor. This was immediately eliminated by pouring a new concrete floor having a slope toward the outlet drain. The old stone and sand filtering mediums were replaced with new stone and sand. The beds are now draining more readily and the time required for the sludge to dry has been reduced considerably.

The walls of the gas vents have been raised until the top of the gas vents are at the same elevation as the top of the slab which covers the sedimentation chamber. This has limited the overflowing of scum and reduced the nuisance thus encountered.

COLLECTION OF SAMPLES AND PROCEDURES

Messrs. Meredith and Cultice made preliminary studies on the raw sewage of the Virginia Polytechnic Institute to determine the time of day and the day of the week when the sewage would be most nearly an average sewage. They found, as would be expected, that the concentration of the sewage fluctuated from hour to hour during each day and from day to day during each week. There seemed to be no time when the sewage could be expected to be an absolutely average sewage. It was decided, however, that if samples be taken at two and eight P. M. on Wednesdays, a fairly representative sample of the week's flow of sewage could be had. Collections of samples were then made at both two and eight P. M. every Wednesday.

No such preliminary studies were made when this study was begun. Instead, Professor McGauhey suggested that samples be collected at the time decided upon by Messrs. Meredith and Cultice. The Virginia Polytechnic Institute sewerage system is a separate system, and the sewage handled is almost entirely domestic sewage. While the quantity of sewage now being treated has increased enormously since Messrs. Meredith and Cultice made their studies, the habits of the people being served by the system have changed very little, if any, and an average sewage should be obtained by collecting samples at two and eight P. M. on Wednesday. Samples were, therefore, collected at that time, and aliquot portions being taken at two and eight P. M. were combined to secure a composite sample which was kept in a refrigerator until Thursday morning when experiments were begun.

Separate samples were taken at the strategic points in the treatment of the sewage so that the efficiency of each unit of the plant might be determined as well as the plant as a whole. Each sample comprised a gallon of sewage, one-half gallon being collected at two P. M., and the other half gallon at eight P. M.

Sample No. 1 was taken at the influent to the plant and comprised only the raw sewage.

Sample No. 2 was taken at the effluent to the Imhoff tank and was compared with sample No. 1 to determine the efficiency of the Imhoff tank.

Sample No. 3 was collected at the influent to the final sedimentation or humus tank. It was really the effluent from the contact beds and by comparison with sample No. 2 gave the degree of purification accomplished by the contact beds.

Sample No. 4 was collected at the effluent to the humus tanks and represented the final treated product. By comparison with sample No. 1, the over-all efficiency of the plant was determined.

On numerous occasions none of the contact beds were emptying at the time samples were being collected, and it was necessary to take sample No. 3 from the sewage standing quiescently in the contact beds and sample No. 4 from the sewage retained within the humus tank. This probably introduced a slight error in the results, but it is small enough to be considered negligible.

List of Tests

The tests made were the usual routine tests for plant control as recommended by the American Public Health Association in "Standard Methods of Water and Sewage Analysis." They were selected with the idea of showing the efficiency of the treatment process and consisted of the following:

Temperature: The temperature of each sample and the atmospnere were taken and recorded in degrees Centigrade.

Alkalinity: The Methyl Orange alkalinity was determined and expressed in terms of p.p.m. $CaCO_3$.

Chlörides: Chloride determinations were made with $AgNO_3$ using potassium chromate as an indicator.

Turbidity: A standard Jackson turbidimeter was used for determining the turbidity.

Ammonia Nitrogen: Ammonia nitrogen was determined by distillation and subsequent Nesslerization of the distillate.

Organic Nitrogen: The organic nitrogen determination was made immediately following that of the ammonia nitrogen, utilizing the residue of distillation, which was digested and then diluted before redistilling.

Nitrite Nitrogen: This determination was made colorimetrically, using sulfanilic acid, and alpha-naphthylamine acetate solution.

Nitrate Nitrogen: The phenoldisulfonic acid method was used to determine the nitrate nitrogen content. The color of the samples was not easily compared with the standards, and it was necessary to make a comparison of depth rather than of actual color.

Dissolved Oxygen: Dissolved orygen was determined by the Rideal-Stewart or permanganate modification of the Winkler method.

Biochemical Oxygen Demand: B.O.D. was determined after allowing diluted samples to incubate for five days. The dilutions used were samples No. 1 and No. 2, 1-250, 1-100, and 1-50; and for samples No. 3 and No. 4, 1-250, 1-50, and 1-25.

Oxygen Consumed: The oxygen consumed from permanganate represents the amount used by digesting the water for thirty minutes.

Relative Stability: Relative stability was determined only for samples No. 3 and No. 4, and these possessed such low stabilities, less than eleven per cent in all cases that these tests proved of little value.

Total Solids: The total residue on evaporation was obtained by evaporating 100 ml. of the sample.

Total Volatile Solids: The residue from the total solids determination was ignited at 600°C in an electric muffle. The loss of weight represented the total volatile solids.

Suspended Solids: Gooch crucibles were not used for determining the amount of suspended solids. Instead, Alundum crucibles were used and better results were obtained.

Suspended Volatile Solids: Suspended volatile solids were determined in the same manner as total volatile solids.

pH: The pH for all samples was found by use of the standard La Motte set.

DISCUSSION OF RESULTS

Temperature Studies

Since sewage treatment depends largely upon biological activity, temperature measurements are important. Within the range of temperatures, commonly observed, the higher the temperature the more active are the organisms that bring about the desired changes in the organic matter.

Table I

Temperatures

Average Results by Months (°C)

Month	Johnson			Cultice		
	Atmos.	Raw Sew.	Sludge*	Atmos.	Raw Sew.	Sludge#
Aug.	29.4	22.8	20.8	21.7	18.9	18.6
Sept.	25.6	25.0	20.3	21.5	19.4	18.9
Oct.	26.7	25.0	19.4	15.2	18.9	18.7
Nov.	21.7	22.8	19.0	9.8	17.2	17.4
Dec.	10.6	20.8	18.7	7.9	15.0	16.2
Jan.	6.7	20.6	15.6	8.5	13.3	13.4
Feb.	1.4	16.6	13.9	7.9	13.3	13.9
Mar.	15.0	18.7	15.6	7.0	12.8	16.1
Apr.	15.6	21.4	16.7	10.3	14.4	13.4
May	19.4	23.6	21.1	16.1	16.3	14.9

* Temperature of sludge at sludge line
\# Average sludge temperature

It is interesting to note the range of atmospheric temperatures as compared with those of sewage and sludge. The average sewage temperatures tend to stay lower than the atmospheric temperatures during the months of warm weather; namely, August, September and October. During the colder months, however, the average temperature of the sewage is considerably higher than the atmospheric temperatures. The temperatures of the sludge are always lower than the sewage temperatures. They tend to stay lower than the atmospheric temperatures during the warmer months and higher than the atmospheric temperatures during the cooler months.

The atmospheric temperatures have more effect upon the sludge temperatures than upon the temperatures of the sewage. Great fluctuations in the average temperatures of the sewage are not prevelant. This is due to the fact that warm water from the households is being added to the sewage. As the specific heat of water is about five times that of air, the temperatures of sewage are higher than the local air temperatures during most of the year and are lower only during the hottest months.

Methyl Orange Alkalinity

Sewage is normally alkaline, receiving its alkalinity from the water supply, the ground water and the sewage matters themselves. Alkalinity may be due to the presence in the sewage of the carbonates, bicarbonates or hydroxides of elements such as calcium, magnesium, sodium, and potassium or of ammonium; calcium, and magnesium being the most common.

Table II

Methyl Orange Alkalinity

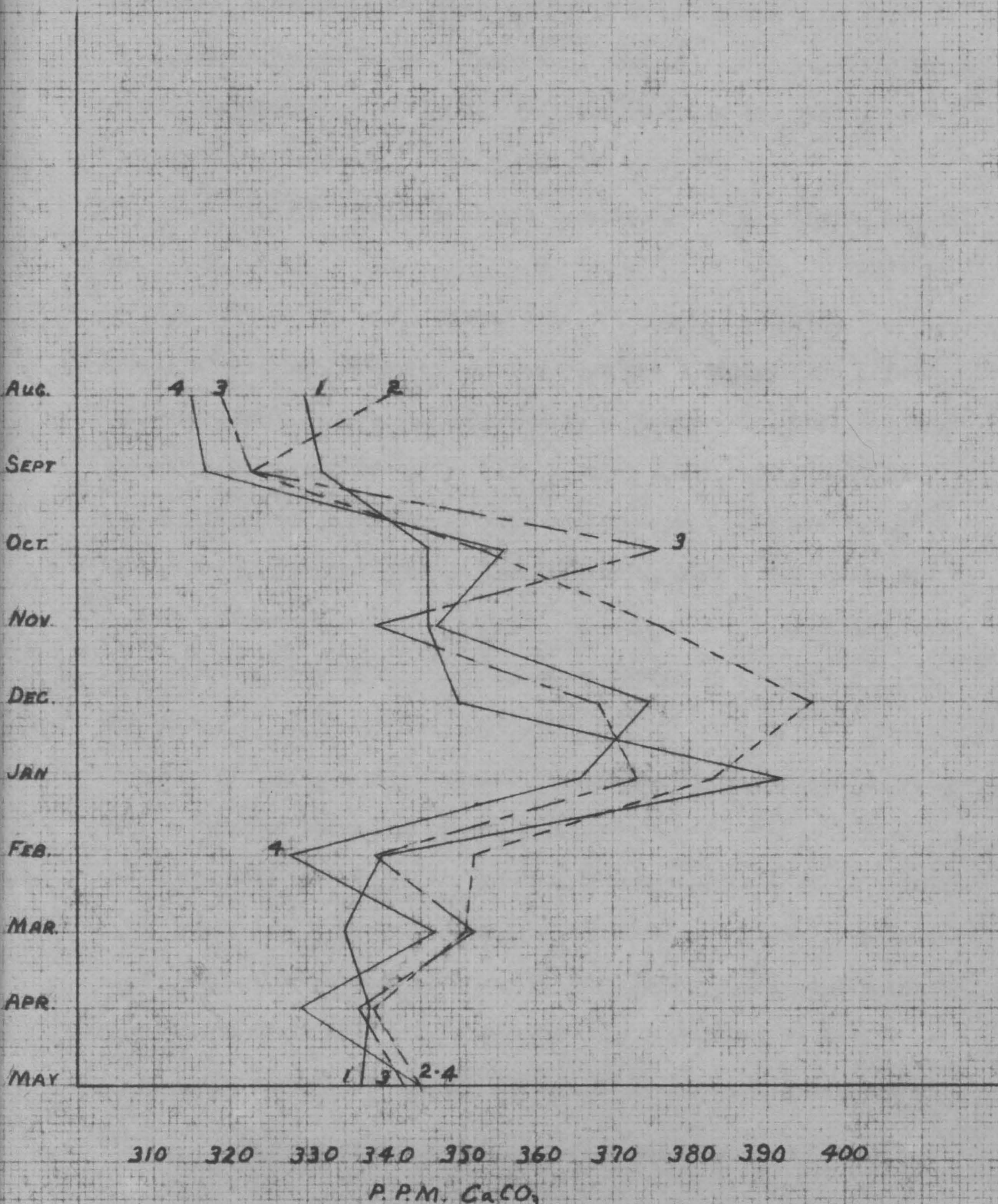
Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	330	341	319	315	286	316	316	292
Sept.	332	323	323	317	232	328	338	326
Oct.	346	353	376	356	426	378	372	370
Nov.	346	376	339	347	376	359	347	333
Dec.	350	396	368	375	420	376	330	332
Jan.	392	383	373	366	309	336	302	296
Feb.	340	352	339	328	366	345	319	323
Mar.	335	351	352	347	326	351	337	325
Apr.	338	339	337	329	357	345	342	366
May	337	345	343	345	266	272	284	278
Ave.	344.6	345.1	346.9	342.5	336.4	338.6	338.7	324.1

The alkalinity of the samples was entirely methyl orange alkalinity and due entirely to the presence of bicarbonates. The results given here are, therefore, the methyl orange alkalinity expressed in terms of calcium carbonate ($CaCO_3$).

FIGURE 1.

METHYL ORANGE ALKALINITY



Very little information relative to the efficiency of operation of a sewage treatment plant can be obtained from the alkalinity determinations as no great change in the alkalinity of the various samples was noted. There was, however, an appreciable increase in alkalinity as the sewage flowed through the Imhoff tank and subsequent reduction in the effluent from the contact beds, the final product showing a slight decrease in alkalinity throughout the plant.

Mr. Cultice's results showed a general increase during the fall months of October, November and December and a sudden drop right after Christmas. This was followed by a steady gain until May when the alkalinity dropped again. The present study revealed no such fluctuations; in fact, the results were exceptionally consistent throughout the entire study. The alkalinity during the month of January was considerably higher than at any other time. This, however, was the only time any appreciable deviation from the average was noted.

The alkalinity content varies inversely with the amount of rainfall. This was borne out by Mr. Cultice's results and accounted for the pronounced variations in his determinations, the high alkalinities being noted during periods of moderate rainfall and the low alkalinities occurring during periods of heavy rains. During the period which this more recent study was made, there was only a moderate amount of rainfall, and the month of January can be singled out as the period of least rainfall.

Chlorides

Sewage is higher in chlorides than the original water supply, because the salt used in food is excreted in the body wastes. The test for chlorides, therefore, has a limited use as an index of sewage strength. The chloride content undergoes no changes except as diluting water of lower or higher chloride content becomes mixed with the sewage.

Table III

Chlorides

Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	32	32	34	30	35.1	37.9	29.9	28.9
Sept.	46	41	38	37	38.0	36.0	35.0	33.0
Oct.	42	46	40	41	47.1	44.8	36.0	34.8
Nov.	58	48	42	35	48.0	45.0	35.0	33.2
Dec.	35	40	42	42	40.0	42.0	35.0	34.0
Jan.	36	35	37	32	33.1	35.9	30.3	29.6
Feb.	29	30	30	31	35.0	29.8	26.0	25.9
Mar.	38	39	36	35	29.5	32.3	29.0	28.0
Apr.	58	58	49	48	37.5	33.8	30.4	28.5
May	58	58	55	60	34.0	24.0	26.5	26.0
Ave.	43	43	40	39	39.8	36.2	31.3	30.2

The results show that there is a slight reduction in chlorides throughout the plant, the greatest reduction taking place in the contact beds. The previous studies revealed the same decreases in chlorides across the plant though to a much greater extent.

The average chloride content is greater than it was previously.

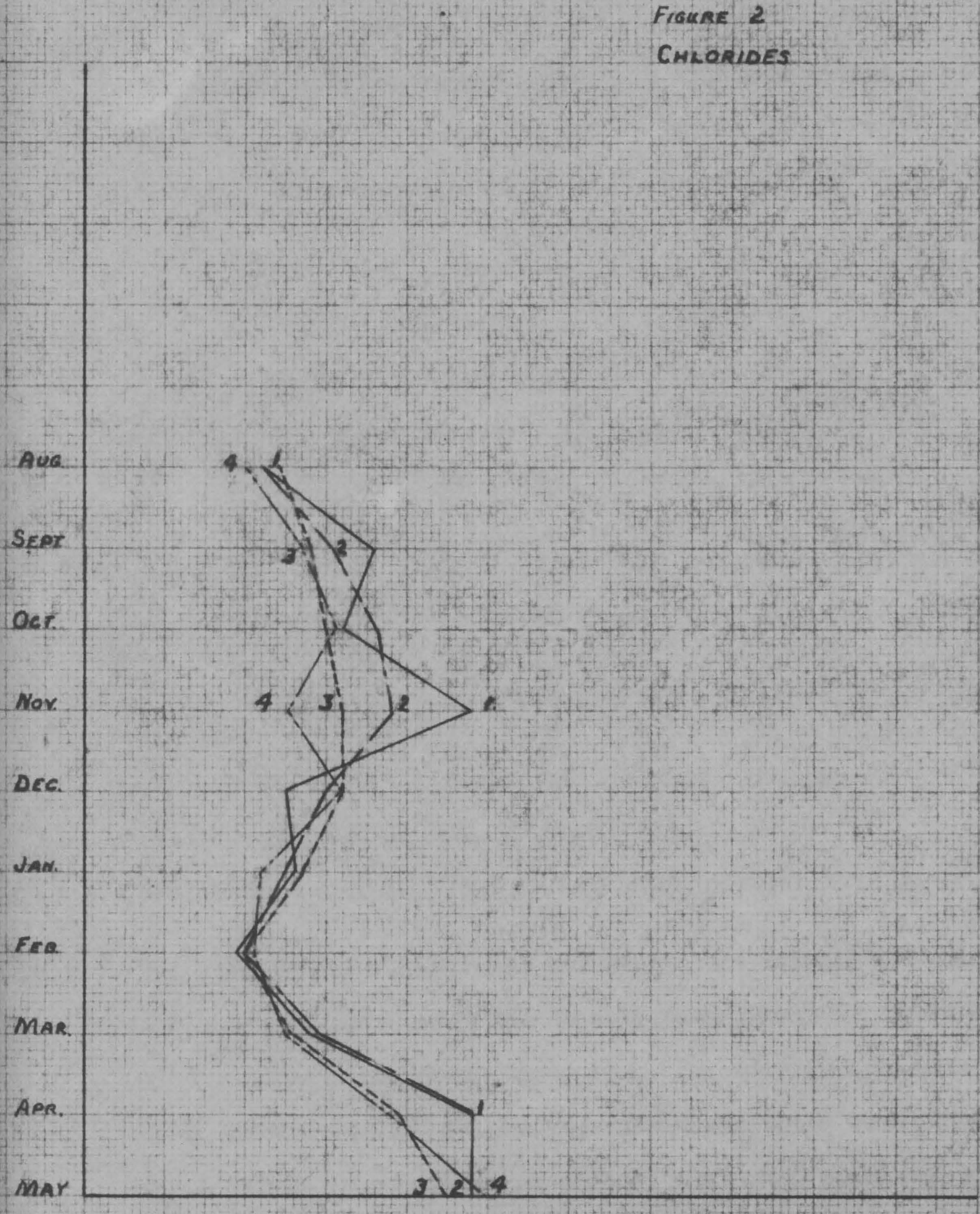


FIGURE 2
CHLORIDES
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
20
30
40
50
60
70

Turbidity

Turbidity is an expression of an optical approximation of the suspended matter in sewage. Turbidity determinations give only a very rough estimate of the efficiency of a treatment plant. It is of importance chiefly because the average layman judges the condition of the sewage almost entirely by its appearance and turbidity.

Table IV

Turbidity

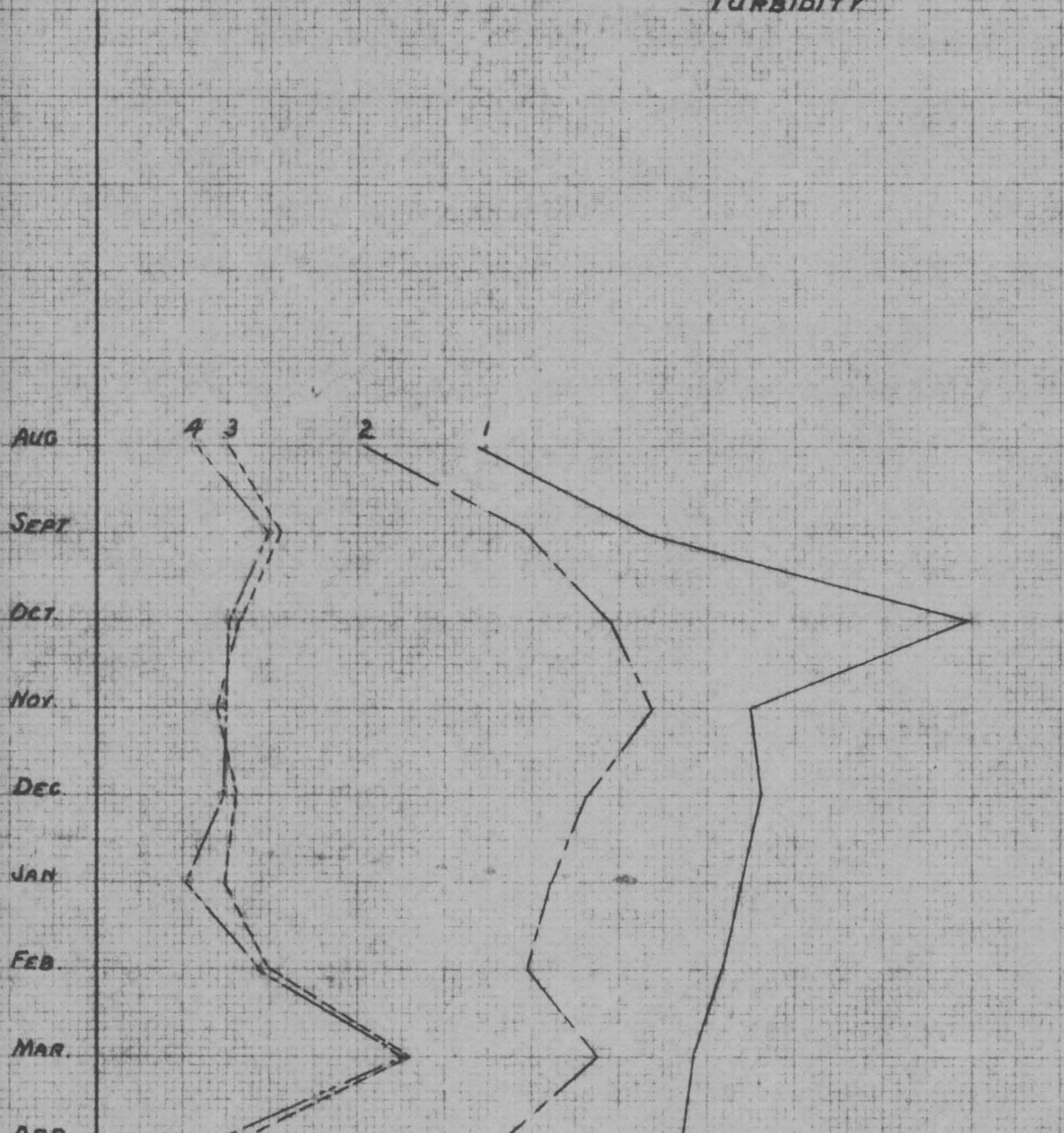
Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	174	123	60	46	175	113	<100	<100
Sept.	255	196	84	80	200	146	"	"
Oct.	360	236	66	61	386	188	"	"
Nov.	300	255	55	58	403	210	"	"
Dec.	305	225	65	59	700	240	"	"
Jan.	294	209	60	42	260	164	"	"
Feb.	288	199	80	75	190	135	"	"
Mar.	274	230	144	143	180	135	"	"
Apr.	270	186	64	53	187	128	"	"
May	285	195	70	60	130	125	"	"
Ave.	280.5	205.4	63	57.6	281.1	158.4	"	"
% Red.	80.5	25.0	69.5	8.6	75	44		

A quite marked reduction in turbidity was obtained, both through the Imhoff tank and through the contact beds, though there was very little reduction through the humus tank. The average reduction through the Imhoff tank was 25% and the reduction through the contact beds was 70%, while the average reduction through the entire plant was 80%. Mr. Cultice's results showed much greater reduction through the Imhoff

FIGURE 3

TURBIDITY



tank (44%) and less through the contact beds (51%). The reduction in turbidity throughout the entire plant, however, was about the same in both studies.

The decrease in the turbidity removal through the Imhoff tank was probably due to the fact that the detention period through the Imhoff tank has decreased. This naturally puts a greater burden on the contact beds and accounts for the pronounced increase in reduction of turbidity through the beds.

Turbidity varies inversely with the amount of rainfall and subsequent surface flow. This accounts for the wide variation in Mr. Cultice's results, the high turbidity being recorded during periods of dry weather and the low turbidity during rainy periods. The greater consistency in the results obtained during this recent study is attributable to the fact that the rainfall has been consistently moderate throughout the period of study.

Free Ammonia Nitrogen

Ammonia determinations have been used quite extensively in the past for estimating plant unit efficiencies as the ammonia nitrogen in sewage is the result of the breaking down of urea and the anaerobic decomposition of organic nitrogen such as proteins.

Table V

Free Ammonia Nitrogen

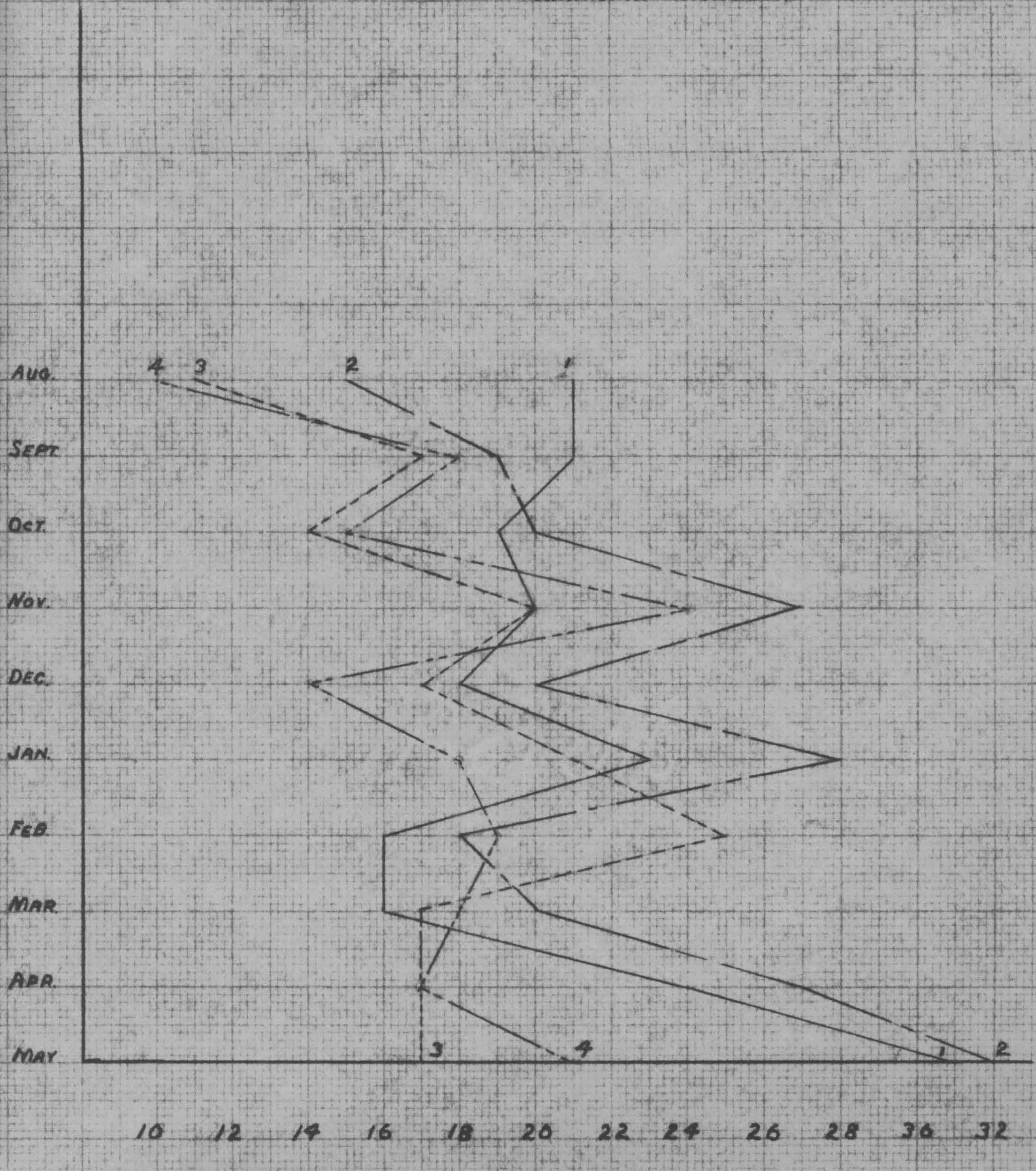
Average Results by Months (p.p.m.)

Months	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	21	15	11	10	14.9	13.5	7.0	10.6
Sept.	21	19	17	18	12.8	16.2	10.7	7.4
Oct.	19	20	14	15	17.8	18.1	14.4	14.4
Nov.	20	27	20	24	19.0	17.0	15.0	15.0
Dec.	18	20	17	14	10.0	14.0	8.0	10.0
Jan.	23	28	21	18	12.0	12.5	9.7	9.5
Feb.	16	18	25	19	11.9	12.9	9.4	10.9
Mar.	16	20	17	18	12.1	12.0	10.0	10.5
Apr.	24	27	17	17	13.9	13.5	12.6	8.3
May	31	32	17	21	7.4	12.0	9.0	9.0
Ave.	20.9	22.6	17.6	17.4	13.2	14.2	10.6	10.6
% Red.	17	8	22		20	7.6	25	

The results show an average increase of 8 per cent in the ammonia content of the sewage after it has passed through the Imhoff tank. This checks closely with Cultice's results which showed an increase of ammonia of 7.6 per cent across the Imhoff tank. Ammonia, as before stated, is the product of anaerobic decomposition of organic nitrogen and as the organic nitrogen in the sewage undergoes such a decomposition in the Imhoff tank, it is natural to expect an increase in ammonia across the

FIGURE 4.

AMMONIA NITROGEN



Imhoff tank.

An average production of 22 per cent was accomplished in the contact beds. Mr. Cultice's results show a reduction of 23 per cent. Ammonia is broken down by aerobic bacteria and converted by oxidation into nitrite nitrogen and subsequently into nitrate nitrogen. Oxidation takes place in the contact beds and accounts for the reduction in ammonia across the contact beds.

Neither study revealed an appreciable change in ammonia nitrogen across the humus tank.

The entire treatment process removed an average of 17 per cent of the ammonia nitrogen in the sewage which checks closely with Mr. Cultice's results of 20 per cent removal.

Organic Nitrogen

Organic nitrogen is a measure of the total nitrogenous matter in the sewage except that present as ammonia nitrogen, nitrites, and nitrates. It becomes ammonia in anaerobic decomposition and nitrites or nitrates in aerobic decomposition.

Table VI

Organic Nitrogen

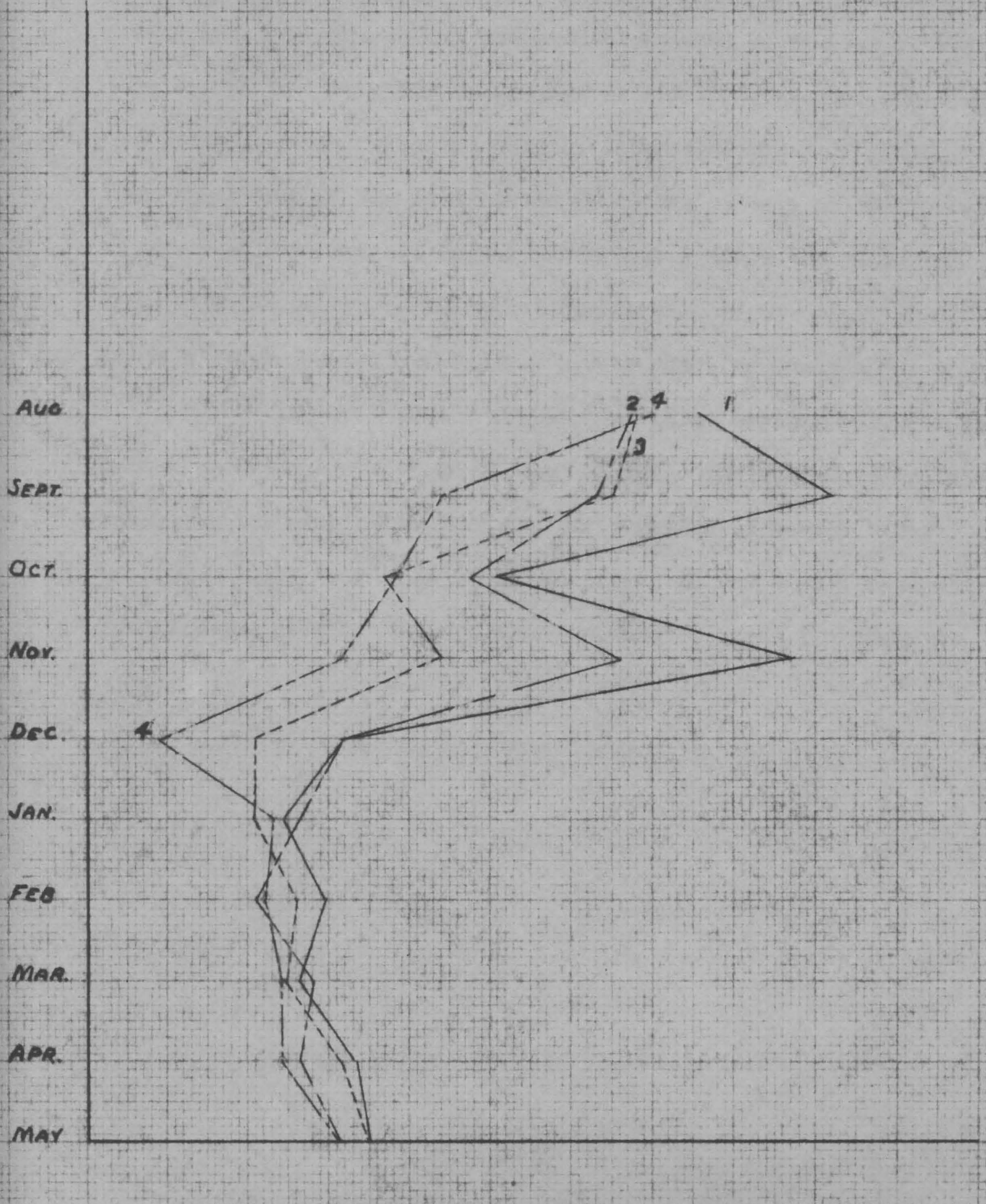
Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	15.2	13.5	13.6	14.0	18.2	9.6	23.0	11.0
Sept.	18.4	12.6	13.0	8.8	10.1	6.9	5.0	4.4
Oct.	10.2	9.5	7.4	7.7	27.7	15.9	12.9	11.6
Nov.	17.5	13.2	8.8	6.3	23.2	20.4	11.0	9.4
Dec.	6.3	6.3	4.2	2.8	32.0	18.0	8.0	10.0
Jan.	4.9	5.3	4.2	4.6	21.0	14.3	10.1	7.8
Feb.	5.9	4.2	5.2	4.2	22.3	10.3	7.9	8.0
Mar.	5.3	5.6	4.9	4.9	9.9	5.0	2.8	2.7
Apr.	6.7	5.3	6.3	4.9	9.3	10.3	2.4	2.0
May	7.0	6.3	7.0	6.3	6.0	3.2	4.8	4.8
Ave.	9.7	8.2	7.5	6.5	18.0	11.4	8.8	7.2
% Red.	33	15	8.6	13.0	60	37	23	18.0

The results obtained during this more recent study show a marked decrease in the average organic nitrogen in the raw sewage as compared to Mr. Cultice's determinations. Also, there appears to be a great reduction in the efficiency of the sewage treatment plant as far as removal of organic nitrogen is concerned.

FIGURE 5

ORGANIC NITROGEN



It is significant to note that while the raw sewage now contains much less organic nitrogen when it reaches the plant, the amount of ammonia nitrogen is much greater now than when Mr. Cultice made his studies. Since the previous study was made, the sewage system has been extended to accommodate several of the more remote sections of the town; and the sewage is not as fresh when it reaches the plant as it was when the earlier determinations were made. Therefore, some of the less stable compounds of organic nitrogen are broken down into ammonia before the sewage reaches the plant and there results an increase in the ammonia and a decrease in the organic nitrogen content of the raw sewage entering the plant.

The low plant efficiency in the removal of organic nitrogen is probably due to the fact that only the more stable organic matter reaches the plant. Also, the greater quantity of sewage being treated has shortened the detention period in the Imhoff tank where normally the greatest reduction in organic nitrogen is obtained.

Nitrites

The nitrite nitrogen in sewage is an immediate product of the oxidation of ammonia nitrogen to nitrate nitrogen. The test for nitrites, therefore, indicates the amount of nitrogen that has been partially oxidized.

Table III

Nitrite Nitrogen

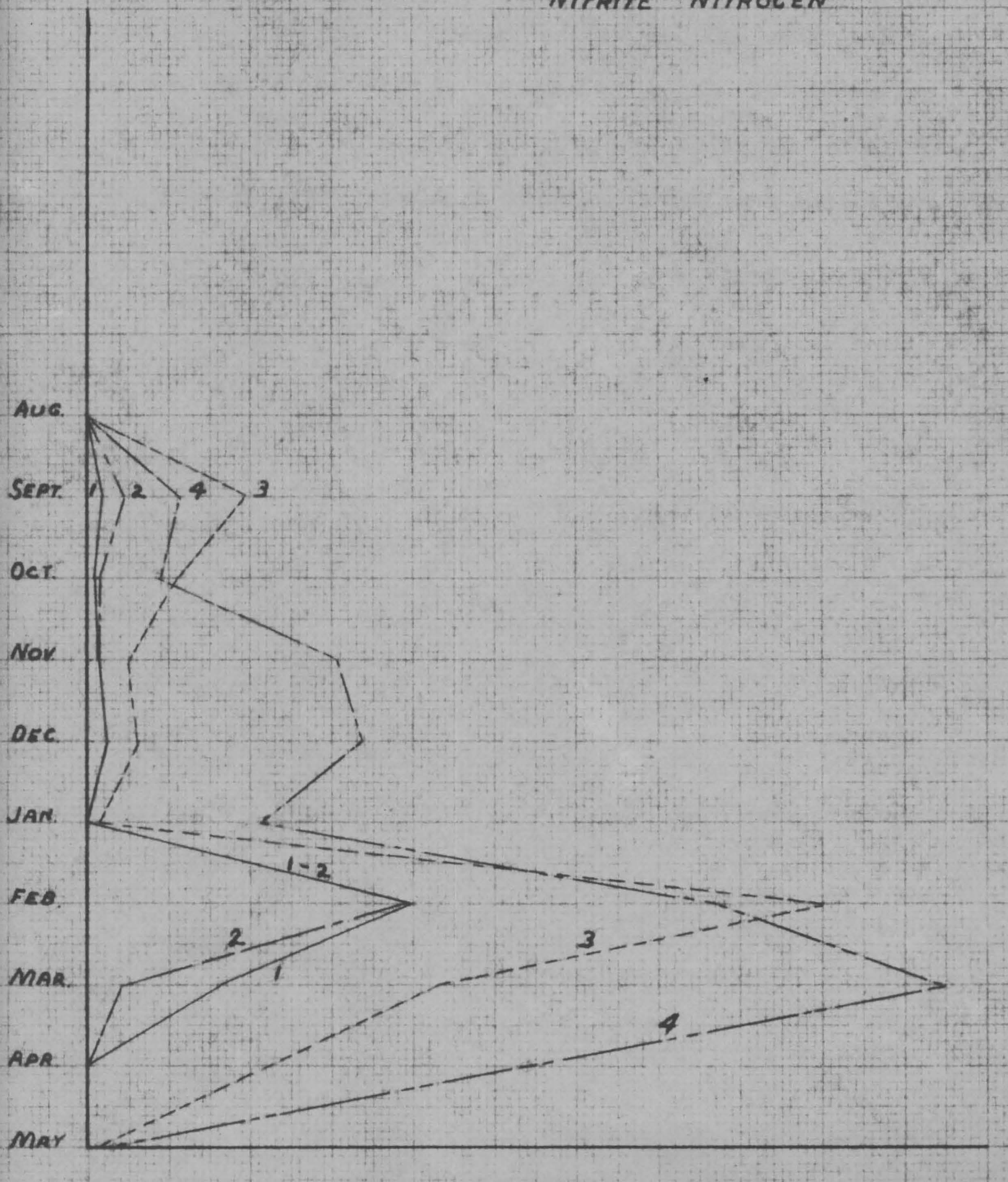
Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	.000	.000	tr	tr	.030	.000	.340	.050
Sept.	.019	.044	.194	.110	.000	.000	1.010	.550
Oct.	.006	.013	.110	.090	.000	.000	.160	.350
Nov.	.013	.013	.050	.308	.000	.000	.190	.130
Dec.	.025	.025	.063	.338	.000	.000	.350	.280
Jan.	.000	.000	.013	.213	.000	.000	.220	.270
Feb.	.400	.400	.900	.775	.100	.100	.340	.350
Mar.	.160	.044	.431	1.050	.000	.000	.190	.180
Apr.	.000	.000	.225	.540	.170	.000	.200	.360
May	.000	.000	.013	.038	.250	.000	.200	.180
Ave.	.057	.056	.200	.326	.055	.010	.320	.272

The amount of nitrite nitrogen in the sewage varies inversely with the free ammonia and organic nitrogen content. Samples of raw sewage and effluent from the Imhoff tank rarely ever contained any nitrites, and in most cases the nitrite content of the contact bed effluent and the plant effluent were low. There were a few instances, however, when the nitrite content in all samples was considerably above the average. This was probably due to nitrite

FIGURE 6

NITRITE NITROGEN



compounds of the soil being worked into the mains during heavy rains.

The results check very closely with those obtained by Mr. Cultice. Both show that a much greater degree of nitrification was accomplished within the contact bed and the humus tank than in the Imhoff tank. It is interesting to note that while Mr. Cultice found a decrease in the nitrites across the humus tank, the present study revealed a considerable increase across the tank.

Nitrate Nitrogen

The amount of nitrates in sewage shows the progress toward complete oxidation and stability. A completely treated sewage should have a relatively high proportion of nitrates.

Table VIII

Nitrate Nitrogen

Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	.040	.040	.070	.540	.000	.000	.200	.050
Sept.	.010	.130	.130	.180	.100	.400	1.500	2.700
Oct.	.025	.025	.100	.130	.200	1.200	2.300	3.600
Nov.	.090	.110	.180	.180	.000	tr	.050	.690
Dec.	.000	.000	.060	.060	.000	.000	.800	1.300
Jan.	.015	.015	.030	.030	.000	.000	2.300	2.300
Feb.	.080	.080	1.490	1.490	.100	.100	6.100	6.200
Mar.	.070	.070	.040	.700	.100	.100	2.700	3.900
Apr.	.000	.000	.000	.250	.300	.000	1.740	2.600
May	.000	.000	.000	.000	.000	.000	.000	.000
Ave.	.035	.049	.246	.256	.080	.180	1.770	2.380

Nitrates, like nitrites, vary inversely with the free ammonia and organic nitrogen in sewage and the results tend to bear this out very nicely. There is a slight increase in nitrate nitrogen across the Imhoff tank, a very pronounced increase across the contact beds, and a noticeable increase through the humus tank.

The results do not check with those obtained by Mr. Cultice. Instead, there appears to be an enormous reduction in the nitrification efficiency of the plant. The contact beds have not been cleaned since the plant was put into operation and are probably clogged with mud

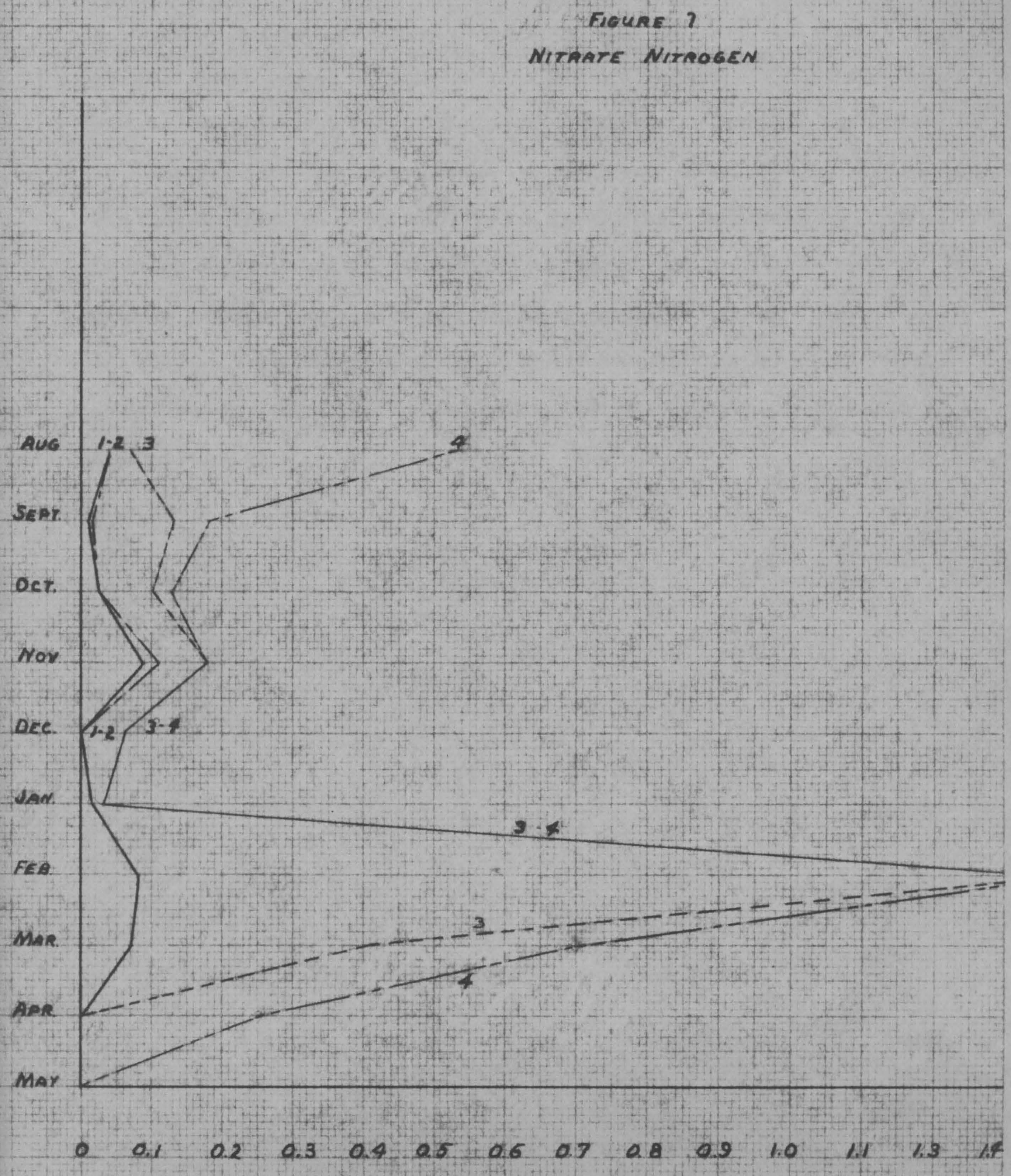


FIGURE 7
NITRATE NITROGEN
AUG
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
1-2
3
4
3-4
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.3
1.4

and dead bacteria to such an extent that aerobic decomposition of sewage is greatly hindered and production of nitrate nitrogen reduced.

Certain bacteria reduce nitrates to gaseous nitrogen while still other bacteria reduce nitrates to nitrites and ammonia and liberate gaseous nitrogen from either of these. Furthermore, bacteria may convert ammonia into the living matter of their own cells. Results of the ammonia nitrogen tests show that a considerable reduction in ammonia is being accomplished by the various treatments and results of the nitrate nitrogen tests show very little increase in nitrates across the plant. Evidently most of the nitrites and nitrates are being reduced just as fast as they are produced and gaseous nitrogen is being liberated.

Oxygen Consumed

The test for oxygen consumed is used very little in present practice. However, it does give some indication of the amount of carbonaceous matter sewage. It is used primarily for determining sewage strength and to check or control the efficiency of treatment plants.

Table IX

Oxygen Consumed

Average Results by Months (p.p.m.)

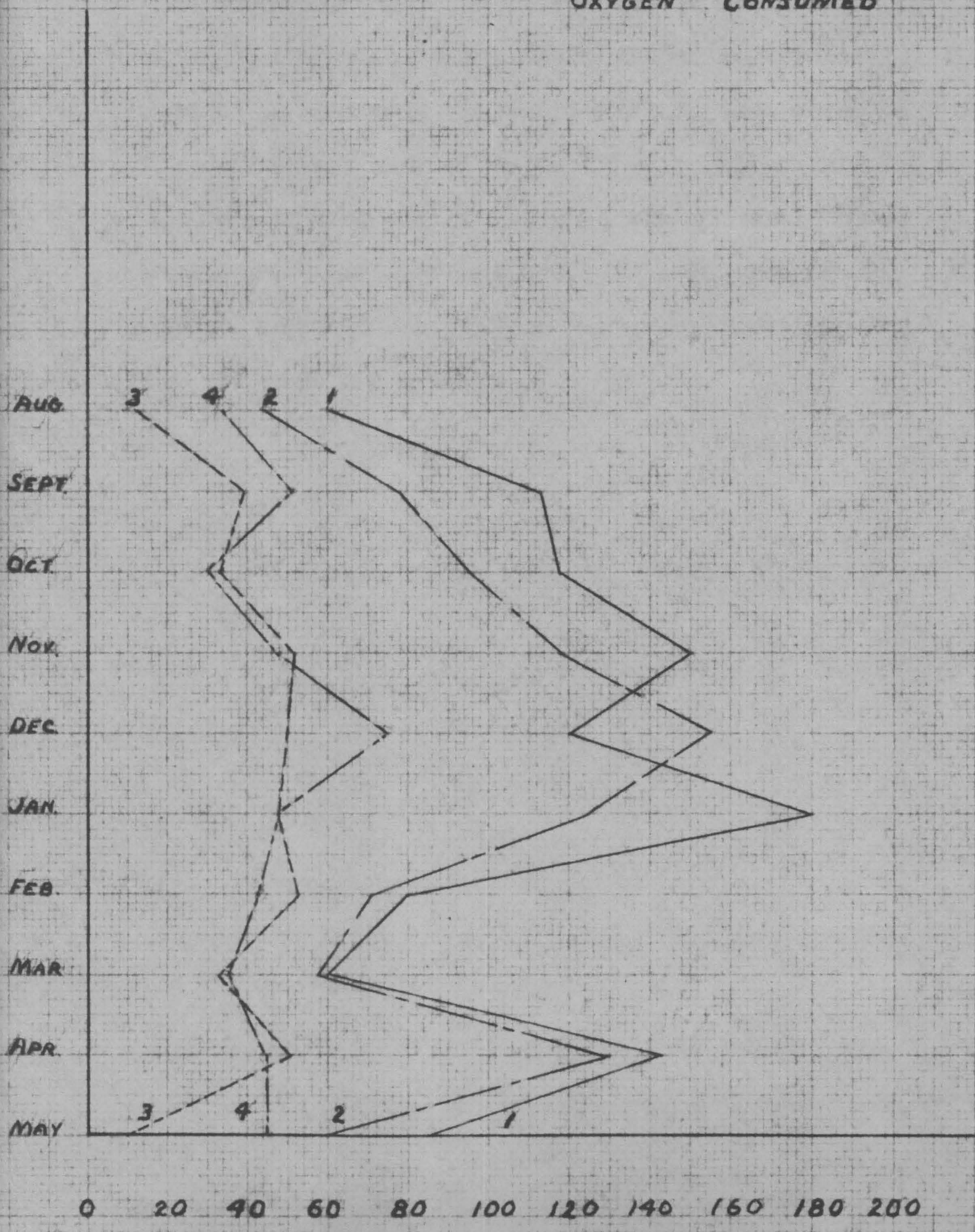
Month	Johnson				Cultice			
Aug.	60	45	12	34	51	41	24	17.0
Sept.	113	78	39	51	99	71	38	34.0
Oct.	118	95	33	30	135	75	38	26.0
Nov.	150	118	52	48	131	77.5	36.5	26.0
Dec.	120	155	50	75	105	82.0	31.0	39.0
Jan.	180	125	48	48	121.9	82.4	26.8	25.3
Feb.	80	71	53	43	111.1	79.7	26.7	21.7
Mar.	60	58	33	33	84.6	59.7	18.9	19.4
Apr.	143	130	51	45	98.0	58.1	37.7	26.1
May	85	60	10	45	43.0	45.6	14.0	13.0
Ave.	111	94	38	45	98.0	67.2	27.6	24.8
% Red.	60	15	60	18	75	32	59	10

The present study shows a greater consumption of oxygen than revealed by previous studies. This indicates that the sewage now carries a higher concentration of carbonaceous matter than before.

If the oxygen consumed is considered as a check on the efficiency of a sewage plant, there has been a reduction in the efficiency of the contact beds. The decrease in oxygen consumed across the entire plant

FIGURE 8

OXYGEN CONSUMED



is 60 per cent or practically the same as when Mr. Cultice made his study. However, there appears to be an average increase in the oxygen consumed after the sewage has passed through the humus tank.

Mr. Cultice has correlated his oxygen consumed and B.O.D. tests by giving the ratios of the B.O.D. to the oxygen consumed for different stages of treatment. Using his results, there was a value of 1.72 on raw sewage, 1.37 on the Imhoff tank effluent, 0.97 on the contact bed effluent and 1.02 on the plant effluent. The ratios have increased until now there is a ratio of 1.96 of raw sewage, 1.73 on the Imhoff tank effluent, 1.46 on the contact bed effluent and only 0.9 on the humus tank effluent.

Dissolved Oxygen

Very fresh sewage may still contain a small amount of dissolved oxygen from the water supply; however, it will soon disappear. When a high degree of treatment is given, however, dissolved oxygen should appear in the effluent, and the test becomes an important indication of efficiency.

Table X

Dissolved Oxygen

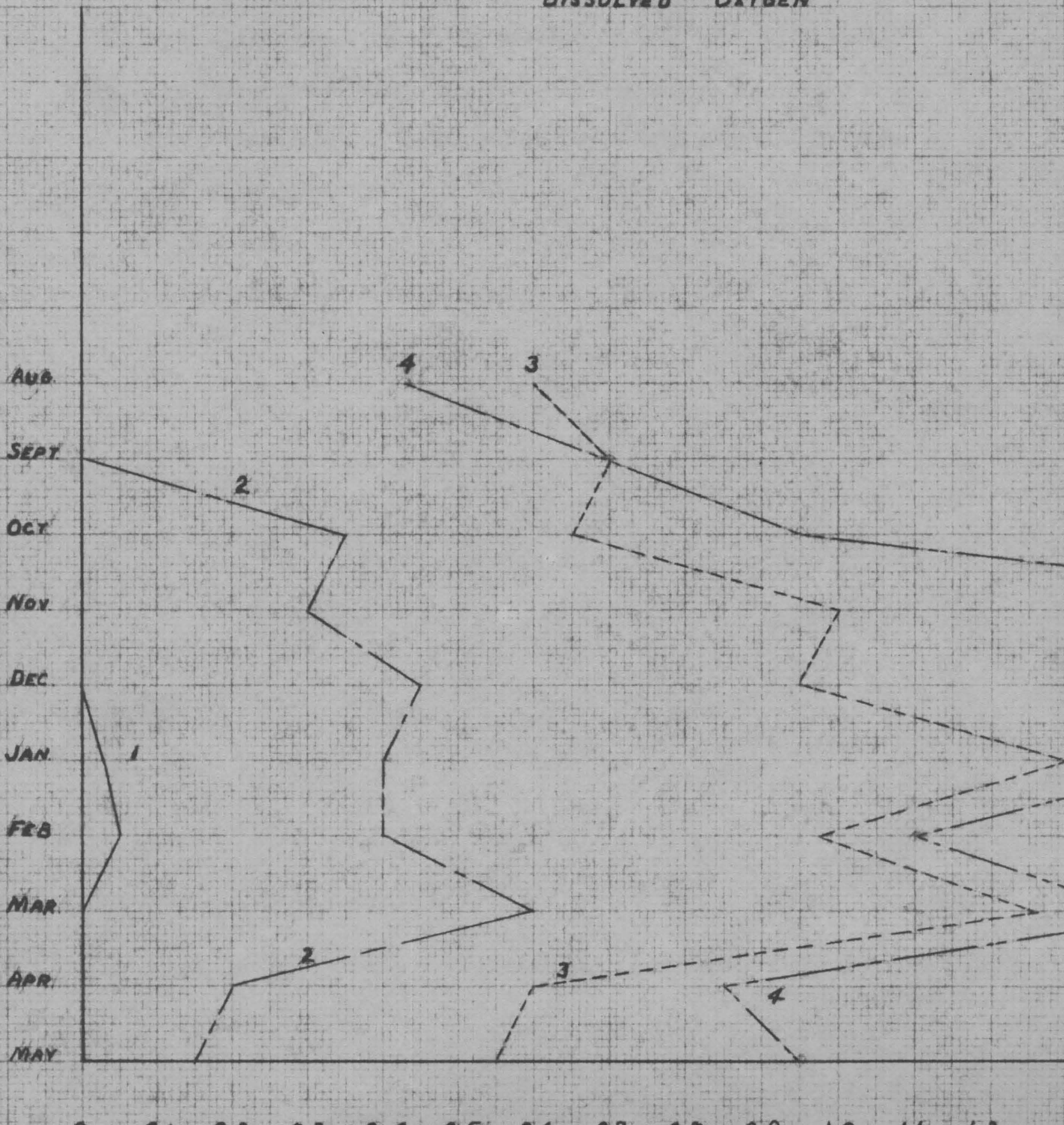
Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
Aug.	.00	.00	.60	.43	tr	.40	1.20	1.40
Sept.	.00	.00	.70	.70	.00	.10	.40	.80
Oct.	.00	.35	.65	.95	.00	tr	1.60	1.60
Nov.	.00	.30	1.00	1.80	tr	tr	.65	.35
Dec.	.00	.45	.90	2.00	1.10	.60	2.10	1.60
Jan.	.03	.40	1.30	1.40	.30	.20	.90	.70
Feb.	.05	.40	.95	1.10	.20	.10	1.40	1.10
Mar.	.00	.60	1.25	1.48	.50	.45	1.30	1.85
Apr.	.00	.20	.60	.85	.23	.20	.33	.10
May	.00	.15	.55	.95	.10	.00	.50	.30
Ave.	.01	.285	.85	1.17	.24	.205	1.04	.98

Mr. Cultice found that the raw sewage contained an appreciable amount of dissolved oxygen. The results of the present determinations show that the raw sewage contains practically no dissolved oxygen. This is a good indication that the sewage is not nearly as fresh when it reached the plant as it was when the previous study was made.

FIGURE 9

DISSOLVED OXYGEN



Ordinarily there should be a reduction in the dissolved oxygen when the sewage flows through the Imhoff tank. The results indicate a marked increase across the Imhoff tank. This was probably due to a slight aeration of the samples as they were collected.

Considerable aeration took place across the contact beds and secondary sedimentation tank, and the dissolved oxygen was increased by both treatments.

Biochemical Oxygen Demand

Decomposition and mineralization of organic matter by bacterial activity are accompanied by depletion of the dissolved oxygen. The avidity of sewage of sewage for oxygen, therefore, reflects both the nature and the quantity of the organic matter it contains. Determination of the biochemical oxygen demand gives a measure of the oxygen required by natural aerobic decomposition.

Table XI

Biochemical Oxygen Demand

Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	141	99	51	22	107	50	18	13
Sept.	139	118	27	21	159	95	23.0	21
Oct.	349	249	82	37	366	198	32.9	30.4
Nov.	295	188	85	85	191	148	62.0	46.0
Dec.	177	187	44	46	205	--	20.0	--
Jan.	235	179	38	21	142	82.4	26.8	25.3
Feb.	177	153	63	41	81.5	44.5	13.0	13.4
Mar.	209	170	89	67	87.0	82.5	24.2	17.7
Apr.	178	141	45	33	113	55.8	36.0	33.0
May	158	140	39.8	31	233	72	7.4	27.0
Ave.	216	162.4	55.5	40.4	168.5	92.0	26.8	25.2
% Red.	81	25	66	27	85	45	71	6.0

The results indicate an 81 per cent B.O.D. efficiency across the plant which is only a little less than the 85 per cent efficiency determined by Mr. Cultice. There has been a considerable decrease in reduction in B.O.D. across the Imhoff tank for the recent tests reveal

FIGURE 9

BIOCHEMICAL OXYGEN DEMAND

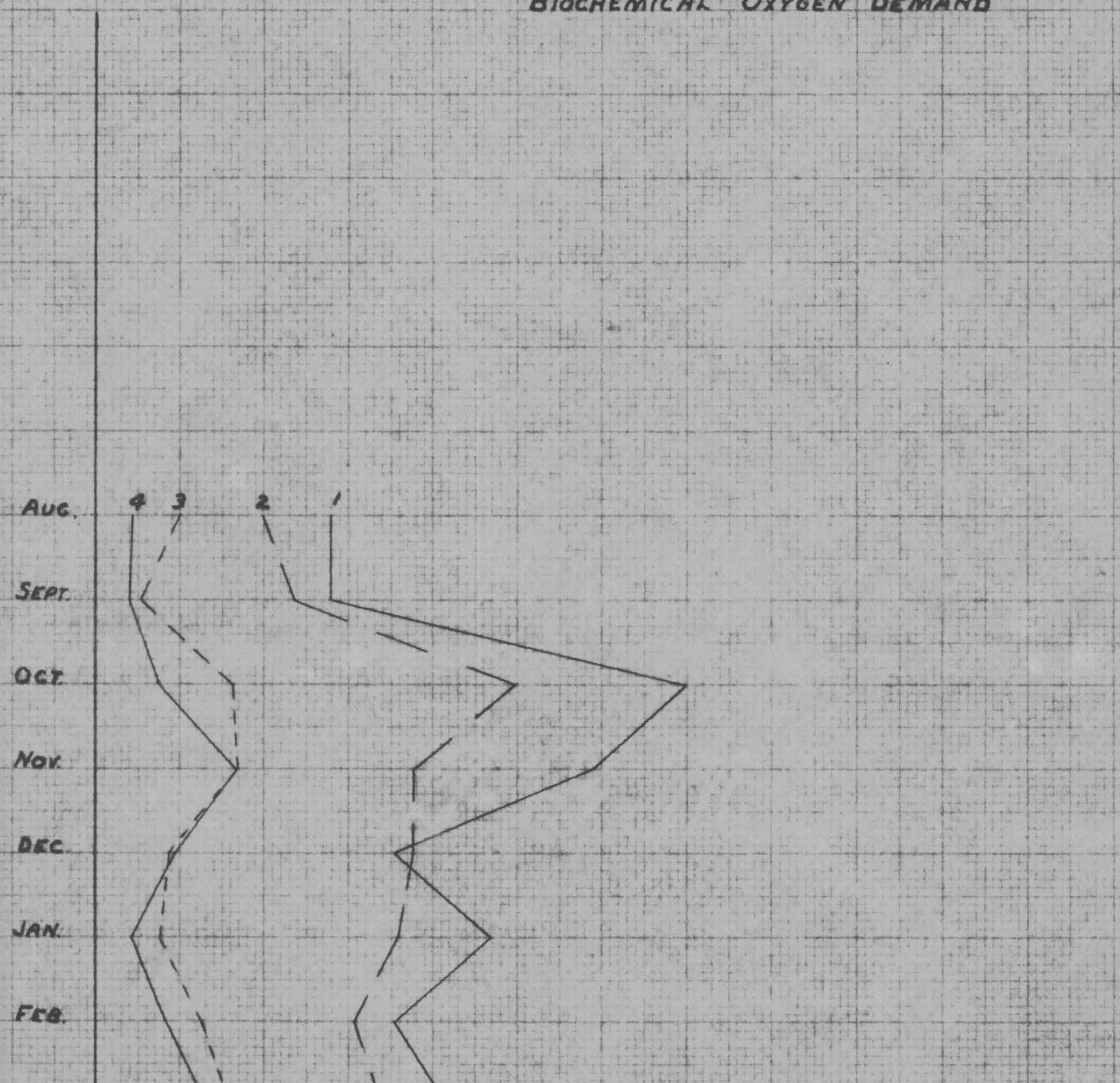
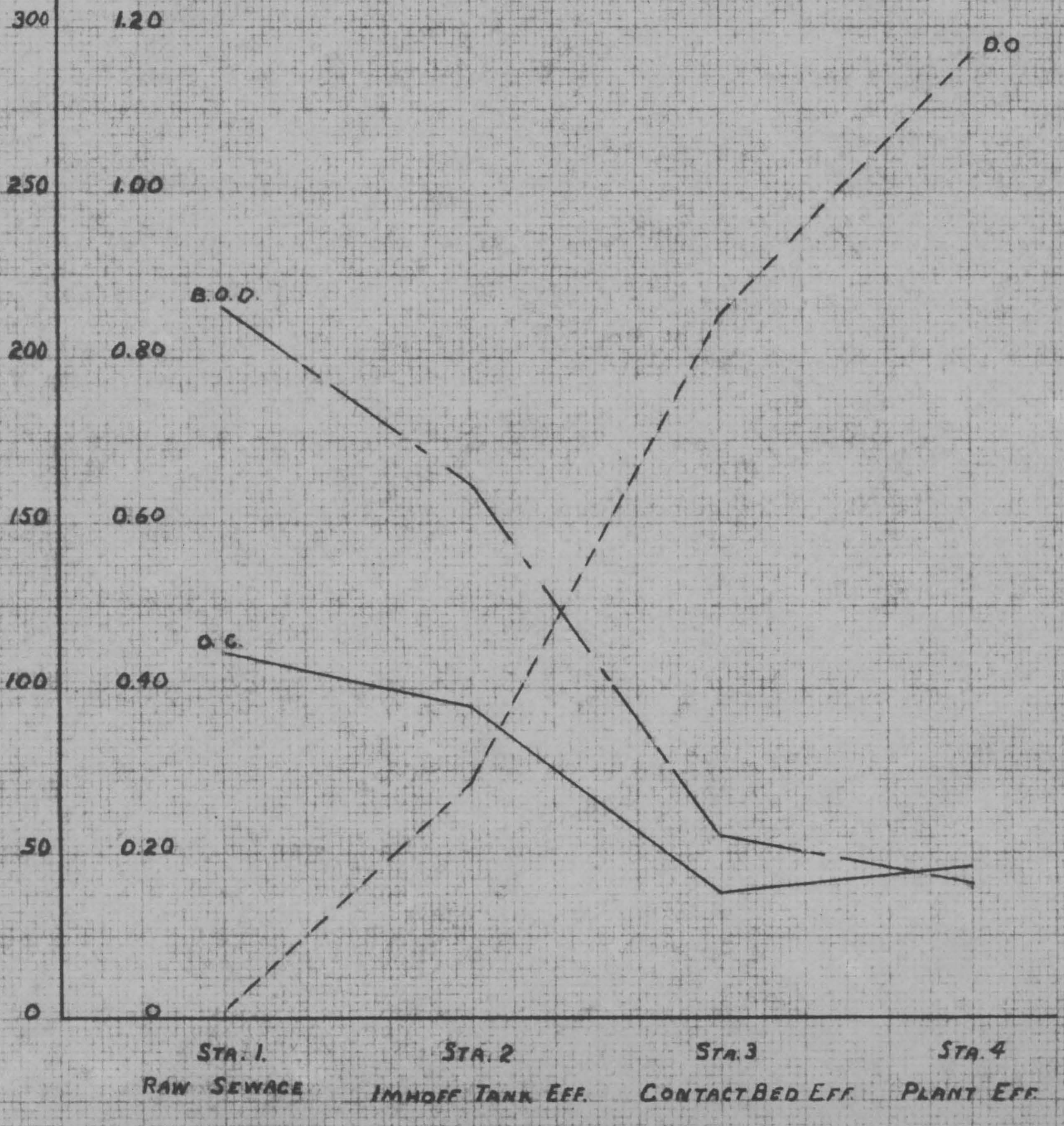


FIGURE 10

DISSOLVED OXYGEN, B.O.D.,
AND
OXYGEN CONSUMED



only a 25 per cent reduction across the tank as against the 45 per cent reduction determined by Mr. Cultice. This decrease is probably due to the fact that a greater quantity of sewage is flowing through the Imhoff tank and the period of detention has been decreased enough to curtail the settling out of oxidizable material. The percentage reduction across the contact beds amounts to 66 per cent while previous determinations reveal a reduction of 71 per cent. The humus tank seems to be much more effective than when the earlier studies were made. The reduction across the humus tank has increased from 6 per cent to 27 per cent.

The biochemical oxygen demand is considerably greater now than at the time Mr. Cultice made his study and indicates that the content of decomposable organic matter in the sewage is higher than when the previous tests were made.

Relative Stability

Relative stability may be defined as the per cent ratio of oxygen available as dissolved, nitrite, and nitrate oxygen to the total oxygen required to satisfy the biochemical oxygen demand. Determinations of the relative stability are not nearly so accurate as the biochemical demand determinations and are being replaced by the B.O.D. tests. An effluent that does not decolorize in four days is considered practically stable and should cause no trouble if discharged into a stream.

The effluent from the disposal plant for Virginia Polytechnic Institute causes no trouble when discharged into Struble's Creek even though the dilution factor is not more than three or four to one. The relative stability of the effluent as indicated by the tests made during this study, however, was always less than 11 per cent.

Suspended Solids

The suspended solids are those which are retained when sewage is filtered through an alundum crucible. Tests for suspended solids show the concentration of sewage and provides a fair check upon the efficiency of sedimentation tanks and other treatment units.

Table XII

Total Suspended Solids

Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	378	111	42	61	128	62	37	32
Sept.	247	144	68	94	271	150	66	60
Oct.	566	306	114	77	541	196	50	28
Nov.	423	216	90	71	287	192	--	12
Dec.	478	332	148	130	---	---	--	--
Jan.	483	316	201	159	493	192	62	37
Feb.	324	267	133	130	291	170	70	69
Mar.	563	242	150	150	253	163	109	76
Apr.	427	249	109	104	262	187	131	110
May	224	125	74	67	149	151	46	53
Ave.	411	231	114	104	297	163	71	53
% Red.	74.6	44.[illegible]	50.6	8.8	82.2	45.1	56.4	25.3

The results indicate a 44[illegible] per cent reduction across the Imhoff tank, a 50.6 per cent reduction across the contact beds, and an 8.8 per cent reduction across the humus tank, with a total of 74.6 per cent across the entire system. Mr. Cultice's figures show a slightly higher efficiency of removal of suspended solids. He found 45.1

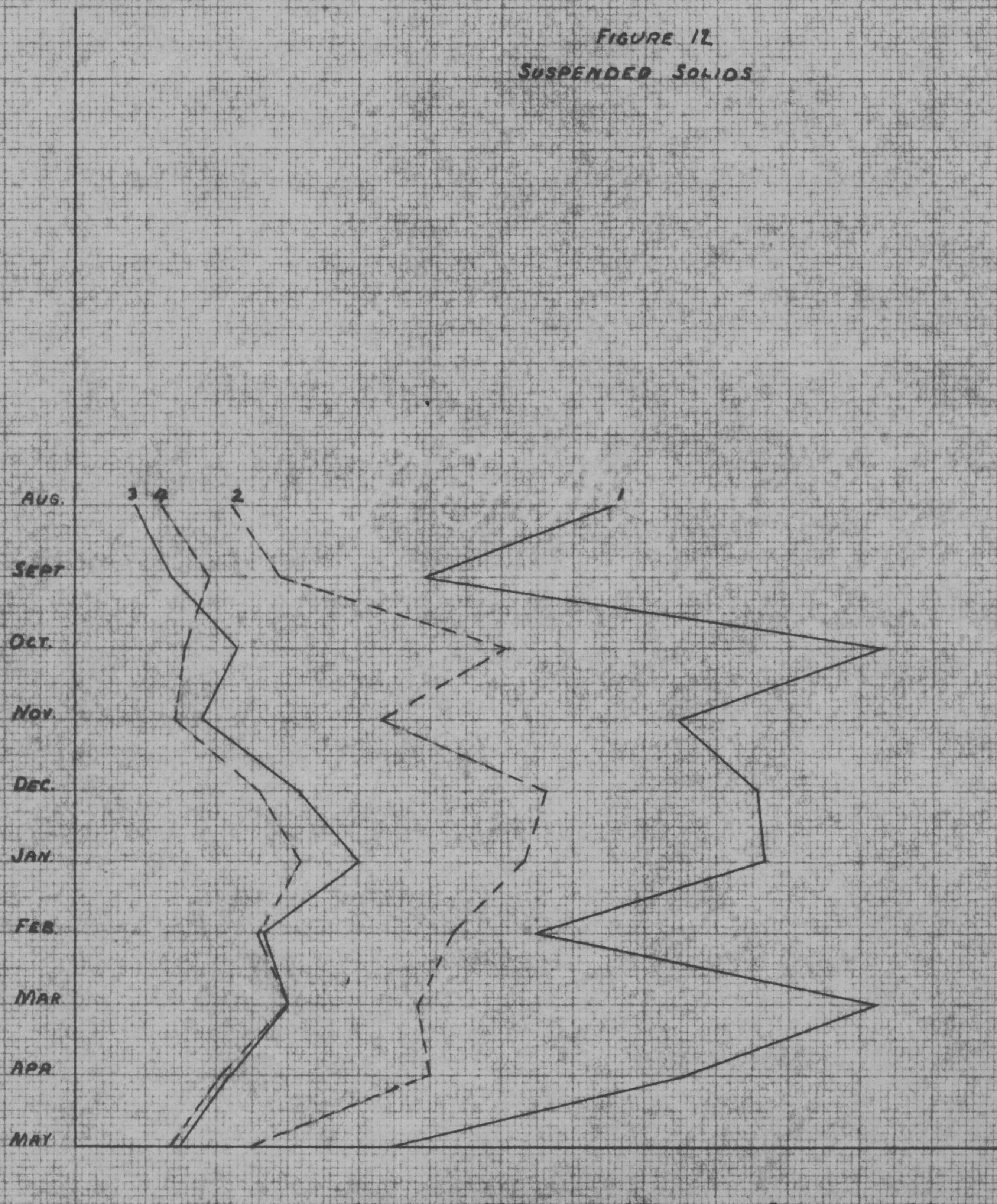


FIGURE 12
SUSPENDED SOLIDS
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
3
4
2
1
100
200
300
400
500
600

per cent reduction across the Imhoff tank, a 56.4 per cent reduction across the contact beds, a 25.3 per cent reduction across the humus tank, and a total of 82.2 per cent across the entire plant.

The amount of suspended solids in the sewage is much greater now than at the time of Mr. Cultice's study. This is a good indication that the sewage is somewhat stronger now than when the earlier study was made.

The removal of suspended solids accomplished in the Imhoff tank is due almost entirely to the settling out of the settleable solids while aerobic decomposition and to a certain extent filtration accounts for the reduction of suspended solids across the contact beds.

Suspended Volatile Solids

Colatile solids are usually classed as organic matter and comprise a considerable portion of the suspended solids in sewage.

Table XIII

Suspended Volatile Solids

Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	250	107	43	46	---	---	--	--
Sept.	205	135	58	72	---	---	--	--
Oct.	451	203	77	68	---	---	--	--
Nov.	395	177	69	67	---	---	--	--
Dec.	392	267	104	84	---	---	--	--
Jan.	385	263	142	113	---	---	--	--
Feb.	266	194	96	85	253	101	30	45
Mar.	298	207	117	115	199	109	53	60
Apr.	355	192	72	65	223	138	41	71
May	178	98	55	58	98	83	13	13
Ave.	317	185	83	77	193	108	34	47
% Red.	75.7	41.6	55	7.25	75.7	44	68.5	38.2
% Vol.	77	60	73	74	81	64	38	61

Suspended matter in completely treated sewage usually has a lower proportion of volatile solids than in raw unsettled sewage. The results obtained during this study show very little reduction in the proportion of volatile suspended solids. The average percentage of removal of total suspended and volatile suspended solids is practically the same at every stage of treatment.

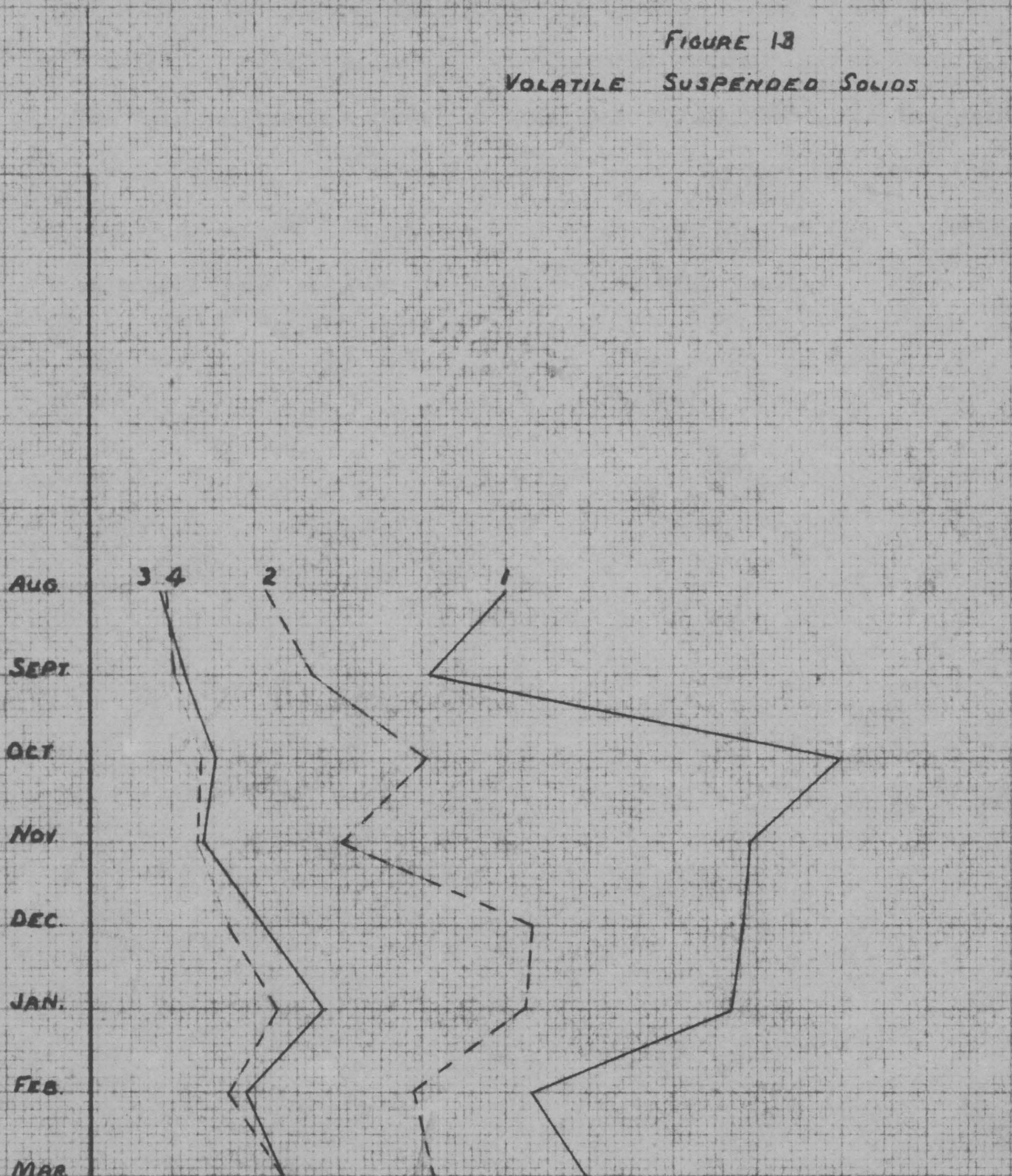


Figure 13
Volatile Suspended Solids
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
3
4
2
1
100
200
300
400
500

The percentage of removal of volatile suspended solids accomplished by the entire treatment process is the same now as when Mr. Cultice made his study. A small percentage of volatile suspended solids is being removed as the sewage passes through the final sedimentation tank while previous studies revealed an increase in volatile suspended solids across the final sedimentation tank.

Total Solids

The total solids include both the suspended and the dissolved solids. A large part of the dissolved solids in sewage comes from the water which is its principle constituent and is chiefly mineral matter.

Table XIV

Total Solids

Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	603	444	404	354	563	467	357	358
Sept.	868	683	483	475	745	516	432	408
Oct.	1008	690	461	477	1243	627	492	481
Nov.	707	670	435	435	1010	582	444	415
Dec.	650	650	457	470	--	--	--	--
Jan.	940	717	536	486	672	541	442	415
Feb.	653	627	514	502	680	520	434	441
Mar.	592	615	383	517	571	567	480	500
Apr.	844	619	457	492	682	513	471	460
May	928	659	533	508	442	483	420	515
Ave.	801	637	476	472	734	535	441	444
% Red.	41.2	20.5	25	--	39.5	27.2	17	--
% Sus.	51.3	36.3	23.9	22.1	40.5	30.5	16.1	12

The percentage of total solids removed by the complete treatment of the sewage is practically the same now as the time of Cultice's determinations. There has been, however, a slight reduction in the percentage of solids removed by the Imhoff tank and subsequent increase in the percentage of the solids removed by the contact beds.

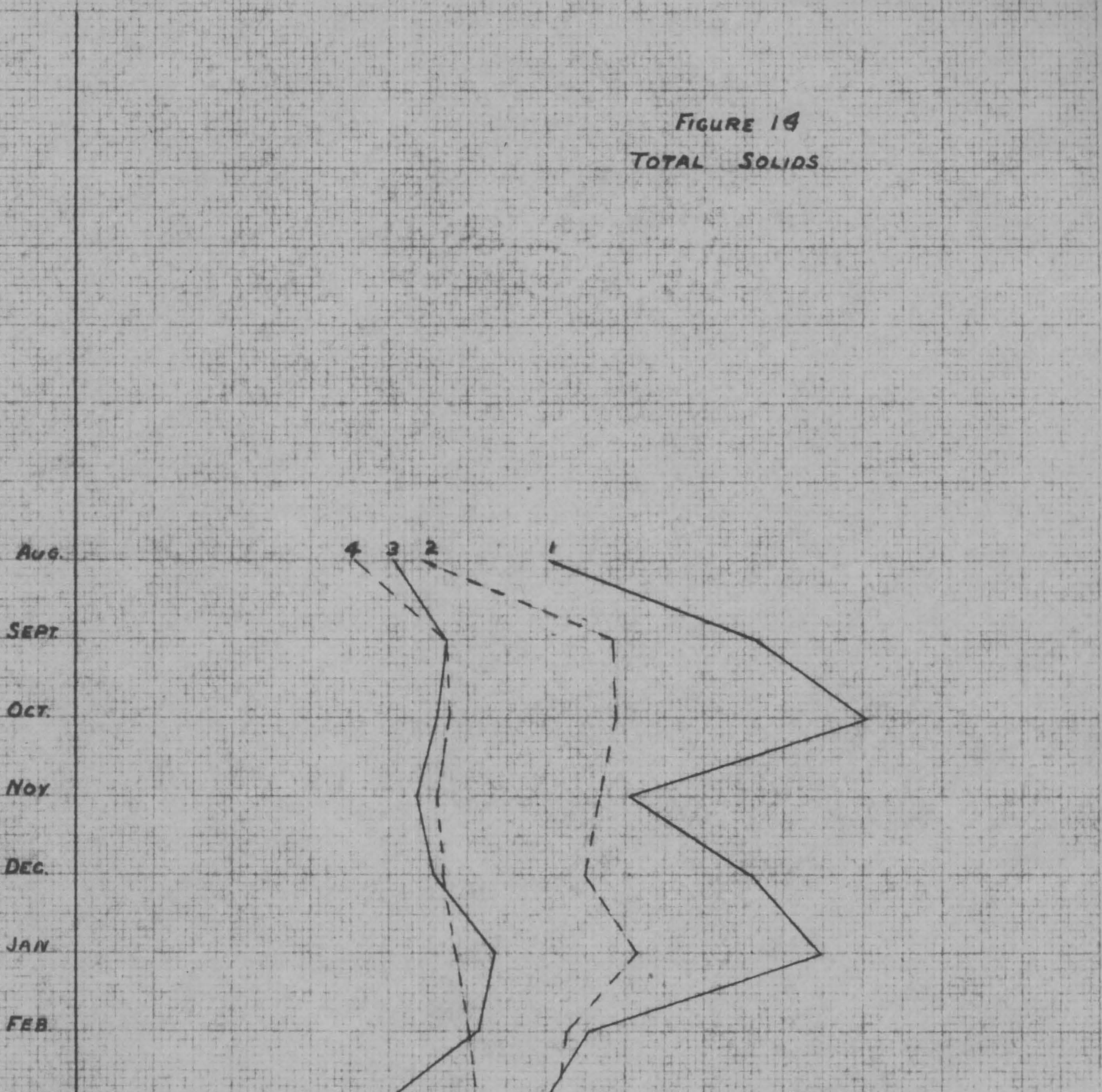


FIGURE 14
TOTAL SOLIDS
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
4
3
2
1
200
400
600
800
1000

The results of both studies show that the secondary sedimentation tank has no appreciable effect on the total solids.

The percentage of total solids comprised of suspended solids is greater now than at the time of previous studies. This is a good indication that the sewage has increased in strength.

Total Volatile Solids

As before stated, the volatile solids give some idea of the quantity but not the character of the organic matter present.

Table XV

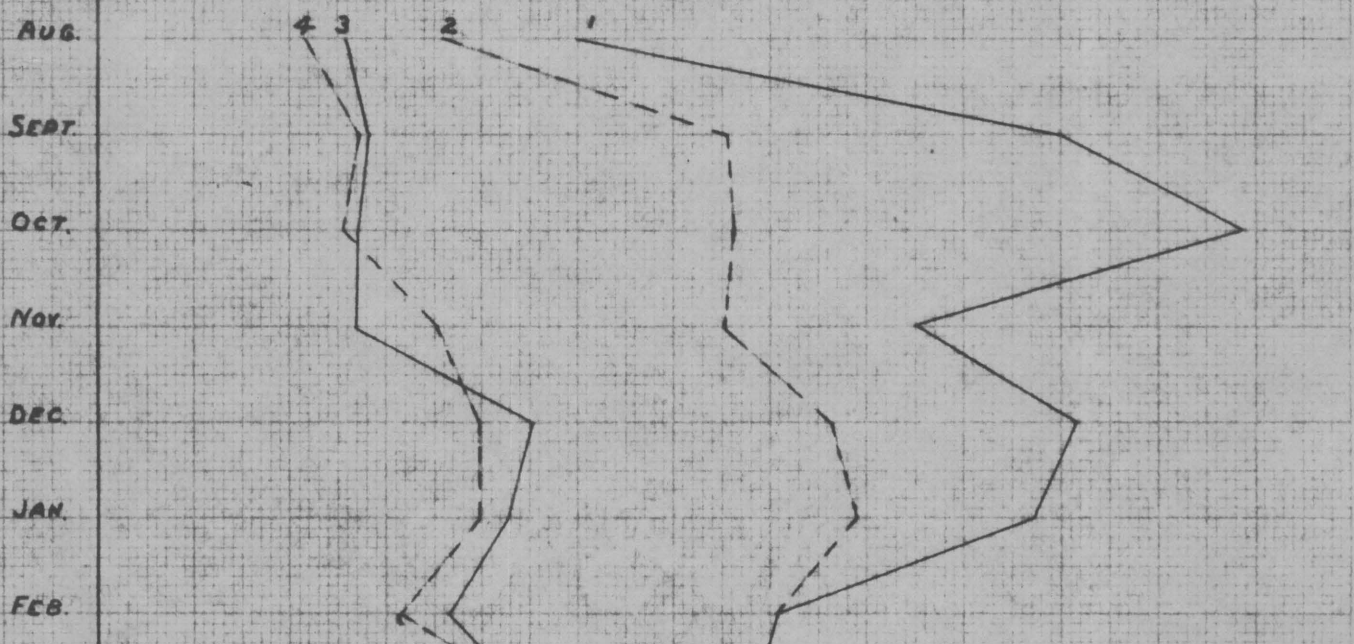
Total Volatile Solids

Average Results by Months (p.p.m.)

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	249	179	128	109	302	207	120	145
Sept.	499	327	142	137	415	228	144	148
Oct.	594	331	136	128	891	391	244	135
Nov.	425	326	135	176	575	270	82	16
Dec.	509	383	226	199	--	--	--	--
Jan.	487	395	214	198	412	290	130	119
Feb.	354	354	182	158	340	233	145	149
Mar.	340	338	231	239	357	306	241	219
Apr.	470	288	250	225	381	262	171	188
May	586	332	190	158	237	203	98	165
Ave.	450	325	183.4	173	433	266	153	143
% Rd.	61.5	27.8	43.7	5.5	67	38.5	43	6.5
% Vol.	56.2	51.0	38.4	36.6	59.1	49.7	43.7	32.3

The percentage of reduction of the total volatile solids across the plant is just slightly lower than at the time of previous studies. As was the case with total solids, there has been a reduction in the removal of total volatile solids across the Imhoff tank and subsequent increase in the removal across the contact beds. Again, the results show only a slight removal of solids across the secondary sedimentation tank.

FIGURE 15
TOTAL VOLATILE SOLIDS



The percentage of volatile matter in the total solids is approximately the same now as when Mr. Cultice made his determinations.

Fuller and McClintock state that 50 per cent or more of the total solids may be dissolved mineral matter. The results of this study show that the total solids are 56 per cent volatile matter and only 44 per cent non-volatile are mineral matter. The sewage, however, may be considered as average sewage because part of the mineral matter may be volatilized during the test for volatile matter.

Hydrogen Ion Concentration

The hydrogen ion concentration (usually referred to as the pH value) is a method of expressing the degree of alkalinity or acidity of sewage. The determination of hydrogen ion concentration is particularly significant in connection with the life processes of the bacteria that decompose sewage matter and the chemical reaction involved in sewage treatment as both proceed most rapidly at a well-defined optimum pH.

Table XVI

Hydrogen Ion Concentration

Average Results by Months

Month	Johnson				Cultice			
	#1	#2	#3	#4	#1	#2	#3	#4
Aug.	7.03	7.10	7.20	7.28	7.00	7.10	7.40	7.50
Sept.	7.05	7.10	7.20	7.25	7.10	7.10	7.40	7.50
Oct.	6.85	7.05	7.30	7.33	7.0	7.2	7.6	7.6
Nov.	6.9	7.0	7.3	7.4	7.0	7.3	7.5	7.5
Dec.	7.1	7.2	7.5	7.5	7.6	7.3	7.4	7.4
Jan.	6.8	7.07	7.25	7.47	7.0	7.3	7.5	7.5
Feb.	7.05	7.05	7.15	7.23	7.3	7.3	7.5	7.5
Mar.	7.07	7.05	7.23	7.27	7.3	7.2	7.5	7.5
Apr.	7.03	7.2	7.25	7.33	7.5	7.1	7.5	7.5
May	6.9	7.1	7.2	7.2	7.3	7.1	7.3	7.3
Ave.	6.99	7.1	7.26	7.32	7.2	7.2	7.46	7.48

Fresh sewage will be slightly akaline, but as it becomes stale it will become acid. The average pH of the sewage entering the plant is below 7.0 and this signifies acidity. Mr. Cultice's results show

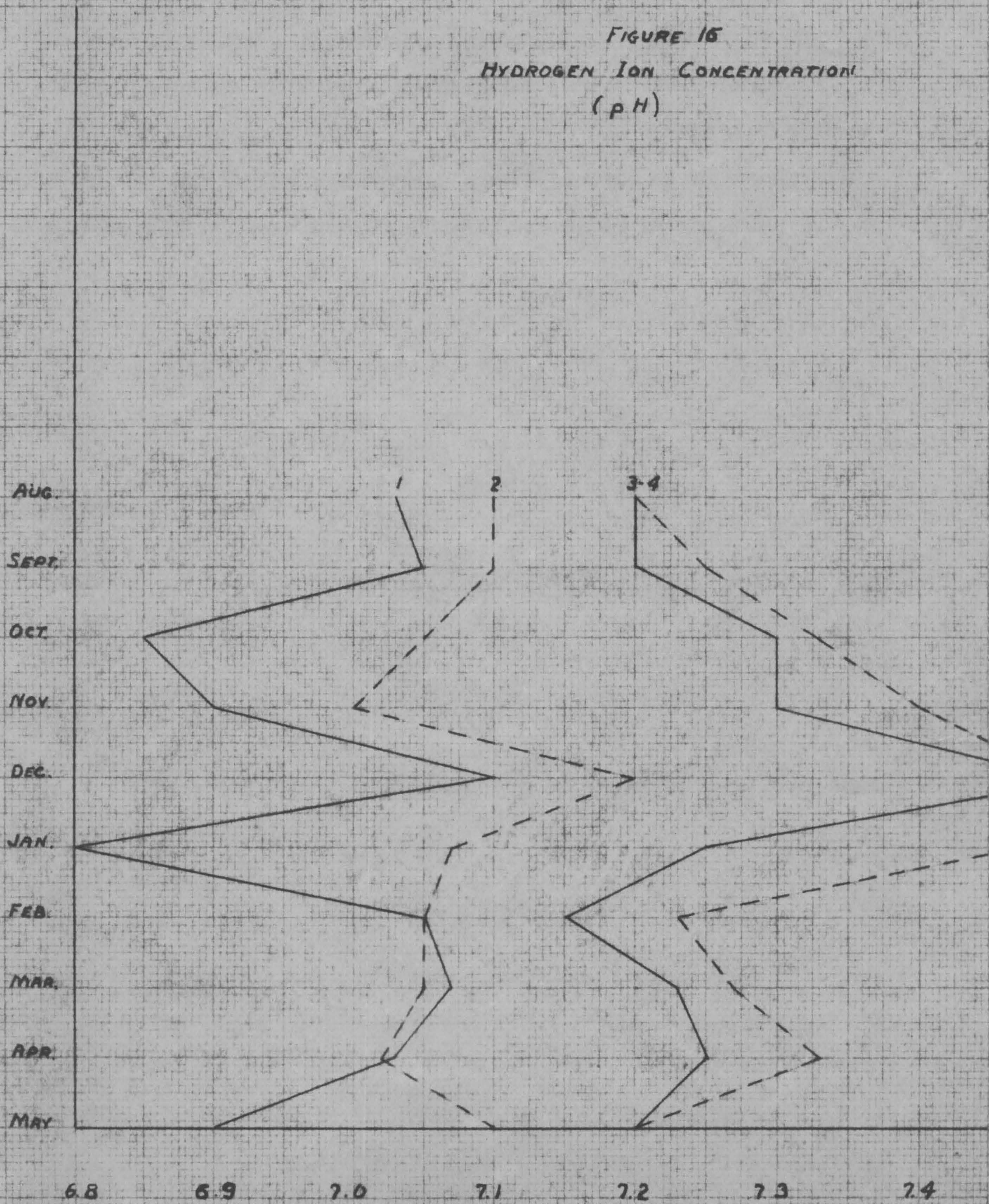


FIGURE 16
HYDROGEN ION CONCENTRATION
(pH)
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
1
2
3-4
6.8
6.9
7.0
7.1
7.2
7.3
7.4

that the average pH of the sewage entering was above 7.0 and indicates alkalinity. Apparently, then the sewage is not as fresh when it reaches the plant as it was when the previous study was made.

The results indicate a gradual increase in the pH value through the plant. Evidently the carbon dioxide content of the sewage has been decreased and the alkalinity of the sewage increased.

Attention Patron:

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SLUDGE STUDIES

Analyses of the sludge from the Imhoff tank were made at monthly intervals. The samples of sludge were collected by means of a small pitcher pump and a piece of weighted garden hose. The samples were taken from the sludge at the sludge line.

The procedure for the examination of sewage sludge and muds as outlined in "Standard Methods for the Analysis of Water and Sewage" was followed in making the tests. The tests made were pH, specific gravity, percentage of moisture, total solids, fixed solids, and organic nitrogen (dry sludge).

Hydrogen Ion Concentration

The test for pH is very important in controlling sludge digestion which proceeds most rapidly at a well-defined optimum pH. The activities of the micro-organisms of decay and the life processes of bacteria that decompose sewage matters are dependent upon the range of pH values of the sludge. Metcalf and Eddy state that the optimum pH is in the vicinity of 7.2 or 7.3 but any value above 6.8 will produce good results.

Three major stages may be distinguished in the course of digestion of freshly deposited sewage solids: (1) intensive acid production -- pH range 6.8 to 5.1; (2) acid regression or acid digestion -- pH range 5.1 to 6.6 or 6.8; (3) intensive digestion of more resistent materials --pH range 6.9 to 7.4. In sludge-digestion units all three stages of digestion are operative at the same time.

Table XVII

Hydrogen Ion Concentration

	Johnson	Cultice
Sept. 19, 1938	6.9	7.5
Oct. 19, 1938	6.8	7.4
Nov. 30, 1938	6.8	6.8
Dec. 14, 1938	6.8	---
Jan. 18, 1939	6.7	6.6
Feb. 8, 1939	6.7	6.65
Mar. 22, 1939	6.8	6.7
Apr. 19, 1939	7.0	6.8
May 10, 1939	7.0	6.65
Average	6.83	6.8

The results show an average pH of 6.83 and indicate a slightly acid sludge. The sludge nearer the surface is probably much fresher than that beneath and intensive acid production proceeds more rapidly than either of the other two stages of digestion.

Specific Gravity

The specific gravity remained practically the same during the period of this study. Mr. Cultice's figures show a wider range in specific gravity during the period of his study. The average specific gravity of the sludge was practically the same for each study.

Table XVIII

Specific Gravity

	Johnson	Cultice
Sept. 19, 1938	1.017	1.03
Oct. 19, 1938	1.018	1.03
Nov. 30, 1938	1.015	1.01
Dec. 14, 1938	1.016	----
Jan. 18, 1939	1.02	1.006
Feb. 8, 1939	1.011	1.011
Mar. 22, 1939	1.019	1.010
Apr. 19, 1939	1.014	1.012
May 10, 1939	1.013	1.006
Average	1.016	1.013

Moisture

The moisture content varies inversely with the specific gravity and the solids content varies directly with it. The average moisture content was only slightly lower during the period of this study than during the period of Mr. Cultice's study.

Table XIX

Moisture

	Johnson		Cultice	
	% Moist.	% Tot. Sol.	% Moist.	% Tot. Sol.
Sept. 19, 1938	94.9	5.1	91.8	8.2
Oct. 19, 1938	95.1	4.9	93.0	7.0
Nov. 30, 1938	94.8	5.2	95.3	4.7
Dec. 14, 1938	92.7	7.3	----	---
Jan. 18, 1939	95.8	4.2	95.3	4.7
Feb. 8, 1939	95.6	4.4	96.3	3.7
Mar. 22, 1939	95.6	4.4	96.7	3.3
Apr. 19, 1939	96.0	4.0	96.0	4.0
May 10, 1939	96.4	3.6	97.7	2.3
Average	95.2	4.8	95.26	4.74

Volatile and Fixed Matters

A measure of the volatile solids is an approximate measure of the organic matter in sludge. The percentage of volatile solids in a well-digested sludge should be 60 or less.

Table XX

Volatile and Fixed Matters

	Johnson		Cultice	
	Volatile	Fixed	Volatile	Fixed
Sept. 19, 1938	66.7	33.3	48.3	41.7
Oct. 19, 1938	62.0	38.0	54.5	45.5
Nov. 30, 1938	63.2	36.8	57.9	42.1
Dec. 14, 1938	60.0	40.0	----	----
Jan. 18, 1939	57.1	42.9	64.3	35.7
Feb. 8, 1939	50.0	50.0	66.4	33.6
Mar. 22, 1939	60.0	40.0	64.5	35.5
May 10, 1939	58.0	42.0	64.5	35.5
Average	58.6	41.4	61.8	38.2

The results of this study show that the average percentage of volatile matter is slightly less than 60.

Total Nitrogen

(Percentage Dry Basis)

It was planned to make an analysis of the total nitrogen in each sample of sludge, but no accurate results were obtained until January 18, 1939.

The nitrogenous matter in sludge is readily decomposed by bacterial action and free nitrogen liberated. A well-digested sludge contains less nitrogenous matter than fresh sludge, and the measure of the nitrogen is, therefore, a measure of the degree of sludge digestion.

Table XXI

Total Nitrogen

	Johnson	Cultice
Jan. 18, 1939	3.00%	3.19%
Feb. 8, 1939	3.36%	3.18%
Mar. 22, 1939	3.64%	3.51%
Apr. 19, 1939	4.00%	2.70%
May 10, 1939	3.50%	2.63%
Average	3.50%	3.04%

The results reveal that the sludge now contains a greater amount of nitrogen than it did when Mr. Cultice made his determination.

SUMMARY AND CONCLUSIONS

From the foregoing study it is apparent that the efficiency of operation of the sewage disposal plant is not as high as it was in 1932. It is interesting to note that there has been a decrease in efficiency of the Imhoff tank, a subsequent increase in efficiency of the contact beds and a decrease in the over-all efficiency of the plant.

Table XXII

Table Giving the Plant Efficiency According to Various Tests*

Test	Through the Imhoff Tank		Through the Contact Bed		Through the Final Tank		Over-all Efficiency	
	J.	C.	J.	C.	J.	C.	J.	C.
Free Ammonia	8.0	7.6	22.0	25	1.0	0.0	17.0	20
Organic Nitrogen	15.0	37	8.6	23.0	1.3	18.0	33.0	6.0
B. O. D.	25.0	45.0	66.0	71	27.0	6.0	81.0	85.0
Oxygen Consumed	15.0	32.0	60.0	59.0	18.0	10.0	60.0	75.0
Total Solids	20.5	27.2	25.0	17.0	00.0	00.0	41.2	39.0
Suspended Solids	44.0	45.1	50.6	56.4	8.8	25.3	74.6	82.2
Turbidity	25.0	44.0	69.5	--	8.6	--	80	75.0

* All given as percentage reduction

This is to be expected. The quantity of sewage now being treated is slightly in excess of the capacity of the plant and considerably more than was being treated at the time Mr. Cultice made his study. The period of detention varies inversely with the quantity of sewage flowing through, and the efficiency of the tank varies directly with the period of detention. Therefore, the greater quantity of sewage now being treated has brought about a decrease in the period of detention in the Imhoff tank and a subsequent reduction in the efficiency of the tank. The percentage (80%) of volatile matter in the suspended solids of the effluent from the Imhoff tank was greater than that (77%) in the raw sewage. This indicates that only the heavier solids, mostly mineral matter, are settling out as the sewage flows through the Imhoff tank. The lighter solids, mostly organic matter, are passing on to the contact beds where usually the greatest removal of organic matter is obtained. This probably accounts for the increase in the efficiency of the contact beds.

The sewage now being treated at the plant is somewhat stronger than that which was being treated at the time the previous study was being made. This is indicated by the increase in chlorides, B.O.D., oxygen consumed, suspended solids, and total solids as shown by the results obtained during this study.

The nitrification efficiency of the plant is alarmingly low. Evidently the contact beds are clogged with mud and humus to such an extent that oxidation has been curtailed. This probably accounts for the low stability of the plant effluent.

The increase in the ammonia content and subsequent decrease in the organic content of the raw sewage is a fair indication that the sewage now entering the plant is somewhat staler than it was when Mr. Cultice made his study. This is borne out by a comparison of the pH of raw sewage as shown by the results of the two studies. Fresh sewage is ordinarily alkaline. The first stage of sewage digestion is characterized by intensive acid production. Therefore, as Mr. Cultice's results show that the raw sewage had a pH of 7.2 and the results obtained during this study show that the raw sewage now has an average pH of 6.99, a staler sewage is now entering the plant.

The secondary sedimentation tanks appear to aid very little the treatment of sewage. They do, however, participate somewhat in the nitrification of the sewage.

The results of the sludge analyses are hardly complete enough to give any information pertinent to the determination of the efficiency of sludge digestion. Samples should have been taken at several intervals through the depth of the sludge in the digestion tank.

The time required to dry the digested sludge drawn from the sludge digestion chamber has been considerably lessened since the sludge drying beds were reconditioned.

RECOMMENDATIONS

1. Imhoff Tank: As before mentioned, it is desirable to have a gas vent area of approximately 20 per cent of the total tank area. The V. P. I. plant has a gas vent area that is only 1.41 per cent of the total tank area. Mr. Cultice recommended that the gas vent opening be increased by removing the slab of concrete originally installed to keep the scum below the water line. The author certainly endorses this recommendation.

2. Contact Beds: The contact beds have not been cleaned since the plant was put into operation. Observations reveal that the beds are clogged with mud and humus to such an extent that their capacities are appreciably reduced and oxidation retarded. The author recommends that the beds be cleaned as soon as possible.

3. Secondary Sedimentation Tanks: The secondary sedimentation tanks are now being used in rotation, and the sewage passes through without an appreciable period of retention. The three tanks were designed to be operated as one unit. The author recommends that all three beds be used as one unit.

4. Sludge-Drying Beds: Metcalf and Eddy recommend that open sludge-drying beds have a drying area of 1/3 to 1 square foot per capita and that no drying bed should be designed with walls over 18 inches above the sand level. The drying beds at the V. P. I. disposal plant are designed to have a drying area of 0.48 sq. ft. per capita and to accommodate a population of 5,000. The beds are glass

covered so the drying area provided should be sufficient. The walls, however, extend three feet above the sand level and retard the drying of the sludge near the wall. As the plant is now accommodating approximately 5,000 people, it would be advisable to build an additional sludge drying bed sometime in the near future.

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APPENDIX

Results of Weekly Analyses

Aug. 17, 1938 to May 10, 1939

Date	Temperatures Degrees Centigrade					M. O. Alkalinity ($CaCO_3$)				Chlorides				Turbidity				Ammonia Nitrogen			
	Atmos	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Aug. 17	31.1	20	24.5	21.5	24	300	318	308	298	31	31	30	29	220	140	65	50	14	6	6	8
Aug. 24	30	24.5	24.5	24.0	24.5	340	336	322	306	32	30	29	28	250	190	95	70	20	20	8	8
Aug. 31	27.8	24	23	23	23.5	350	368	328	342	34	36	42	33	225	160	80	65	28	20	20	14
Sept. 7	29.4	23.5	23.5	22.5	22.5	326	334	316	322	39	29	31	30	240	180	100	80	20	20	14	14
Sept. 14	30	25	25	22.5	23	300	346	342	342	44	41	39	37	230	160	90	110	34	28	20	20
Sept. 21	15.6	25	24	20	20	332	370	376	348	41	41	42	41	260	240	70	45	8	8	4	4
Sept. 28	27.2	26	26	23	22.5	368	242	256	254	29	51	41	41	290	205	75	83	20	20	28	34
Oct. 5	24.4	25	24	21	20	346	352	374	364	34	49	42	47	270	200	75	66	14	28	20	20
Oct. 12	24.4	24	23	21	21	364	374	372	362	55	49	36	34	350	275	70	60	28	24	14	16
Oct. 19	30.6	26	25	21	22	324	330	388	350	42	44	40	43	376	230	45	62	20	20	14	14
Oct. 26	26.7	24.5	23	19	19	350	356	370	338	36	41	41	38	450	240	75	55	14	8	8	18
Nov. 2	25.6	24.5	23.5	20	20.0	334	380	338	348	64	48	40	33	320	245	50	45	20	34	20	28
Nov. 30	17.8	21	20	15.5	15	358	372	346	346	51	48	43	36	280	265	59	70	20	20	20	20
Dec. 7	12.2	21.5	20.5	15	15.5	326	398	372	380	37	42	42	42	310	230	67	60	20	20	20	14
Dec. 14	8.3	20	19.5	15	15	384	394	364	370	32	37	42	41	300	220	62	58	16	20	14	14
Jan. 4	15.6	28	28	24	23.3	420	384	374	364	40	38	35	34	280	220	68	28	28	34	20	14
Jan. 11	9.4	21	19.3	14.7	14.7	400	385	376	365	33	35	31	30	310	225	48	55	20	24	20	14
Jan. 18	3.9	17.5	17.0	13.8	13.5	386	390	370	368	30	30	33	30	315	190	61	42	20	20	20	20
Jan. 25	-1.7	16	14.0	11.5	11.5	360	372	374	368	40	37	35	33	270	200	61	44	24	34	24	24
Feb. 1	5.6	18	17.5	13	12.5	362	358	366	360	32	32	33	34	240	200	59	57	24	24	20	8
Feb. 8	15.6	19	17.7	13.5	13.3	364	362	374	332	30	31	33	34	240	170	33	30	14	16	16	16
Feb. 15	2.8	13.5	13.5	13.5	13.5	278	282	268	270	20	18	22	22	200	185	170	168	8	8	14	14
Feb. 22	-5.6	16	14.5	11.0	11.0	354	406	346	248	33	39	33	34	270	240	58	43	16	24	50	36
Mar. 1	8.3	17	17	14	14.5	308	326	344	314	40	55	43	37	245	180	47	52	18	20	16	24
Mar. 8	20.6	19	18.2	13.1	14.2	318	322	328	348	47	52	44	50	230	190	38	41	14	14	8	14
Mar. 22	15.6	18.8	18.5	19.4	19.2	320	348	332	328	36	36	39	36	320	348	332	328	18	16	20	16
Mar. 29	16.1	20	20	15.6	15.6	402	406	404	398	14	14	17	17	300	200	160	140	14	28	24	20
Apr. 5	16.7	21	19.4	16.7	16.6	340	364	366	366	46	47	45	47	290	200	85	65	20	26	16	20
Apr. 12	12.2	19.3	19.3	13.9	14.8	336	320	316	312	62	56	54	52	235	200	57	50	28	34	14	14
Apr. 19	11.1	21.2	20.3	17.7	16.8	340	342	330	308	62	77	52	44	255	205	52	42	26	30	18	18
Apr. 26	21.1	23.9	22.8	20.5	19.9	336	332	336	328	62	52	44	50	300	140	62	55	20	18	18	14
May 3	13.3	22.7	21.3	18.7	18.1	322	352	356	334	63	60	57	54	270	190	65	55	34	40	20	18
May 10	25.6	24.5	23.7	21.5	21.7	352	338	330	356	52	56	52	66	300	200	75	65	28	24	14	24
Ave.	17.5	21.7	21.2	18.0	18.1	345	345	347	343	43	43	40	39	281	205	63	58	20.9	22.6	17.6	17.4

Date	Organic Nitrogen				Nitrite Nitrogen				Nitrate Nitrogen				Dissolved Oxygen				Biochemical Oxygen Demand				Oxygen Consumed			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Aug. 17	11.95	13.3	15.0	19.6	0	0	0	0	0	0	0	0	0	0	0	0	90	73	55	60	90	50	20	90
Aug. 24	19.6	13.3	11.9	8.4	0	0	tr	tr	0.12	0.12	0.16	1.6	0	0	1.8	0.7	116	71	12	0	45	45	10	10
Aug. 31	14	14	14	14	0	0	tr	tr	0	0	0.12	0.12	0	0	0	0.6	76	51	34	6	45	30	5	0
Sept. 7	17.4	5.6	7	5.6	0	0.1	0.20	0.35	0	0.08	0.12	0.20	6	0	1.2	1.0	116	106	18	4	50	30	10	15
Sept. 14	16.8	16.8	16.8	5.6	0	0	0.175	0	0	0.40	0.20	0.20	0	0	0.3	0.5	144	121	39	39	123	73	27	40
Sept. 21	14	11.2	11.2	7.0	0.05	0.05	0.35	0	0	0	0.08	0.12	0	0	0	0	171	145	26	21	70	90	10	70
Sept. 28	17.4	16.8	16.8	16.8	0.025	0.025	0.05	0.15	0.04	0.04	0.12	0.20	0	0	1.3	1.4	123	99	26	18	210	120	110	80
Oct. 5	8.4	5.6	5.6	5.6	0	0.025	0.15	0.25	tr	tr	tr	tr	0	0	0.2	0.8	398	180	43	28	100	100	70	50
Oct. 12	11.2	8.4	8.4	8.4	0	0	0	0	0.10	0.10	0.20	0.20	0	0.8	0.4	0.5	323	273	126	38	120	120	20	10
Oct. 19	12.6	7.0	7	7	0	0	0.25	0	0	0	0.06	0.12	0	0.6	1.0	1.2	330	250	90	40	250	80	20	50
Oct. 26	8.4	16.8	8.4	9.8	0.025	0.025	0.05	0.1	tr	tr	0.12	0.20	0	0	1.0	1.3	343	273	67	42	200	80	20	10
Nov. 2	11.2	19.6	13.3	8.4	tr	tr	tr	tr	0.13	0.13	0.20	0.20	0	0.2	0.8	1.5	295	180	49	24	140	90	34	20
Nov. 30	23.8	6.8	4.2	4.2	0.025	0.025	0.1	0.625	0.04	0.08	0.16	0.16	0	0.4	1.2	2.6	295	195	120	145	160	146	70	75
Dec. 7	8.4	8.4	4.2	4.2	0.025	0.025	0.025	0.5	0	0	0	0	0	0.6	1.0	2.0	208	193	31	29	140	180	60	130
Dec. 14	4.2	4.2	4.2	1.4	0.025	0.025	0.1	0.175	0	0	0.12	0.12	0	0.3	0.8	2.6	145	180	57	62	100	130	40	20
Jan. 4	2.8	2.8	2.8	1.4	0	0	0.025	0.125	0	0	0	0	0	0.5	2.0	1.8	370	345	33	10	180	120	50	50
Jan. 11	7.0	7.0	5.6	5.6	0	0	0	0.	0.06	0.06	0.12	0.12	0.1	0.8	1.0	1.2	178	173	49	19	140	110	70	30
Jan. 18	5.6	7.0	4.2	7	0	0	0	0.7	0	0	0	0	0	0.4	0.9	1.4	146	125	29	24	240	160	40	40
Jan. 25	4.2	4.2	4.2	4.2	0	0	0.025	0.025	0	0	0	0	0	0	1.2	1.3	245	74	39	29	160	110	30	70
Feb. 1	7.0	2.8	11.2	8.4	0	0	0	0	0	0	0	0	0	0.1	1.0	1.1	145	129	94	46	80	130	100	110
Feb. 8	5.6	5.6	1.4	2.8	0	0	2.5	2.0	0	0	5.4	5.4	0.2	0.6	0.9	0.9	246	146	14	26	65	20	5	5
Feb. 15	7.0	5.6	5.6	5.6	1.7	1.7	1.0	1.0	0.32	0.32	0.56	0.56	0	0.3	1.1	1.5	146	171	129	62	68	45	56	22
Feb. 22	4.2	2.8	2.8	0	0	0	0.1	0.1	0	0	0	0	0	0.7	0.8	0.9	169	164	16	28	106	90	51	34
Mar. 1	4.2	8.4	5.6	5.6	0	0	0.025	1.4	0	0	0	0.80	0	1.0	1.3	1.2	220	195	31	26	84	73	22	39
Mar. 8	4.2	2.8	2.8	2.8	0.425	0.175	1.7	2.8	0.28	0.28	1.60	2.0	0	0.7	1.5	1.4	186	134	64	46	45	39	39	34
Mar. 22	7.0	5.6	5.6	5.6	0	0	0	0	0	0	0	0	0	0.5	1.3	1.8	208	180	63	46	67	84	50	39
Mar. 29	5.6	5.6	5.6	5.6	0	0	0	0	0	0	0	0	0	0.3	0.9	1.5	220	170	163	148	55	34	22	20
Apr. 5	4.2	4.2	4.2	4.2	0	0	0	1.4	0	0	0	0.20	0	0	0.6	0.9	223	183	63	43	157	168	22	11
Apr. 12	7.0	4.2	5.6	4.2	0	0	0.25	0.25	0	0	0	0.80	0	0	0.3	0.8	153	140	59	24	100	90	45	90
Apr. 19	8.4	5.6	8.4	7.0	0	0	0.5	0.5	0	0	0	0	0	0.8	0.9	0.9	221	196	28	41	168	146	102	67
Apr. 26	7.0	7.0	7.0	4.2	0	0	0.15	0	0	0	0	0	0	0	0.5	0.8	113	43	29	24	146	56	34	11
May 3	7.0	5.6	9.8	8.4	0	0	0.025	0.025	0	0	0	0	0	0.3	0.7	0.9	155	145	39	27	90	70	10	50
May 10	7.0	7.0	4.2	4.2	0	0	0	0	0	0	0	0	0	0	0.4	1.0	160	135	40	35	80	50	10	40
Ave.	9.7	8.2	7.5	6.5	.057	.056	0.20	0.326	.035	.049	.246	.256	0.01	0.285	0.85	1.17	216	162	56	40	111	94	38	45

Date	Stability		Suspended Solids				Volatile Suspended Solids				Total Solids				Total Volatile Solids				pH			
	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Aug. 17	<11	<11	440	106	52	74	238	70	48	50	745	410	373	253	255	115	104	66	7.0	7.1	7.2	7.2
Aug. 24			340	120	40	50	291	80	30	42	506	391	402	401	251	160	127	116	7.1	7.1	7.2	7.2
Aug. 31			354	108	34	60	220	170	50	45	558	530	438	407	242	262	153	144	7.0	7.1	7.2	7.2
Sept. 7			354	108	34	60	300	96	26	50	526	521	436	431	228	195	99	101	7.1	7.2	7.2	7.2
Sept. 14			392	268	162	184	386	268	162	166	1068	760	563	552	705	402	257	229	7.1	7.1	7.2	7.3
Sept. 21			52	40	48	44	50	40	48	42	805	726	470	460	420	370	110	115	7.0	7.1	7.2	7.3
Sept. 28			190	158	28	88	82	134	4	30	1074	725	463	457	644	339	101	103	7.0	7.0	7.2	7.2
Oct. 5			442	102	80	56	430	80	24	50	1046	720	503	497	671	257	185	62	6.9	7.1	7.4	7.4
Oct. 12			330	240	93	84	300	204	30	8	810	632	398	442	473	328	105	151	7.0	7.1	7.3	7.3
Oct. 19			750	420	135	80	478	260	108	80	1093	681	466	480	688	327	122	141	6.6	7.0	7.2	7.3
Oct. 26			740	460	146	88	594	266	135	85	1084	726	475	490	544	412	132	157	6.9	7.0	7.3	7.3
Nov. 2			450	228	112	80	394	150	70	72	598	650	419	421	310	261	123	196	6.8	6.9	7.3	7.3
Nov. 30			396	204	68	62	396	204	68	62	816	690	450	448	540	390	147	155	7.0	7.1	7.3	7.5
Dec. 7			486	286	106	78	486	286	106	78	833	667	489	481	559	390	245	236	7.0	7.2	7.6	7.6
Dec. 14			470	378	210	182	298	248	102	90	687	633	425	460	458	376	206	162	7.2	7.2	7.4	7.4
Jan. 4			452	320	168	132	408	270	96	108	961	787	549	499	624	479	199	201	6.9	6.9	7.3	7.6
Jan. 11			426	324	228	214	268	248	158	126	916	724	561	482	565	398	253	196	6.8	7.2	7.5	7.5
Jan. 18			566	308	198	130	494	300	180	128	1033	675	523	486	660	326	176	176	6.8	7.1	7.3	7.3
Jan. 25			448	312	210	158	370	232	132	88	814	683	511	426	497	375	226	217	6.7	7.1	7.3	7.5
Feb. 1			334	250	90	81	306	220	78	75	667	637	442	464	362	345	124	132	7.3	7.0	7.3	7.4
Feb. 8			286	252	146	138	272	230	134	124	693	695	576	577	412	501	274	235	6.8	7.0	7.1	7.2
Feb. 15			180	212	146	148	80	102	76	62	505	508	467	455	276	168	165	141	7.1	7.1	7.0	7.1
Feb. 22			496	354	150	152	406	224	94	78	745	669	552	510	365	401	164	122	7.0	7.1	7.2	7.2
Mar. 1			278	220	88	86	200	198	82	80	581	622	541	420	250	398	160	140	7.1	7.1	7.2	7.2
Mar. 8			310	264	120	134	240	240	104	102	653	613	538	522	408	360	260	269	7.1	6.9	7.2	7.2
Mar. 22			390	245	150	148	300	210	120	117	593	616	584	517	399	338	231	240	7.1	7.1	7.2	7.4
Mar. 29			563	238	242	230	442	178	160	162	793	611	671	609	541	256	274	309	7.0	7.1	7.3	7.3
Apr. 5			416	208	94	80	354	140	80	48	876	583	448	398	517	250	108	204	7.0	7.2	7.3	7.4
Apr. 12			484	334	118	150	454	290	86	108	872	720	480	597	493	398	191	317	7.0	7.2	7.3	7.4
Apr. 19			368	218	110	56	276	160	44	22	771	586	416	384	411	247	134	125	6.9	7.2	7.3	7.3
Apr. 26			440	236	112	130	334	178	78	82	857	586	484	587	460	258	167	263	7.2	7.2	7.3	7.3
May 3			183	124	73	71	183	124	73	71	861	629	581	505	567	330	200	144	7.0	7.1	7.2	7.2
May 10			265	126	74	63	172	72	37	45	794	689	484	511	604	333	180	171	6.8	7.1	7.2	7.2
Ave.	<11	<11	411	231	114	104	317	185	83	77	801	637	476	472	450	325	183	173	6.99	7.1	7.26	7.32