In nephelometry, however, occlusions are of no consequence as the standard, having practically the same occlusion or adsorption, would cancel the error. Of course, it does not follow that occlusion or adsorption in nephelometric precipitates causes any difference in the amount of reflected light, as the occlusion may be in a dissolved phase, and, therefore, would not reflect light. Furthermore, as organic reactions as a rule are more specific, and, therefore, more accurate, nephelometry and colorimetry enable us to make use of organic substances, which means that our sources of reagents and possible methods are unlimited.

The great advantage of nephelometric analysis over gravimetric, outside of the enormous saving in time and labor as well as in material, is in its more complete control over the media of precipitation. By the great dilution necessary ordinarily in nephelometry, color and other interfering substances are so reduced that they seldom play a rôle.

The accuracy obtainable in nephelometry, as the instruments and methods steadily improve in efficiency, is growing rapidly. With the instrument, as it now is, when properly adjusted and used, it is not difficult to obtain an accuracy of 0.25-0.50 per cent in a single reading, and with two to three readings 0.1-0.2 per cent. Not all nephelometric suspensions have been developed, however, so that the maximum accuracy of the instrument is utilized. As in gravimetric work, the accuracy obtainable in final results depends on the particular method and precipitant, as well as on the balance. As we have become so accustomed to gravimetric work, to agglutinate or crystallize our precipitates, it is difficult for most of us to consider doing our work in an exactly reverse way. Like all other methods it takes time to get accustomed to a new way of doing things, no matter how good or convenient it is. Much more progress is made when the new way is the only way an experiment can be done at all. We all know when once an old method has been entrenched, as it were, by custom, it takes considerable time for the new to find its way into favor, irrespective of its merits.

Much more work remains to be done, especially the study, from as many angles as possible of the quantitative production of suspensions.

Almost all colloidal chemistry, heretofore, the theoretical or practical study, especially that of colloidal suspensions, has been qualitative and not quantitative. We need a great deal more information about quantitative colloidal chemistry for nephelometry to find its greatest usefulness.

How many more applications nephelometry will find in applied and quantitative chemistry the future alone will tell. This much we are sure of: the nephelometric method must be used for colorless colloidal suspension and for the accurate determination of amounts of material which give no delicate color reaction and are too minute to filter, but which are daily commanding our interest and attention. The use of the method has already been extended to all classes of substances and since, by careful work, considerable accuracy can be obtained, its application promises to be general in the different branches of chemistry.

SUMMARY

To sum up, attention has been called to the following:

I—A few erroneous conceptions about nephelometry and the pitfalls of many beginners in nephelometry.

II—The great sensitivity of:

(a) Graves' nephelometric reagent for ammonia, which is able to detect 1.0 part of ammonia in 160 million of water and its usefulness in various tests and Kjeldahl estimations.

(b) Kober and Egerer's nephelometric reagent for phosphorus which will detect 1.0 part in 333 million of water and its usefulness in various tests and in phosphorus estimations applied to iron and steel as illustrated by an experiment.

(c) Lyman's nephelometric reagent for calcium which will detect 1.0 part in 5 million of water and its usefulness in various tests and calcium estimations applied to water and milk.

(d) Marriott's nephelometric reagent for acetone which will detect 1.0 part in 100 million of water and its usefulness in determining acetone quantitatively applied to various distillates.

(e) Bloor's method for estimating fats and oils with which 0.05 mg. of fat can be estimated quantitatively and the presence shown of 1.0 part of fat in a million of water, its usefulness in nephelometric fat estimation in milks, and its application in Woodman, Gookin, and Heath's nephelometric estimation of essential oils.

(f) Kober's nephelometric method of estimating proteins which will show the presence of 1.0 part of protein in a million parts of water.

III—The advantage of nephelometry, its possible accuracy, its enormous field, and its possible future.

DIVISION OF LABORATORIES AND RESEARCH
STATE DEPARTMENT OF HEALTH
ALBANY, NEW YORK

MUNICIPAL CONTRIBUTION TO CONSERVATION THROUGH GARBAGE UTILIZATION¹

By EDWARD D. VERY

The word "garbage" is commonly used indiscriminately to define any kind of refuse and is generally considered as a synonym for "offal," but for the purpose of this paper it is used to define the waste of both animal and vegetable matter which results from the preparation of food for human consumption. It is further limited to that portion of this class of waste which is collected and disposed of as a municipal function.

When we take into consideration the fact that this material results from action governed by no set rule or regulation and is, in fact, subject only to the whim of the individual, there would seem to be no general statement possible as to the constituents of garbage, and yet it is found that this class of material, as it is collected in different parts of the country, does not vary widely in quantity per capita, weight per unit of volume, or in mechanical or chemical analysis, and it is possible, within reasonable limits, to make a statement of the average content of garbage.

The average quantity of garbage produced per capita per day is one-half pound.

The average weight of garbage is 1100 lbs. per cu. yd.

The average sample of garbage contains:

16 per cent animal matter
79 per cent vegetable matter
5 per cent rubbish

and it analyzes, approximately:

70 per cent moisture
20 per cent tankage
3.5 per cent grease
1.5 per cent bones
5 per cent rubbish

Published analyses from the cities of New York, Cleveland, and Washington show this comparison as follows:

	NEW YORK	CLEVELAND	WASHINGTON
Pounds per capita per annum....	181	193	286
Pounds per cu. ft.....	41	49	47
Moisture, per cent.....	67	76	74

LABORATORY ANALYSES

	Per cent	Per cent	Per cent
Ether extract.....	4.85	4.00	5.00
Phosphoric acid as P ₂ O ₅	0.59	0.24	0.39
Nitrogen, Kjeldahl method....	0.94	0.64	0.71
Potash as K ₂ O.....	0.33	0.30	0.28

The figure here given for the pounds per capita per annum for Washington seems at variance with the others, but it must be remembered that this city has an enormous floating population which produces garbage but is not considered in the census. Then, too, in Washington practically all of the hotels and res-

¹ Read before New York Section, American Chemical Society, May 10, 1918.

taurants have their garbage collected by the municipality, whereas in some cities the garbage is not so collected, but is taken by private collectors, under an arrangement with the proprietors of these establishments.

The quantity of garbage produced varies by seasons very materially, the maximum daily amount being collected during the summer months when vegetables and fruits constitute the principal diet, and the minimum amount being collected during the winter months. Usually August is the highest month, with about 11 per cent of the total annual amount, and February the lowest month, with about 6 per cent. The moisture content is high in percentage in the summer months and low in winter, whereas the grease content and the chemical plant food values are low in the summer and high in winter, for obvious reasons.

Fresh garbage, as it reaches the can, will remain, in ordinary weather, at a temperature of about 70° F. for from 12 to 14 hrs. before any change takes place. From that time alcoholic fermentation sets in and this will continue for another period of, approximately, 12 to 14 hrs. If the can is loosely covered, acetic acid fermentation develops, but if cans are fairly well closed, the alcoholic fermentation continues for about 36 hrs., when there is practically no further action. There is no decomposition of the animal matter, as that is inhibited by the alcoholic fermentation. By test it has been found that in garbage which has remained in the can under ordinary temperatures for from 3 to 4 days, and even as long as 21 days, the free fatty acids of the grease are not more than from 1.5 to 7 per cent, whereas where matter of a like nature is subjected to putrefactive action, the grease analyzes from 30 to 40 per cent of free fatty acids, which indicates the absence of decomposition in ordinary garbage as it is contained in the can.

The fermentation noted develops small amounts of alcohol and acetic acid, with slight changes in the vegetable oils, but none in the animal oils.

The sour odor of garbage is the result of this fermentation developing acetic acid, together with certain fruit esters, aldehydes, and alcohol.

We have then a material made up of a combination of moisture, fat, starch, sugar, albuminoid and nitrogeous bodies, cellulose, and ash. The problem is to recover from this mass whatever may be of value, in the most economical manner, having at the same time due regard for the sanitary requirements.

Disregarding the method of final disposition of municipal wastes which attempt no reclamation of by-products, we find the methods which have been adopted for the treatment of garbage, as herein defined, are pig feeding, or some mechanical treatment commonly known as reduction.

According to the latest statistics, there are in the United States, 75 cities of 90,000 population and upwards; of these, 13 resort to dumping or burial, 21 have incinerators, 11 feed to pigs, 6 sell or give to farmers, probably to be used for pig feeding, and 24 use a reduction process.

Those who have reduction plants are:

Boston, Mass.	Baltimore, Md.
New Bedford, Mass.	Washington, D. C.
Bridgeport, Conn.	Akron, Ohio
Buffalo, N. Y.	Cincinnati, Ohio
New York, N. Y.	Cleveland, Ohio
Rochester, N. Y.	Columbus, Ohio
Syracuse, N. Y.	Dayton, Ohio
Utica, N. Y.	Toledo, Ohio
Philadelphia, Pa.	Indianapolis, Ind.
Pittsburgh, Pa.	Chicago, Ill.
Reading, Pa.	Detroit, Mich.
Wilmington, Del.	Los Angeles, Cal.

The feeding of garbage to pigs is a matter which caused considerable discussion, both as to its economical phase and also as to its propriety from the standpoint of sanitation.

Tersely, the advantages of pig feeding have been stated as "using the pig as a middle-man, we find that 25 per cent of the

protein and 45 per cent of the total energy is returned to the consumer as pork. The pig charges 55 per cent brokerage for converting vegetable protein and fat into animal protein and fat."

Of course, we must remember that there is a considerable portion of the garbage that the pig will not consume, such as fish scrap, fruit skins, coffee grounds, and miscellaneous rubbish. Then, too, the garbage must come to the piggery fresh, especially in the summer time.

Again, there is the menace of hog cholera, or the foot and mouth disease, which may cause the total loss of "plant." To be sure, modern science is ready with methods of prophylaxis, which may prove a safeguard, but there is always the peril of slipshod methods, which result in a partial or complete loss.

The United States Food Administration, in a booklet entitled "Garbage Utilization," issued in February 1918, says:

"We have indicated that the reduction process is hardly suitable for cities of under 100,000 population. A proper question would be, is pig feeding more applicable to cities now reducing than the reduction process?"

"In so far as the monetary return applies, the two methods are practically identical. The reduction process possibly has the advantage of improvement to a greater extent than pig feeding. By improving the breed of the hog, gains might be made more economically, but the reduction process requires only simplified machinery, or additional recovery to make a ton of garbage more valuable.

"It also seems that the larger the city the less adapted its garbage to pig feeding. One might say that smaller cities were better managed, but it is obvious that the difficulties of controlling materials placed in the garbage increase more rapidly than does the population. Although a pig is blessed with a digestive system capable of assimilating almost anything, its efficiency cannot be compared with the mechanical digestors of the reduction plants.

"While from a purely conservation standpoint, pork production may seem more important than the production of grease and fertilizer tankage, the use of the grease recovered releases an equivalent amount of edible oils, while our stock of agricultural fertilizers is so depleted, at the present time, that fertilizer tankage is a national resource not to be overlooked.

"The test of the practicability of the feeding method of disposal is the selling possibilities of the pork produced. There is no benefit in feeding if the pork is unfit for food, or if a popular prejudice will prohibit it from selling freely.

"We have not been able to find any market where garbage-fed hogs are being sold at a lower price than grain-fed animals.

"There is at present a mistaken idea throughout the country as to the value of garbage. In a large number of cases it is a question whether the value will be sufficient to pay the cost of collection and transportation. Where collection and disposal both are to be made by the contractor, we doubt if the work will be done without cost to the city, unless the quality of the garbage is exceptional, and there is keen competition for the material.

"The ratio of 1 lb. of marketable pork to 50 lbs. of garbage has already been established. With pork on the hoof at 15½ cents, this would give a gross feed value of \$6.20 to a ton of garbage. In a general way, it is safe to assume that the cost of disposal, after the farm is reached, including overhead charges at the farm, would not exceed \$3.00 per ton."

Reduction processes now in use in this country are of three types, the drying method, the cooking method, and the Cobwell process.

In the drying method the green garbage is first deposited on a floor or belt to facilitate the picking out of the bottles, tin cans, and similar refuse. The material is then fed into a disintegrator, either of the chopping or the crushing type, wherein the garbage

is ground to a fairly uniform size throughout, to allow of efficient drying and percolating action. From the disintegrator the material passes through a direct heat dryer so that the moisture content may be reduced. It is then fed into a percolator, in which, by the action of a solvent, grease is taken out and reclaimed, leaving a resultant tankage fairly free from both grease and moisture.

The dryer consists of a revolving cylindrical steel shell, fitted with lifting vanes, which keep the material moving toward the discharge end and at the same time draw it to the top of the cylinder and drop it in a film through the hot gases, which are passing through the dryer from a furnace to the stack.

The percolator may be either of two styles, a stationary vertical or a horizontal rotary.

The former consists of a cylindrical tank, into which the garbage is fed through an opening at the top. When filled sufficiently, a heated solvent is introduced through perforated pipes at the top, and this solvent percolates through the mass and is withdrawn at the bottom, taking with it the grease which it has absorbed in its passage. This introduction of solvent is repeated until the outgoing liquid appears to carry too little grease to warrant further attempt at recovery. Live steam is then introduced into the percolator at the bottom, in order to drive off, so far as possible, the solvent which has been taken up by the tankage. The tankage is then taken out of the percolator, through a door near the bottom, by means of a hoe, rake, or some similar tool.

Results from the stationary vertical percolator are unsatisfactory, principally because the solvent jets usually form channels through the material by which the remaining solvent finds its way to the bottom without having been in contact with a considerable portion of the material being treated, thus resulting in an incomplete recovery of the grease. Similar channels are formed by the steam, thus giving an equally incomplete result in the driving off of the retained solvent.

The horizontal rotary percolator consists of a cylinder, having three openings on one side for receiving and discharging the tankage. There are three pipe sections running the full length of the cylinder inside, perforated for the spraying of the heated solvent on to the material being treated. There is also a burlap-covered strainer-plate, made of brass cloth, extending the full length, and so supported as to form a chamber beneath, into which the saturated solvent, after passing the strainer, passes to an outlet at one end of the cylinder. There are vapor lines for the introduction of the steam.

The operation of this percolator is as follows:

The percolator is charged by feeding the material to be treated through the three charging openings. The covers of these openings are then put in place and securely bolted. The cylinder is then revolved a one-quarter turn, thus bringing the solvent pipes to the upper side and the strainer chamber to the lower side. Heated solvent is then pumped into the cylinder in sufficient quantity to fill all the voids and to completely submerge the material. This solvent is allowed to stand for about 10 min. and is then withdrawn by pumps, after passing through the material, becoming thoroughly saturated, and passing through the strainer. This operation is repeated until the outflowing saturated solvent appears to carry insufficient grease to warrant further attempt at reclamation. After the final washing and after all solvent possible has been withdrawn by the pumps, live steam is introduced into the cylinder under a pressure of from 15 to 20 lbs. per sq. in. This pressure forces out the major portion of the remaining solvent through the strainer. The cylinder is then revolved so that the three openings are at the bottom and the tankage is emptied through them onto the floor or into a conveyor.

The saturated solvent from the percolator, in either case, is piped to a still, wherein, by the application of heat, the solvent is driven off as a gas, leaving the grease to be withdrawn, separated from any water present by gravity, and then barreled for shipment. The vaporized solvent is then condensed and re-used.

The last two washings are usually used for primary washing in succeeding treatments because they are imperfectly saturated.

The tankage from the percolator is passed through a dryer and thence to a screen and that portion which fails to pass through the screen is taken to a grinder and pulverized and again sent to the screen.

This method is practically the first used in this country and is still in use in Chicago, Allegheny City, and Buffalo. It is the cheapest when first cost is considered, but the results are in proportion to its cost of installation, and so, while as an investment it may prove satisfactory, it still does not give the full possible recovery of grease. In the drying of the material, carbonization takes place, which affects the quality of the grease and tankage adversely, and also in this part of the process there is a very considerable loss of ammonia.

This method is operated with a considerable resultant nuisance from odors because of the great volume of gases passing off from the dryers, which cannot be economically deodorized.

According to test made in Chicago, which is probably representative, by this process, 46 lbs. of grease per ton were recovered.

In the cooking method the garbage is picked over for the removal of the glass, tin cans, etc., and is then fed into large vertical tanks, known as digestors or autoclaves.

These tanks, when filled, are sealed by a bolted cap, a small quantity of water is added, live steam is introduced and the mass is cooked, under pressure, until the whole has become a pulpy mass, with the grease sacs ruptured and the entrained grease released. The material is then pressed to express what moisture can be mechanically released, the material then passes to the dryer, thence to the percolator, to the redryer, the screen, and then to storage.

The expressed moisture is piped to a settling tank or basin, wherein the grease separates by gravity, is skimmed or pumped off and placed in tanks to allow the final separation of the grease from whatever slight amount of water is present, and then the grease is drawn off and barreled.

These types vary usually and only in the manner of pressing.

In one type the pressing is done in the tank, there being a perforated plate fitted just above the bottom, and pressure is obtained by the introduction of live steam at the top, resulting in the material being compressed and the expressed liquid being forced through the perforations to the pipes leading to the settling tanks or basin.

Another uses a roller press, having an endless perforated metal belt, which, after receiving the material, passes between rollers, causing the fluid to pass through the perforations to the pipes leading to the settling device.

Another uses the old cider press, wherein the mass is fed into forms made up of slats covered with burlap, which are built upon a car and are then placed under a hydraulic ram, causing the expression of the liquid through the burlap.

Then there is the curb press, wherein the material is fed into a latticed steel basket, which later is run under a hydraulic ram.

The steam cone press is also used. This press is in the form of two bottomless cones, lying horizontally, with their bases meeting, and fitted with a bottom of perforated plates. After the material has been fed into this form, steam is applied and the liquid is forced through the perforations.

The operations of this method, which follow the pressing, are similar to those described for the drying method after the disintegration, except that some operators attempt the reclamation of valuable portions of the tankage which are carried away in suspension by the expressed liquid. This reclamation is made up by the use of triple-effect evaporators and results in a gelatinous material, known as "stick," which is added to the tankage before drying and adds something to the fertilizing value.

In the cooking method, the material being subjected to pressure and high temperatures gives a resultant grease wherein the free fatty acids and glycerin are split to a great extent, causing a considerable loss of glycerin, and unsaponifiable bodies are

formed to an undesirable extent. Then, too, the starches and sugars are changed to glucose and dextrin and are more or less caramelized and even carbonized, leaving them indigestible and of small nutritive value. The albuminoids are broken up and rendered difficult of digestion. The final product is made up principally of cellulose fiber with small amounts of nitrogen and bone phosphates. This material is under suspicion as a fertilizer as to its availability because of the length of time necessary for the chemicals to be released in the soil.

This method is in use in all of the cities of the country using reduction methods, except those noted above and New York, Los Angeles, and New Bedford.

The operation of this method is usually the cause of considerable complaint because of the odors which arise from the emission of gases, fumes, and liquids consequent to the different processes, but there are reasonable means for the elimination of those noxious features which can be used, although their use entails a consequent reduction of the value of the reclamations.

Reclamation of grease by this method varies from 50 to 80 lbs. per ton, depending upon the efficiency of the individual plant.

We now come to the Cobwell process, and while I desire to avoid any appearance of taking advantage of your courtesy by introducing a trade argument, I am forced to use this trade name as there is no other means of differentiating this method from the others, because in theory and practice it differs materially from them. In order to carry out my intention to present facts to you without any prejudice, I take the liberty of quoting verbatim from a paper read before Section D, Engineering, of the American Association for the Advancement of Science, in December 1916, by C. R. Tuska, consulting engineer and also lecturer on municipal waste disposal at Columbia University, who is in no way connected with the company which controls this process.

After describing the other methods and their results, Mr. Tuska said:

The operation of this process is as follows:

The raw garbage is placed in a closed tank which is sealed air-tight. This tank or reducer is constructed with jacketed walls and jacketed bottom. Into these jackets the steam, which is used in the reduction of the garbage, is delivered, these jackets being so designed that it is impossible, under proper operation, for the steam to enter the tank or come in contact with the garbage. In the interior of this tank there is an agitating device operated by power from the exterior. When the proper charge of garbage has been placed in the reducer and the covers placed thereon, the tanks are sealed and the solvent is pumped into the reducer and steam admitted to the jacketed walls. The heat from the steam which is transmitted to the garbage through the walls of the reducer, causes the evaporation of the solvent and the water in the garbage.

Garbage is usually composed of over 75 per cent by weight of water. The steam heat vaporizes the solvent and the water from the garbage and these mixed vapors are drawn off from the reducer to the condenser. The economy in this method of evaporation rests in the fact that water is vaporized at a lower temperature when evaporated with a solvent having a low boiling point than when evaporated without such solvent.

The mixed vapors of the solvent and water, while in the condenser together, are conveyed to a closed tank. Owing to the solvent being of lighter specific gravity than the water, the solvent and the water are separated by gravity, the solvent rising to the top from which it is drawn back to the storage tanks from which it is pumped back to the reducers and used over and over again. The condensed water which has been largely diluted, owing to the jet condensers used, is discharged into sewers or waterways.

When the garbage has been thoroughly dried by this method, the solvent is pumped into the reducer and dissolves the grease. The solvent with the grease is drawn off into a closed tank or evaporator where the same is heated by steam pipes, where the steam is kept separated from the grease. The solvent therein is vaporized and carried to a condenser where the same is again liquefied and carried to storage tanks to be used again.

After the grease has been extracted from the garbage in the reducer, the garbage is further dried by means of the steam in

the jacketed walls and is now in the form of degreased garbage tankage, which is used for fertilizer purposes, after being ground and screened.

It will be seen from the above description of the process that if there are any leakages or vents in any of the tanks or piping where the solvent is handled, more or less solvent is lost, and thereby a substantial additional expense is imposed upon the operation of the system. It is evident, therefore, that it is to the financial interest of the owner of the plant to see that the same is properly operated.

Furthermore, under this system, the garbage is at no time brought in contact with the atmosphere, from the time of its original entrance into the reducer until, after 12 hrs. of cooking, it is finally discharged therefrom as finished products, dried, sterile, and practically odorless. These finished products are grease and the tankage above referred to.

It will be seen by the description that the process is one of straight dehydration, and from the time the material is at the boiling point, no further chemical action takes place. No process of "digestion" occurs, and, therefore, the odors and gases incidental to such process are not created. Only the volume of gas contained in the raw material is driven out and only the essential oils of an extremely volatile nature are carried over in the current of steam and solvent vapor evolved. That little or no conversion takes place in the operation is shown by the fact that in the dehydrated material, at the end of the operation, there exists practically the same amount of unconverted starchy bodies as existed in the garbage at the time of its entrance into the reducer.

The water condensed contains all the gases evolved and has, when fresh, a slight odor of the mixed essential oils. Some traces of alcohol are detected in the effluent and a very small quantity of fixed oils is carried over. Any ammonia evolved, if it has escaped the acid in the garbage, is neutralized by acid carried over in the vapor. Whatever albuminoid ammonia exists in the effluent is carried over by mechanical entrainment, as dust particles, during the steaming out of the solvent.

The effluent from this process consists of almost pure water, this water being the condensed moisture drawn from the reducer while the garbage is being treated and from which the solvent has been extracted as completely as possible. The effluent is cold and gives forth no steam or vapor and is practically odorless, and, as a result, can have no effect when run into a large body of water.

Mr. Tuska's paper continues to give some very excellent data on this subject, but I will refrain from quoting further because my time is limited.

The grease, which is the principal by-product from garbage treatment, is a combination of glycerol and fatty acids, the principal fatty acids being palmitic, stearic, and oleic. At the present time this is sold as recovered and the purchaser refines it and obtains glycerin, stearin, stearic acid, red oil, candle tar, and soap fats.

The glycerin content of grease from the reduction methods, other than Cobwell, runs from 5 to 6 per cent, the free fatty acids from 18 to 40 per cent. In Cobwell the glycerin runs from 7 to 8 per cent and the free fatty acids not to exceed 10 per cent. The purchaser demands that saponifiable shall run about 97 per cent.

While there are many solvents which might prove available in this work, economy has reduced the number to gasoline or kerosene distillate, and engine distillate has been used. In using an economical solvent due regard must be given to the practicability of freeing the grease and tankage from any residue from it at the end of the process.

As to the cost of a reduction plant, it is impossible to make a general statement, as so much depends upon local conditions, and also the cost of machinery varies as the market price of

steel fluctuates. However, it is usually estimated that a cooking method plant will cost, approximately, \$1,500 per rated ton with steel at 3 cents per lb., while the cost of a Cobwell plant will be about one-third more than this. In net recovery values it is generally stated that for the cooking method \$2.00 per ton is a fair average, while Cobwell gives, approximately, \$1.00 more per ton. The only safe method of estimating is to analyze the material in each case. I have no definite figures as to the drying method.

While in most of the cities the disposal of garbage is done by contract, and in the majority of cases a bonus is paid to the contractor, the following cities receive payment from the contractor:

New York.....At the rate of about 45 cents per ton
Los Angeles.....At 51 cents per ton

Minneapolis has just closed a contract for pig feeding at a revenue of \$1.26 per ton, and Richmond, Va., under the same system, expects to receive \$2.00 per ton. Denver was the first to adopt pig feeding under contract, without the payment, and is doing so at no cost to the city nor is anything paid to it.

These figures appear very attractive, but it is well to be conservative as to the expected revenues from this source, as this system is, as yet, under trial and the result of the experiment will only be assured when a renewal of such contracts show that the contractor has been successful in operating under such a method of payment. An inspection of successive reports from the cities which operate municipal reduction plants gives a very good idea of the uncertainty of the revenue derived from year to year.

I am very much impressed with the patriotic purpose evidenced by this association in giving so much of its valuable time to the study of the subject of municipal waste disposal, with the intention of performing a civic duty in endeavoring to promote more efficient methods and better financial results, if possible, through the employment of the high professional skill of its members, and I, therefore, take the liberty of calling your attention to the fact that the United States Food Administration recommends that at this time such energy be used in obtaining more efficient operation of existing methods rather than the evolution of new methods.

COBWELL CORPORATION
50 CHURCH STREET
NEW YORK CITY

AMERICAN GARBAGE DISPOSAL INDUSTRY AND ITS CHEMICAL RELATION¹

By RAYMOND WELLS

It is undoubtedly true that before the world war there were chemists in this country and that they were doing most wonderful and useful work, but we were so bewitched by the work done by German copyists and grinds, that when the awakening came, we were astonished to find that the animals at home were likewise endowed with horns and of no inconsiderable magnitude.

At once every industry that had ever thought of the possibility of chemical assistance obtained three of this rare species, and those that had never thought of it at all clamored for at least one. Every business, industry, and manufacture wished for this strange new thing—"scientific control," obtained it as best it might, and found it good. Of course there may be some things the chemist cannot do, but they do not exist in the popular mind.

An industry at this date without a chemical advisor, director, or, at least, a plain ordinary "lab. man" is in the same class with the great auk, and yet there have been explorers who have claimed to have seen specimens of this rare bird, even at the present time. It does not take an explorer to locate the

"garbage industry," but it might prove a stiff task for anyone without the natural instincts of the lowly ferret to find more than one or two even "lab. men" in the business, leaving out of consideration a "regular chemist."

An industry has grown up in this country, taking care of the household table and kitchen waste of 17,000,000 people, serving twenty-nine large cities and returning an annual revenue from the by-products of this service amounting to \$11,500,000. At the same time disposition is made of 1,200,000 tons of raw garbage, from which, disregarding the monetary return, the nation is the richer by producing from its own so-called waste 70,000,000 lbs. of grease and 175,000 tons of valuable fertilizer. And such an industry is practically without a chemist or without even being given recognition by chemists as being one of the few unexplored fields, for their efforts, at the present day.

The disposition of garbage with recovery of the by-products is essentially a chemical problem and its neglect has been due to several causes. The attitude of all or of practically all men or corporations engaged in the business, has been one of antagonism toward chemists, either as individuals or as representatives of science. They were not very unreasonable in this, since all of those chemists attempting to work or to improve the garbage business, did so by long range treatment of garbage as it ought to be from a theoretical standpoint, and from their knowledge of some other business in their mind similar to it. It is not like any other business under the sun, so they fell down most lamentably and the so-called "practical swill man" stood off and scoffed. The "swill man," satisfied with partial success, with sometimes profit and sometimes loss, but with the profit just enough in the right pan of the balance to keep the attraction always there, did not like the idea of disturbing things which had been done, and was thus prevented from asking anything of science. His whole attitude has been one of secrecy about the simplest of operations and one of horror at the idea of starting anything which might or might not turn out to their pecuniary advantage.

Don't blame the swill man for his attitude. He set out to make something out of nothing, out of something which everyone turned away from, about which no one knew anything, and in approximately thirty years built up a real industry, without assistance from anyone. It was all "try it and see," and after a period of several years something was arrived at, which was moderately satisfactory and sometimes made a little money. After that, why change? Changes meant increased investment, possible big financial failure—better to jog along and keep quiet, taking all that could be obtained and when not obtained, slip it over quietly to the next chap.

Seeing this attitude and not looking into what promised only to be a dirty, disgusting hot, sweaty business, where things were accomplished by rather circuitous methods at times, viewed from political and engineering standpoints, the chemist withdrew to more savory and apparently more promising fields. As a matter of fact he chose, as usual, the line of least resistance.

In spite of this neglect from the chemist, the business has prospered and is doing very excellent work for the city and for the nation. A short time ago the city and the nation woke up to the garbage situation and were surprised to find that a real industry existed. Immediately propaganda started and continue to start, which is well, for out of them may grow an interest both popular and scientific, valuable to the industry and to the nation.

Before venturing too far in denouncing our nation as a nation of wasters and as a nation neglectful of its waste materials, it is well to consider all of the facts in the case.

For instance, the largest city in the United States has the largest garbage plant in the world and the most up-to-date one from the chemical and engineering standpoints, representing the effort and financial hazard of many men. This plant possesses the *sine qua non* of the swill business, it is sanitary and does not

¹ Remarks following Mr. Very's paper, New York Section, American Chemical Society, May 10, 1918.