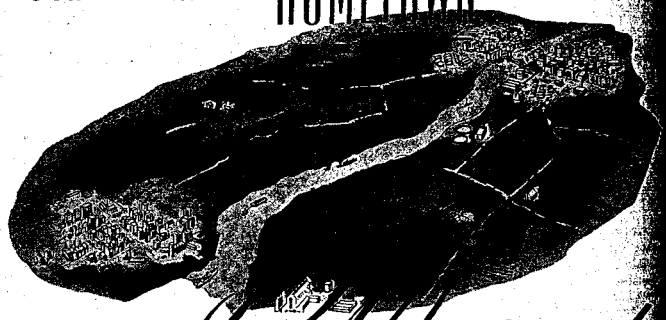
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H. A. WOLOFF

Industrial Wastes

INDUSTRIAL WASTE DISPOSAL *

By George E. Symons, Ph.D.

Associate Editor, Water Works & Sewerage, New York, New York

The subject of industrial waste and its disposal has, within the last few years, reached the place of highest importance in the field of sanitary engineering. After many years of indifferent or complete lack of attention, followed by slowly awakening interest in this important problem, it appears that in the postwar period the disposal of industrial waste is to be the leading topic.

This trend, accelerated perhaps by the war, has become evident in many ways: In the programs of various technical organizations and societies; in the requests of engineering organizations to be addressed on the subject; in the report of the U.S.P.H.S. which makes an estimate of the amount of construction of remedial works to treat industrial wastes; in industrial advertising calling attention to the application of some product in industrial waste treatment; in the work of various stream control commissions in the United States and in Canada; in the work of the U.S.P.H.S. and the Ohio Stream Pollution Survey; in the calling of conferences on industrial waste by universities co-operating with state departments of health; in the continued research programs and the establishment of new ones by trade associations; and in articles appearing in the trade journals. Yes, it is evident that Industrial Waste Disposal is the problem of Today and its solution is the program of Tomorrow.

A problem of the complexity, magnitude, and variety of industrial waste disposal obviously cannot be presented in detail in any single paper. One can but hope to present certain broad aspects of the subject, and emphasize some generalities not usually considered in papers dealing with specific details of definite wastes and problems thereof.

One concept so frequently lost sight of in discussions of industrial waste is that disposal means "to get rid of" and, as far as industrial wastes are concerned, "disposal" may mean with or without treatment; in this paper that definition will be borne in mind.

Using an editor's prerogative, I have gathered for use here opinions and statements from persons who have had intimate contact with some phases of the problem.

Wastes—How Much and From What?

With this introduction, we may well ask, whence come these wastes? Obviously, if industry uses water in its processes one may, with surety,

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expect the water to become contaminated in the process. It is this contaminated water that must receive treatment or else impose a pollution load on the receiving body of water. The tremendous quanti-

Table I.—*Industrial Water Requirements* *

A—Water Requirements for Selected Chemical Industries	
1. Ammonia	31,000 gal./ton NH_3
2. Ammonium sulfate	200,000 gal./ton salt
3. Carbon dioxide	23,000 gal./ton CO_2
4. Caustic soda	21,000 gal./ton 11% solution
5. Cellulose nitrate	10,000 gal./ton nitrate
6. Corn refining	333 gal./ton corn
7. Glycerine	1,100 gal./ton glycerine
8. Gun powder	200,000 gal./ton powder
9. Hydrogen	660,000 gal./ton gas
10. Industrial alcohol	20,000 gal./ton grain
11. Lactose	220,000 gal./ton lactose
12. Magnesium carbonate	39,000 gal./ton salt
13. Paper	
a. De-inking paper	38,000 gal./ton paper
b. Paper board	14,000 gal./ton paper board
c. Strawboard	26,000 gal./ton strawboard
14. Phosphoric acid	7,500 gal./ton 35% acid
15. Soda ash	18,000 gal./ton 58% ash
16. Tanning	16,000 gal./ton hides
B—Water Requirements for Selected Food Industries	
1. Beet sugar	2,600–3,200 gal./ton beets 20,000–25,000 gal./ton sugar
2. Canning	
a. Asparagus	7,000 gal./100 cases No. 2 cans
b. Beans	
(1) green	3,500 gal./100 cases No. 2 cans
(2) lima	25,000 gal./100 cases No. 2 cans
(3) pork and	3,500 gal./100 cases No. 2 cans
c. Corn—cream or whole	4,000 gal./100 cases No. 2 cans
d. Peas	3,000 gal./100 cases No. 2 cans
e. Sourkraut	300 gal./100 cases No. 2 cans
f. Spinach	16,000 gal./100 cases No. 2 cans
g. Tomatoes	
(1) products	7,000 gal./100 cases No. 2 cans
(2) whole	750 gal./100 cases No. 2 cans
3. Meat packing	
a. slaughter house	16,000 gal./100 hog unit
b. packing house	55,000 gal./100 hog unit
c. poultry	220 gal./100 lbs. live weight
4. Milk and milk products	
a. receiving and bottling	450 gal./100 gal. milk
b. butter	250 gal./100 lbs. butter
c. cheese	200 gal./100 lbs. cheese
5. Vegetable dehydration	
a. beets	1,870 gal./100 lbs. product
b. cabbage	750 gal./100 lbs. product
c. carrots	1,580 gal./100 lbs. product
d. potatoes	560–1,250 gal./100 lbs. product
e. rutabagas	1,520 gal./100 lbs. product
f. sweet potatoes	900 gal./100 lbs. product

TABLE I.—*Industrial Water Requirements—Continued* *

C—Water Requirements for Selected Textile Industries

1. Cotton	
a. processing	3,800 gal./100 lbs. goods
b. dyeing	1,000–2,000 gal./100 lbs. goods
2. Linen	10,000 gal./100 lbs. goods
3. Rayon	
a. "dissolving pulp"	9,500 gal./100 lbs. pulp
b. supra-ammonium yarn	8,000 gal./100 lbs. yarn
c. viscose yarn	10,000 gal./100 lbs. yarn
4. Wool-scouring	2,000–15,000 gal./100 lbs. raw wool

D—Water Requirements for Miscellaneous Industries

1. Air Conditioning	6,000–15,000 gal./person/season
2. Blast Furnace	4,000 gal./ton pig iron
3. Coal Carbonizing	3,500 gal./ton coal carbonized
4. Coal Washing	125 gal./ton coal
5. Electric Plant	120,000 gal./ton coal burned
6. Oil Fields	18,000 gal./100 bbl. crude oil
7. Oil Refinery	77,000 gal./100 bbl. crude oil
8. Rock Wool	5,000 gal./ton rock wool
9. Steel Plant	20,000–35,000 gal./ton steel
10. Sulfur Mining	3,000 gal./ton sulfur

* Compiled by Alex C. Burr, Director, No. Dakota Research Foundation

ties of water used in industrial processes are shown in Table I. Alex C. Burr, Director, North Dakota Research Foundation, compiled these data (1) and about them he writes (2),

"The figures cited are not mathematical averages nor are they necessarily typical. They do, however, represent the quantity requirements of operating plants. Requirements for a new plant of a given capacity will depend on design and water economy, and may vary greatly from the figures given. It should be noted that these figures do not include water for waste disposal.

"In many cases easily recognizable, a great portion of the water used will eventually find its way into the waste. This is especially true for those industries in which the steam and process water requirements are low.

"These figures have been obtained from a great variety of sources; some picked up from incidental references in literature, some based on inspection of plants. In every case the experience of at least three plants is involved and used in arriving at a figure.

"It goes without saying that these data should be used with caution. The main value is in emphasizing the quantity of water required."

Classification of Wastes

These values do emphasize the quantity of water required. They also emphasize the problem of waste disposal. Burr's tabulation offers, in a way, a classification of wastes. William S. Wise (3), Chief Engineer of the Connecticut State Water Commission, likewise has a classification of sorts in his list of industrial wastes in that state. From these two lists a broad classification of wastes has been made and is shown in Table II.

Even from this incomplete listing it is obvious that wastes containing both organic and inorganic compounds outnumber those predominantly organic or inorganic in nature.

Inorganic wastes require chemical or mechanical treatment or both, and will not respond to biological treatment. Organic wastes will respond to biological treatment and may or may not require chemical and mechanical treatment as well for complete purification. Mixed wastes may and probably will require both mechanical and chemical treatment as well as biological treatment, with special attention to various and many steps.

E. F. Eldridge (4) has made a slightly different classification under the headings Organic, Toxic and Inert. Generally, Eldridge's toxic wastes fall into the inorganic class, while his organic wastes embrace

TABLE II.—*Partial Classification of Industrial Wastes*

Inorganic	Organic	Mixed
Metallurgical	Vegetable Canning	Textile
Brass and Copper	Corn Products	Dyeing
Iron and Steel	Alcohol Production	Coke and Gas Wastes
Plating	Slaughter House	Paper Board and Allied
Sulfur	Dairy and Milk	Laundry
Sand Washing	Beet Sugar	Tanning
Acid Manufacturing	Citrus Fruit Canning	Cutting Oils
Salts	Brewery	Dye Manufacturing
Alkalies	Meat Packing	Petroleum
Coal Mines		Plastics
		Rubber Reclaiming
		Natural and Synthetic Rubber
		Explosives
		Vegetable Dehydration
		Wool Scouring

most of those listed here as mixed. (Most notable exceptions are the coke oven and gas wastes.)

Economics of Waste Disposal

Historically, the most common means of waste disposal has been by dilution. From earliest industrial development utilizing water power, it was the natural means of disposing of industry's waste.

While quantities of waste were small this method was satisfactory and acceptable. As waste quantities increased with industrial development the capacity of the streams to receive and purify these wastes was overtaxed. Streams formerly the source of fish and available for pleasure became fouled and an economic liability to the region. At the same time losses from industry became an economic factor to be reckoned with.

True, not all waste substances discharged are recoverable or have any economic value. On the other hand, the economic loss to some industries is evident. For example, Dr. C. S. Boruff (5), Technical Director, Hiram Walker and Sons, Inc., estimates that some 1,000,000 tons per year of recoverable materials have a value of $30,000,000, and

comments, "From these figures one can obtain some idea of the economic loss, in the past, of discharging distillery residues to wastes."

Dr. Harry Gehm (6), Technical Advisor, National Council for Stream Improvement of the Pulp, Paper, and Paperboard Industries, quotes the U. S. Dept. of Agriculture estimate of $45,000,000 annually as the economic loss of the pulp, paper and allied industries.

Richard D. Hoak (7), Senior Industrial Fellow, Mellon Institute, has been working for three years on the problem of pickle liquor disposal from the steel industry and has estimated the loss of sulfuric acid "at 125,000 tons each year along with 500,000 tons of ferrous sulfate, if no recovery were practiced." Hoak (7) has also stated that before the mine sealing program of abandoned bituminous mines it was estimated that 2,700,000 tons of sulfuric acid were discharged annually into streams, obviously causing considerable economic damage. He continues, "Actually, considerable ferrous sulfate is recovered from pickle liquor, *but* if this compound were recovered from *all* of the liquor produced there would be a surplus of perhaps twenty (20) times the normal annual demand for ferrous sulfate."

In regard to the economic recovery aspect of this particular waste, Hoak continues,

> "Development of processes for recovery of by-products from it has not been notably successful because of the low value and limited markets for compounds readily prepared from it. Treatment of pickle liquor has been a problem of economics rather than of technology; a variety of useful products can be derived from it, but transportation, operating costs, saturated markets, and other factors frequently make recovery processes more costly than wasting the liquor.
>
> "The American Iron and Steel Institute maintains an industrial fellowship at Mellon Institute for research on steel mill wastes, and a number of processes have been developed which show promise. Until these processes can be studied on a pilot plant scale, however, their economic potentiality cannot be properly evaluated.
>
> "Certain processes may be employed which will reduce the cost of treatment if they are operated on a sufficiently large scale, but it seems unlikely that any process will be developed which will yield a substantial net profit. Companies which produce only a few thousand gallons of waste liquor a week will probably find that time and/or limestone treatment will be the only practicable disposal expedient."

This statement points definitely to one important factor of the "economics of waste disposal," namely, that of markets for recovered by-products.

An extremely sane attitude on this matter has been expressed by Maurice LeBosquet, Jr., Principal Public Health Engineer, Sanitary Engineering Division, Water and Sanitation Investigations of the U. S. Public Health Service. LeBosquet (9) writes,

> "I believe that an erroneous impression is created through the use of the phrases 'Economic loss from industrial wastes' and 'Value of recoverable waste products.' Such terms infer that industry, as a rule, is quite careless and accustomed to discharging materials of value into the sewer. Such instances are the exception rather than the rule and are usually found at the industry that does not sample its own sewers.
>
> "It is true that there may be some value in the contents of industrial wastes, but, in the typical industry, this value is somewhat less than the cost of recovery. It is my feeling that while there remain further possibilities along the line of developing by-products, industry must first conduct extensive studies leading toward development of recovery processes and, in many cases, must also develop the markets to absorb the by-products after they become available.
>
> Many industries now realize that they are confronted with an item of expense in abating pollution, even though part of this expense may come back through the sale of by-products. In the future, I believe all industries will come to this realization. In the meantime let us not place too much stress on the 'Value of recoverable waste products' even though, during the war period, the prospect of recovering war-needed items from industrial wastes is inviting."

One other factor must be considered in any evaluation of the economics of waste disposal. This factor of economic damage to receiving bodies of water cannot be evaluated, but judging from the vehement voices of sportsmen and conservationists it must be an appreciable value even in these days of war expenditures running into the billions.

While it is true that "economic loss from industrial wastes" creates an erroneous impression, it is likewise true that industries sometimes discharge waste to the economic detriment of themselves and their neighbors. We may cite the example of a city situated on an inland lake with several large industries on one part of the dredged stream forming a harbor. Some of the industries discharge sizeable amounts of acids with the result that at periods of low stream flow the harbor becomes quite acid. Industries using this water for cooling purposes have severe corrosion problems. So severe is the corrosion that one industry estimates a corrosion replacement of $50,000 per year is required while another spends $125 a day for lime neutralization during the summer months. This certainly is a highlight of economic loss from industrial waste disposal.

Pollution Abatement Programs

Two factors are paramount in the consideration or development of pollution abatement programs. First, to strike an economic balance between the extent of abatement and the capacity of the receiving body of water. Second, to develop individual abatement programs on a regional or drainage basin basis.

As to who will or should undertake the development of pollution abatement programs, the question has been answered generally by governmental action, municipal, state or provincial, regional, and Federal or Dominion departments of health and conservation. Of recent years, however, industry has itself undertaken programs that are designed to lead to the solution of the problems. Two notable examples are the American Iron and Steel Institute which for several years has been studying the problem of waste pickle liquor at Mellon Institute and the recent organization of a program for study of Paper and Pulp Wastes by The National Council for Stream Improvement.

This latter program has been set forth by Dr. Gehm (6) in a release as follows:

> "In attacking its waste problem, the pulp, paper and paperboard industry has arrived at the stage where co-ordinated effort is imperative. Being one of the first indus-

tries to appreciate the need for research, it has reached the position before many other large industries. Never before has a waste problem been approached in so broad a manner, and in working out the procedure, the magnitude of the program has become increasingly evident.

"Before any large-scale laboratory projects can be initiated, the following information must be collected and assembled in abstracted form for guiding the technical planning and research groups in determining methods leading to a satisfactory solution of the problems with a minimum of duplicated effort:

1. Sanitary analysis of the drainage areas involved.
2. An investigation of prior art.
3. Industry's experience with treatment and recovery processes.
4. An assembly and analysis of the physical and chemical characteristics of the wastes involved in the manufacture of all grades of paper and paper board.

"In order that proper priorities may be assigned, actual conditions of the various plants in regard to stream pollution must be evaluated. This and the collection of industry experience will be the function of regional committees. Acting simultaneously, they will determine their most pressing needs and what contribution to the knowledge of waste treatment they can make to the industry as a whole. In order that a balance may be obtained, each grade of product manufactured in the region must be represented. The committee members, working with the chairman, will assemble the region's problems for submission by the chairman to the Technical Planning and Budget Committee meeting together with the chairman of other regions, the Council's staff, and representatives of the Mellon Institute, to decide on the general course of the work to be assigned to the research groups.

"When research results have reached the stage where they are ready for application by the industries, such data will be made available through the chairmen of the various regional groups. Assistance in applying the knowledge obtained will be rendered by the staff and such members of the research organizations as may be indicated."

Cost of Abatement Programs

The cost of industrial waste treatment to abate pollution in America will not be small. Research programs such as outlined above will require considerable expenditures in themselves.

A survey of industrial waste pollution in any drainage basin by a governmental agency likewise is not inexpensive, considering the necessity for investigation of individual industries, collecting and analyzing samples of various industrial waste and compiling data and information thereon.

The most recent large survey was that carried on in the Ohio River Basin by the Ohio Stream Pollution Survey of the U. S. Public Health Service from its Cincinnati office. About the extent and cost of this survey LeBosquet (8) writes,

"The complete Ohio River Pollution Survey and report cost about $600,000, of which about half was devoted to laboratory studies of the streams and half was devoted to collecting information on methods of sewage and industrial waste disposal and the preparation of the final report.

"The problem of collecting information on industrial wastes, including the preparation of Industrial Waste Guides, required more time than the problem of sewage disposal, so that possibly $200,000 was spent on the question of industrial wastes. This is about $100 per industrial plant included. The industrial waste investigations, however, did not include sampling and gaging studies, except in perhaps 20 cases. A sampling and gaging study might cost from $1,000 to $2,000 for one industry, depending on the complexity of the industry and the number of sewers involved."

Realizing that even the investigation of stream pollution will entail the expenditure of appreciable sums of money, one may well ask, what postwar future exists for industrial waste treatment? How large is the construction job of remedial measures to abate pollution? Three sources of information are available to give some idea of the financial expenditure involved in a comprehensive waste disposal program. These are the National Resources Committee publications "Water Pollution in the United States" (9), the report on "Ohio River Pollutional Control" (10) and the "National Inventory of Needs for Sanitation Facilities" (11).

LeBosquet (8) writes,

"The estimate for a comprehensive waste disposal program, first given in the National Resources Committee publication, is between $800,000,000 and $900,000,000, the annual cost being $200,000,000 to $250,000,000. The estimate is intended to be complete and to include disposal or treatment measures in industries not now generally practicing corrective measures. For example, in certain cases evaporation is assumed, whereas there are no evaporating plants installed at the present time. The estimate does not include any item of cost for rearranging sewer systems within industrial plants. This in itself might double the figure, as one instance has been recorded where an industry spent $250,000 simply for rearranging its sewer system in order to install phenol recovery facilities.

"The report on Ohio River pollution control . . . presents an estimate for treatment and other remedial measures for industrial wastes in the Basin, the total estimated cost being $13,580,000 and the annual charges being $4,265,000.

"This estimate differs from the National Resources Committee estimate in that the cost figure represents what could be spent today, with present knowledge, towards correcting and eliminating industrial waste pollution. It does not include an item of cost for correcting pollution where known successful methods are not now available. It does not include any item of cost for industrial wastes which in our opinion could be disposed of to best advantage in municipal treatment plants. It does not include any item of cost for rearranging sewer systems prior to installation of treatment works. It is apparent that any estimate of cost for industrial waste pollution abatement must be qualified with a statement as to what costs are not included.

"The most recent estimate on industrial waste pollution abatement costs was published in the Public Health Reports. I (M. LeB.) am familiar with the development of the estimates presented, having been connected with their preparation.

"The estimate is based largely on an expansion of the Ohio River Pollution Survey detailed data to cover the country as a whole. Estimated costs of independent industrial waste corrective measures total $160,000,000. In addition, the increased costs of municipal treatment works because of industrial wastes contributed to municipal sewer systems total $153,000,000, making the total cost of industrial waste disposal $313,000,000.

"As in the case of the Ohio River Pollution Survey, corrective measures are confined to those which can be taken now with present knowledge and do not include corrective measures which cannot be taken until after extensive studies have been made in regard to methods to be used. The estimate, again, does not include the cost of rearranging sewer systems preliminary to installing treatment works or other corrective measures.

"In view of the restricted nature of the estimate, it seems likely that the $313,000,000 U. S. Public Health Service estimate and the $800,000,000 to $900,000,000 National Resources Committee estimate are within reasonable agreement."

If one may estimate a similar per capita expenditure in Canada, then it becomes obvious that the construction of industrial pollution abatement may run for a period of years in the postwar period with expenditures of 75 to 100 million dollars a year.

Specific Waste Problems

In a general survey of the broad picture of industrial waste disposal, it is, perhaps, a mistake to attempt any mention of specific wastes, to the exclusion of others. On the other hand, mention has already been made of the extent of some specific waste problems, and it does seem wise to call attention to the complexities of at least two waste problems. When one speaks glibly for example, of the paper and pulp waste, one minimizes the problem out of all reason. The complexity of this waste problem, really several different wastes, is evident from Table III as furnished by Dr. Harry Gehm (6), Technical Advisor, National Council for Stream Improvement.

Table III.—*Types of Waste from the Pulp and Paper Industry*

Type of Waste	Type of Treatment
Sulfite Waste Liquor	By-products Manufacture: Vanillin Alcohol Yeast Others Lagooning, Precipitation Processes, Road Binder and Soil Stabilizer, etc.
Kraft Waste Liquor	Evaporation and Burning
Soda Waste Liquor	Evaporation and Burning
De-inking Waste	Precipitation, Filtration and Lagooning Sludge
White Waters	Precipitation, Flotation, Filtration, Centrifuging, Screening, Re-use of Fiber
Semi-chemical Waste Liquors	Barging, Lagooning, Recovery Processes in Development
Bleach Liquors	Precipitation, Lagooning

As another example of the complexity of wastes one may cite the canning industry. About this seasonal and highly varied industry, Wm. A. Ryan, (12) Industrial Waste Consultant of Rochester, N. Y., writes:

"Wastes from vegetables and fruits are chiefly organic in nature with small amounts of dirt or mineral matter from the washing process. The principal vegetables canned in most plants of New York State are tomatoes, corn, peas, beans, beets and cabbage. The principal fruits are apples, pears, peaches and cherries.

"During the past ten years many canneries have devoted more time to quick freezing and specialties such as soups, potatoes, milk, spaghetti, pork and beans, and baby foods. This practice tends to keep the plants operating the year around.

"Since the war a few plants have added dehydration and have specialized on potatoes, soup stock, tomatoes, etc. It makes little difference what is ultimately done with the fruit or vegetable, there is always wash water, blanching water, and wash down wastes to consider.

"Vegetable and fruit waste is not poisonous. In most cases the waste has an acid reaction and soon becomes putrescible. Peas and corn wastes are most objectionable to fish life due to dissolved organic matter such as sugars, starches, etc. One-third of the tomatoes as received leave the plant as waste. Pea, corn and lima bean ensilage juice should never be allowed to enter a stream or sewage plant. Pea vineries should be located in the country away from the plant.

"Introduction of the lye peel method (caustic soda plus hot water) for loosening the skins of potatoes, beets, carrots, etc., has increased the solids as well as the B.O.D. of the wastes. It is fortunate that this method of peeling has not been too popular.

"Vibrating or rotary screens are the first units to consider in treating canning wastes. Removal of waste from picking tables in plants in the form of garbage reduces the B.O.D. of liquid waste. Lagoons are most popular, after screening, for disposal of waste. Sodium nitrate is an aid in lagoons for keeping down odor and reducing B.O.D. Many large sewage treatment plants accept cannery waste, while small plants are easily overloaded.

"Flotation method for treating tomato waste has merit. Chemical treatment is not popular in New York State. Contact or Dunbar filters followed by riffles are used by many.

"Trickling filters require too long to become active for short season. Odors are a problem but nothing compared to reduction of oxygen in streams with resultant fish kill. Excess dosage of lime is not desirable, due to effect on stream life and fish life."

Not only are canning wastes seasonal and varied, but as Ryan concludes, "Every canning plant is an individual problem and must be studied separately."

Recovery of By-products

As pointed out by LeBosquet, recovery of saleable by-products from industrial waste is not the simple answer to the economics of industrial waste treatment. Not every waste contains a recoverable material that has a potential market sufficient even to pay a part of the waste treatment and recovery costs.

On the other hand, some industries do waste or have wasted valuable recoverable products. For example, about canning wastes, Ryan writes,

"Apple waste has the greatest possibility for recovery of by-products in the North. Pea vines and pods can be dehydrated and ground for feed admixtures, or fed as dry hay. Tomato seeds are recovered in New Jersey and clean tomato and beet waste can be dried and used as an admixture in dog food. In general, however, recovery of other vegetable or fruit waste as saleable by-products has little to offer."

An outstanding example of recoverable wastes has been in the corn products industry, with the recovery of cattle food and other materials from starch waste. Still another example with a highly dramatic story is that of the distillery waste problem, about which Dr. C. S. Boruff (5) writes:

"In pre-prohibition and early post-repeal days distillery residues were a waste disposal problem. This is no longer true; the problem is now one of recovery of valuable materials rather than disposal of a nuisance. Just prior to the war, recovery was at the rate of about 300,000 tons per year. This year there will be about 500,000 tons recovered, and equipment now in the process of being installed will lead to a recovery of 1,000,000 tons a year. This million tons will have a normal peace time value of some $30,000,000. From these figures you can get some idea of the economic loss, in the past, of discharging distillery residues to waste.

"Some plants recover only the material retained on screens. Others recover whole stillage by screening and evaporating the screened stillage. Both these products are used in dairy cattle rations. In 1940, Hiram Walker introduced the practice of drying separately on drum driers a portion of the concentrated (clarified by centrifugation) thin stillage. This product, distillers' dried solubles, is finding ready acceptance in poultry and swine rations because it contains high quality protein plus significant quantities of

the water soluble B vitamins, found to be necessary in poultry and swine nutrition.

"As regards costs, I can say that in peace time, at normal prices, the recovery of by-products is a profitable business when modern recovery equipment and methods are employed."

In at least one instance it is the recovery of water itself which is the essential and controlling factor in the waste treatment. This situation exists at the famous Fontana (Cal.) steel plant of Henry J. Kaiser, where every drop of water is recovered for re-use. Saleable phenol recovered only partly pays for its own recovery, but the extreme shortage of available water makes complete treatment of waste and re-use necessary.

Local Industrial Waste Surveys

While governmental bureaus are generally staffed with personnel familiar with sanitary engineering problems, municipalities, particularly smaller ones, often face an industrial waste problem without an adequate idea of how to proceed.

How then should an industrial waste survey be conducted and toward what ends should it strive? In the first place the end in view must be abatement of pollution, not persecution of industry.

A good example of what not to do was done in Grafton, North Dakota, where the waste from a potato dehydrating plant had been extremely detrimental to the operation of the local sewage plant. Lack of forehand knowledge of these effects had led to the difficulty, but co-operative study of the problem was not utilized as the solution. On the contrary, the municipality adopted a motion prohibiting the dumping of the waste into the sewer system until the company indemnified the city against damage and damage claims, etc. The company closed the plant and moved to another city.

There are numerous examples on the other side of the ledger where co-operative study of the problems involved has resulted in benefit to both parties.

If a municipality has industrial waste problems and desires to eliminate or alleviate them, the first step is to release adequate and informative publicity to the general public, stressing the fact that co-operation and aid to the industry is the paramount consideration.

The second step is to list and classify all industries within the area to be covered by the survey. From these classes (breweries, chemical products, laundries, dairy products, tanneries, etc.) it is possible to divide the classes into two groups, according to the probability or knowledge of liquid wastes of other than sanitary nature. Industries not having liquid industrial wastes need not be investigated. Industries in the other group should be listed in order of their known relative importance and the survey is ready to begin.

Following the early publicity and classification of industries the next step is to notify each industry to be investigated by a letter asking for a conference with the technical representatives of the municipal

authority. First contact should be aimed at establishing friendly understanding of the problems involved and the intent of the survey. This to be followed by a plant survey or investigation of sewers and wastes and, if indicated, sampling and analyses of wastes. In the latter case it is important to remember that sampling should be representative of plant operation and discharges.

Details of questions to be asked, information to be sought and analyses to be made depend largely on the local situation but a good guide to useful questionnaires may be found in the "Final Report to the Ohio River Committee—Supplement 'A', Collection of Data on Sources of Pollution." (13) "Supplement 'B', Organization and Methods of Laboratory Studies" (14) is likewise extremely helpful.

Thereafter the survey consists of interpreting the data and information in order that the co-operation of the industry may be obtained in reaching the desired end in view whether it be elimination of the waste, partial pretreatment of the wastes before discharge into the sewers, or payment by the industry of its fair share of the cost to the municipality for the treatment of the waste.

One interesting story of the need for education happened to the writer. The superintendent of the industry being interviewed said, "We don't have any waste to speak of—we obtain a 98 per cent yield of product." Quite true, but the 2 per cent loss could be 20,000 p.p.m. in his waste and the loss of reactants other than the products could be 95 per cent. In another instance a battery company was dumping a 3.2 per cent solution of sulfuric acid into the sewer at intervals. While 3.2 beer may not have much kick, 32,000 p.p.m. of sulfuric acid wreaks havoc on concrete sewers.

It is not the per cent loss that is important; it is the quantity loss in pounds and its effect on the stream, lake, or treatment works.

Payment for Treatment

As indicated above, in some cases it may be indicated that elimination of the waste is desirable and necessary, in others pretreatment before discharge into sewers, while in still other cases the simplest solution may be acceptance in the municipal sewers with treatment as a part of the city's sanitary waste. In the latter case it is entirely feasible that the industry pay its share of the cost of treatment.

The idea that industry pay the municipality for treating the industrial waste is not new, nor is the idea that payment should be on the basis of service rendered or strength, quantity and amount of waste treated.

Fifteen years ago Frank A. Marston (15) stated,

"Where the sewage is treated, the cost of operation and maintenance of the sewage treatment plant is influenced by the character of the sewage including industrial wastes, ground water and other leakage. Certain industrial wastes may add a considerable burden of expense because of their character; whereas relatively clean rinse waters, although of similar volume, would not involve a corresponding cost. To meet these con-

ditions, it is possible to set up the following: A schedule of charges based not only on the volume of domestic sewage or industrial wastes, but also on the degree of pollution as measured by relative amount of suspended matter, the biochemical oxygen demand, or some other factor."

In a report on Sewer Rentals in Ohio some years ago, F. H. Waring (16), Chief Engineer, said,

"In making up a sewer rental schedule, special allowances . . . should be made for certain unusual premises served, for example,—industrial establishments where liquid wastes are admitted to the sewers. For the latter premises, variations in charges in accordance with the volume may be supplemented by further variation in accordance with the strength of the industrial sewage as compared with the domestic sewage."

One of the early municipal-industry agreements was that in Cedar Rapids, Iowa, where a packing company paid part of the cost of construction of the plant and pays a yearly sum toward operation costs. Other cities in the United States having some arrangements as to payment by industry for waste treatment in the past several years have been Sioux Falls, South Dakota (packing plants); Boulder, Colo. (creameries and laundries); Traverse City, Mich. (grain elevator, creameries and certain other industries); Phoenix, Ariz. (dairy waste); Orville, Ohio (food process industries); Hillboro, Ore. (separate sewer and treatment and special charge for all industry); Freehold, N. J. (special rate for industrial waste delivered to treatment works in separate sewer). There are several others.

Most of these agreements have been on the basis of yearly charge or some other negotiated basis. In the past two years, two municipalities have assessed sewer service charges on the basis of volume of waste, and strength of constituents which contribute to the cost of sewage treatment.

The first of these was Buffalo, N. Y., where, in 1942, this author and his associates developed a formula for charge, based on more than three years' study. The Buffalo service charge has been applied since February, 1943. The second city to make a similar basis of charge was New Brunswick, N. J.

The Buffalo industrial sewer service charge, as reported by Symons and Crane (17) in the March, 1944, issue of *Water Works and Sewerage,* was developed as applicable to all industries and is based on volume, and concentration of suspended solids and chlorine demand, as shown by the following formula (17):

$$R = FP_c\ (C - N_c) + FP_s\ (S - N_s)$$

"Where R = rate of special charge in cents per 1,000 cu. ft. of volume of waste.

F = factor for converting parts per million to lbs. per 1,000 cu. ft.

P_c = contract price of chlorine in cents per lb.

C = concentration, in parts per million, of chlorine demand of the waste.

N_c = normal dry weather chlorine demand of raw sewage in parts per million of sewage as received at the treatment works.

P_s = cost in cents for chemicals used in sludge conditioning and for power for disposal of solids resulting from one lb. of suspended solids received in the raw sewage at the sewage treatment works.

S = concentration, in parts per million, of suspended solids of the waste.

N_s = normal grit-free suspended solids in parts per million of raw sewage as received at the treatment works.

"The factor P_c may vary from year to year according to the contract price for chlorine and the factor P_s may vary according to the costs of chemicals and power involved in the disposal of solids as determined from operations for the previous year or previous two years. The factors C and S may be established by analyses (periodic or otherwise) to obtain average concentrations to be applied for any agreed length of period."

New Brunswick, N. J., decided on "treatment of all wastes at the municipal plant, without pretreatment by industry" and set up industrial waste charges by means of a city ordinance in February, 1944, in which it states:

"The charges for factory effluents or industrial wastes discharged into the city sewers or tributaries thereof, shall be fixed and determined according to flow, suspended solids and chlorine demand, according to the following schedule of rates:

$22 per million gallons.
$ 5 per ton sludge solids.
$ 5 per 100 lb. chlorine demand."

Experience at Buffalo to date has been successful in the application of such charges. Where questions of concentration were raised, cooperative study and friendly negotation were the means of solving the problem. The income from these special charges is an appreciable item in defraying that portion of the cost of operation attributable to the excess chlorine demand and suspended solids in the industrial waste.

About New Brunswick, Mayor Paulus (18) stated his belief

"that if industrialists are willing and do co-operate that most industrial wastes can be handled in adequately designed sewage treatment plants constructed for the treatment of domestic sewage, but, in this co-operation, the industrialists must be prepared to pay their full share of the cost of plant enlargement and plant operation."

Summary

In a broad review of a problem of the size and complexity of that of industrial waste disposal, the discussion of details must perforce remain subordinated. Even so, the presentation may run to some length. It is well, therefore, to recapitulate certain salient points worth bearing in mind.

Not only may waste discharges involve economic loss to the industry in some cases, but damage to receiving bodies of water may constitute an economic loss.

Pollution abatement programs will involve the expenditure of several hundred million dollars in the postwar period. These programs may be initiated generally by surveys conducted by governmental bureaus or political subdivisions thereof. Studies by trade associations will aid materially in the abatement programs.

Pollution abatement should be given first consideration on the basis of drainage basin or other hydrologic region, but municipalities may wish to undertake the solution of their own problems. In making an

industrial waste survey, a municipality must consider that (1) each industry may have a variety of specific problems, (2) co-operation with industry is essential, (3) by-product recovery is not always the solution, and (4) final solution of the problem may involve complete elimination of the waste, pretreatment of the waste before discharge into the city sewers, or acceptance of the waste for treatment by the municipality.

If industrial wastes are accepted in the sewers for treatment at the municipal plant, it is both fair and equitable that industry should pay its share of the cost of such treatment. Equitable means of charging industry can be developed on the basis of volume and concentration of constituents.

Industrial Waste Disposal is the problem of Today; its solution should be a definite part of the postwar planning for Tomorrow.

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Stream Pollution

PLANKTON PRODUCTIVITY OF CERTAIN SOUTHEASTERN WISCONSIN LAKES AS RELATED TO FERTILIZATION

I. Surveys

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Certain of the lakes at Madison, Wisconsin, especially those receiving storm and sanitary sewer drainage, have become notorious because of their algal blooming, resultant offensive odor conditions, and the methods of control which have been practiced. Attention was directed to Lake Monona at an early date. Copper sulfate treatment of that lake was begun in 1918 and has been continued each season since. Lakes Waubesa and Kegonso have been of considerable concern during the past 10 years and have received treatment with copper sulfate since 1935.

Sewage Treatment at Madison, Wis.

The City of Madison is served with a separate sanitary system, the construction of which was started in 1886. Raw sewage was disposed of in Lakes Monona and Mendota, mainly the former, until 1899. From 1899 to 1902 chemical treatment of the sewage was practiced and the effluent disposed of in Lake Monona. A septic tank-filter bed combination was used in the period 1902 to 1914, with Lake Monona receiving all the effluent. From 1914 to 1926 the sewage was treated by plain settling and contact beds followed by trickling filters (Burke Plant), the unsettled filter effluent going directly to Lake Monona. In 1926 the first unit of the present Nine Springs Plant employing an Imhoff-trickling filter system, with drainage to Lake Waubesa, was put into operation to relieve the much overloaded conditions at the Burke Plant. In 1936 the Burke Plant was closed and all sewage was sent to the Nine Springs Plant which had been enlarged with activated sludge facilities for treating the additional load. Since 1936 all treated sewage of the metropolitan area has been discharged to Lake Waubesa. Additional activated sludge facilities were completed at the Nine Springs Plant in 1940.

During 1942 the U. S. Army leased the abandoned Burke Plant and remodeled it for use in treating the wastes from Truax Field, an A.A.F.T.S. The plant was placed in operation during October, 1942, and has been discharging its effluent into Lake Monona.