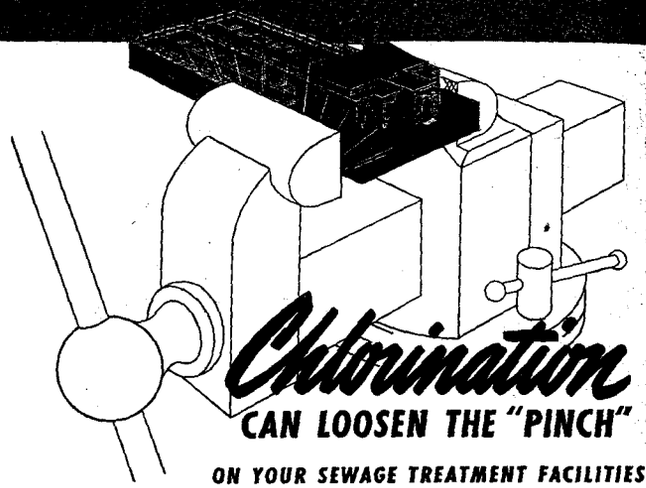
EXPANSION *ruled out*



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Industrial Wastes

INDUSTRIAL WASTES IN WARTIME *

By F. W. Mohlman

Director of Laboratories, The Sanitary District of Chicago

The war has resulted in the introduction of many new industrial waste problems, some of which are directly connected with armament and munitions, others with new products developed for war needs, and still others with the expansion of established industries to new maximum levels of production. Enormous plants have been built for manufacture of explosives, shells, bombs, airplanes and arms; entire new industries have been developed, including synthetic rubber, alcohol, vegetable dehydration, organic chemicals and high octane gasoline; and food industries, meat packing and metal-working industries have been expanded far beyond peacetime capacities.

In the manufacture of explosives and military supplies, and especially in the development of the new synthetic rubber industry and expansion of the organic chemical industries, the chemical engineer has been called upon to exert the utmost skill and ingenuity to design and build plants that will reach required production goals in the shortest possible time. The disposal of wastes has been given consideration in most cases, but the need for adequate provision for waste disposal has been far less urgent than the need for production and consequently the treatment or proper disposal of wastes has been slighted in some cases, in others the equipment installed may have been too elaborate or expensive for the requirements.

This discussion will deal with some of the aspects of the industrial waste problem in relation to the war effort, first with reference to the manufacture of explosives and munitions, second the development of new industries, mostly chemical, and third the effect of expanded industries on sewage treatment works operation and the sanitary condition of streams.

The war industries may be specifically listed under the following three classes:

Explosives and Munitions	New Industries	Increased Production
Trinitrotoluol (TNT)	Synthetic Rubber	Meat Packing
Trinitrophenol (Picrates)	Alcohol	Steel Industry
Smokeless Powder	High Octane Gasoline	
Shell Casings	Food Dehydration	
Airplane Motors and Parts	Organic Chemicals	
(Aluminum and Magnesium)		

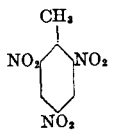
* Presented at the Fourth Annual Convention of the Federation of Sewage Works Associations, Chicago, Ill., Oct. 21, 1943.

Discussion of the detailed industries and their waste problems follows.

Explosives and Munitions

The industries most closely associated with war requirements are the manufacture of TNT, ammonium picrate, smokeless powder, copper and steel shell casings, and airplane motors and parts.

TNT.—Trinitrotoluene is made from toluene and a mixture of nitric and sulfuric acids. Toluene formerly was obtained almost entirely from by-products coke plants, but now greatly increased quantities are available from petroleum refining. Toluene is $C_6H_5CH_3$ and the three nitro groups must be attached symmetrically in the 2-4-6 positions, as follows:



There are no wastes from the nitration process, as the spent mixed acids (nitric and sulfuric) are separated, concentrated and re-used. Large volumes of cooling water are used, however, in the "acid area" and this dilution greatly reduces the concentration of the wastes from the TNT lines. Each line is a complete manufacturing process that is duplicated some six or twelve times in a TNT plant.

The wastes are produced in the wash house, in each line, wherein the "tri-oil" is purified and the TNT crystallized. The "tri-oil" is a mixture of various trinitrotoluenes, of which only the 2-4-6 is desired. The nitration is completed in batches and the liquid tri-oil is run into a wash tank, where it is washed with water; the water is drawn off above the melted impure TNT and run to catch boxes, in which entrained or dissolved TNT crystallizes and settles out and is recovered. A second wash follows, and passes through the catch boxes. The volume of water used in these washes averages 35 gallons per 100 lb. of TNT (based on 35 measurements at three plants) and the wastes are quite acid, with an acidity of about 25,000 p.p.m. in the first wash and 7,000 in the second. The wastes are bright yellow in color and odorless.

After the acid has been largely removed by these washes, the TNT is crystallized and washed with a solution of about 5 per cent of sodium sulfite ("sellite") which has the property of combining with the unsymmetrical isomers, such as 2-3-4 (beta), 2-4-5 (gamma) and other trinitro compounds, to form soluble sulfonates, whereas the pure 2-4-6 (alpha) TNT does not react with the sulfite and remains practically insoluble (2). The waste sulfite solution is usually run directly to the sewer, separate from the acid wastes. It is deep red in color and is alkaline to methyl orange with a pH of 9.2 and an alkalinity of approxi-

mately 900 p.p.m. The volume averages 38 gallons per 100 lb. TNT, based on 33 measurements at three plants.

Typical analyses of these wastes, based on a number of analyses from four plants, follow:

	TNT Wastes from Wash House Parts per Million						
	pH	Acidity	Alk.	Ox. Cons.	Total Solids	Vol. Solids	Color, 1:500
Yellow Wastes							
First Wash	1.0	25,700	—	780	—	—	24
Second Wash	1.7	7,300	—	720	—	—	40
Red Waste							
Sellite Wash	9.2	—	860	8,600	58,000	26,000	570
Composite	1.4	4,500	—	3,300	35,000	—	125

These results show that the yellow wastes are highly acid, have a comparatively low color, and are low in organic matter. The red wastes are alkaline, have a very high color even in 1:500 dilution, and contain nearly 6 per cent total solids, of which about 45 per cent is volatile. The composite wastes are quite acid, contain about 3.5 per cent solids and have a high color even in 1:500 dilution.

It is essential to know the volume and analyses of wastes per batch in order to relate the problem of disposal to the receiving stream. Numerous analyses of "TNT wastes" have been made, but the results of analyses depend entirely upon the production and the amount of cooling water mixed with the actual organic wastes, and unless the results are related to the production at the time the samples were collected, computations of necessary dilution, or experiments on the biological effect of the wastes on fish, on taste, on color, etc., are unrelated to the output of the plant.

The wastes have no odor and no appreciable B.O.D. (3). They are very stable and resistant to biological oxidation. All of the available methods of sewage or waste treatment are ineffective for removal of organic matter and color, except, as was found in laboratory tests when the problem was approached in March, 1942, the use of chlorine for decolorization. It was found that the color could be reduced from 600 to 75 p.p.m. by application of 1,400 p.p.m. chlorine, equal to 1.9 tons of chlorine per day for the plant under consideration (4).

Further studies, however, showed that by taking account of the stream flow in various rivers, providing for storage of wastes direct from the wash house in large holding basins at times of minimum river flow, and discharge of the stored wastes at later periods of increased river flow, no treatment of wastes would be necessary. In cases where the river water downstream is used for water supply, after filtration, experimental studies were made of the effect of alum, coagulation, sedimentation, filtration and chlorination on dilutions of the combined wastes and the river water in question (5). These studies showed that the major problem in all cases was the reduction of color, and this was obtained by proper relation of the flow of wastes to river discharge. Alum was ineffective in removal of the color in even high dilutions and amounts of chlorine that would ordinarily be used in water filtration did not reduce the color appreciably.

The turbidity or natural color of the various river waters in question influenced the resultant color of the wastes in the same dilution. For example the following results were obtained with various river waters:

Color of TNT Wastes Diluted with Various River or Lake Waters

River or Lake	Color Dilution of 1 Part Combined TNT Wastes to			Color River or Lake Water	Increase of Color in Dilution of		
	5,000 Parts	10,000 Parts	20,000 Parts		5,000 Parts	10,000 Parts	20,000 Parts
Ohio River	75	55	50	30	45	25	20
Lake Michigan	45	30	25	3	42	27	22
Susquehanna River	53	32	—	13	40	19	—
Wisconsin River	150	130	120	100	50	30	20
Missouri River	14	11	9	7	7	4	2

The increase of color for the first three normally clear waters varied from 40 to 45, in 1 to 5,000 dilution and from 19 to 27, in 1 to 10,000 dilution. For the colored Wisconsin River, the increase was slightly higher; but for the Missouri River, with the excessive average annual turbidity of 1,900 p.p.m., the color increase was much less than for the clear rivers, because of adsorption of the color on the suspended silt and clay.

For several large TNT works, dilution alone, with provision for storage of the concentrated wastes, has been adopted. Where the water is used for water supply an increase of color of 15 to 20 in the filtered water has been advocated and accepted, based on capacity of the TNT works and minimum river flow, with storage for the period of insufficient dilution. Where the water is not used for water supply, increase of color in the river water up to 75 has been approved by at least one State Board of Health, as permissible during the emergency war period.

The alternative to this scheme comprises a very expensive and elaborate system of neutralization of wastes, evaporation to a syrup in multiple-effect evaporators, incineration of the syrup to an ash or a thick syrup in rotary kilns, and flushing of the ash or liquid to the nearest watercourse. This process has been installed at several plants where dilution is clearly inadequate for the storage and dilution procedure, and also at one plant where there is a large amount of dilution. The utilization of stream dilution, however, has saved large sums of money (several million dollars) and use of critical materials.

This use of stream flow in wartime appears justifiable, where the only effect on the stream is a slight increase in color, no appreciable reduction in alkalinity, no odor, no killing of fish, and no toxic effect on those who drink the filtered water. These other factors have been given consideration and it has been shown that if the dilution is sufficient to reduce the color to acceptable amounts in a filtered, potable water, that is, in a dilution of 1 to 10,000, the other possibilities of harm, including objectionable taste, are eliminated. If the water is not used for drinking purposes, a dilution of 1 to 3,000 is acceptable.

The effect of the wastes on fish has been studied at the University of Illinois, involving the use of hundreds of fish (6). It was shown that the fish would live in dilutions of 1 to 40 and die at 1 to 20. The samples of waste used were diluted considerably, however, and could not be related satisfactorily to the red and yellow wastes, but the dilution was possibly 1 to 20, which would indicate that all fish remained alive at a dilution of combined wastes of 1 to 800 and died at 1 to 400. These dilutions are much lower than the dilution of 1 to 10,000 required for elimination of color.

The Haskell Laboratory of the duPont Company made tests of the toxicity of the concentrated wastes and found that "both TNT acid waste and spent sellite liquors are innocuous when fed to rats in dilutions up to 1 to 240."

A few tests by the U. S. P. H. S. were made at the National Institute of Health, with results as follows (7): "Tests were made of the toxicity of the concentrated waste. The waste was brought to a pH of 7, made isotonic with sodium chloride, and sterilized in an autoclave for 1 hour. Two mice were each given a 0.5 ml. intraperitoneal injection of the sterilized waste and a guinea pig was given 2 ml. intraperitoneally. A rabbit was given an intravenous injection of 15 ml. and observed for any temperature rise. All results were negative and the animals showed no ill effects from the different injections. Apparently the waste is nontoxic to warm-blooded animals."

The use of stream dilution for these wastes, where practicable, has proved a reasonable application of the principle that, in wartime, streams should be utilized for disposal of wastes that have little or no health significance, no obnoxious odor or unsightly properties, and no hazard to the normal uses of the stream.

Picrates.—The manufacture of ammonium picrate as an explosive for naval ammunition involves manufacture of picric acid, by one of two methods (2), followed by treatment with ammonia to give the stable, safe ammonium picrate. In one method, the so-called "American," phenol is sulfonated with sulfuric acid, nitrated with mixed nitric and sulfuric acids, filtered and washed. In the other, or "European" method, dinitrochlorbenzene is treated with caustic soda to give sodium dinitro-phenolate, and the third NO_2 group is added by an easy nitration with mixed nitric and sulfuric acids. In either method, the major

wastes are from the wash water used in the "lines," plus a large flow of cooling water from the acid area, where the spent acid is concentrated for re-use.

The problem of disposal of these wastes (8) is quite similar to that of TNT wastes, as the waste waters are colored bright yellow, and the color persists into high dilution. However, with a dilution of 1 to 650, equivalent to a minimum river discharge of 700 c.f.s., it was determined by laboratory tests that the increase of color would be 63 p.p.m. Inasmuch as the river water is not used for drinking purposes, and as fish survived concentrations of picric acid nearly fifty times this concentration, it was concluded that no storage would be necessary, and the wastes are discharged into the stream untreated, with no difficulty through the past summer even with a stepped-up production 50 per cent more than the initial estimate.

Smokeless Powder.—The wastes from smokeless powder manufacture are far more acid than those from TNT or picrate plants, and have a low B.O.D. Tests by the U. S. P. H. S. (7) at several plants showed an average discharge of 50 tons per day of sulfuric acid, and about 13 tons of nitrate nitrogen, per 50 tons of powder production. The loss of alcohol is from 0.2 to 0.3 lb. per pound of powder (9), and this accounts largely for the B.O.D. The acidity of the wastes is neutralized with lime or limestone before discharge.

Shell Casings.—Shell casings are stamped out of brass or steel. The substitution of steel for brass has been one of the interesting developments of this war. The steel sheets are about 5 ft. long by 11 in. wide by ¼ in. thick. Discs are first stamped out of these sheets and the discs are cleaned in a caustic bath, followed by a pickling solution of sulfuric acid. The discs are then coated with a thin deposit of copper, by passing through a solution of copper sulfate and common salt ("cuprodine"), which merely protects temporarily against corrosion. The discs are then stamped into cups, which go through a heat-treatment annealing process, followed by another cleaning, pickling and coating with copper.

The wastes from this process are mainly the usual ferrous sulfate pickling waste, plus a small amount of copper. In one large plant of this type in Chicago, the company was permitted to discharge the waste to the sewers, after a basin had been installed for neutralizing the acidity, including lime feeding machines and air agitation. The production has been considerably below the original estimates, so that the installed equipment has been ample.

Where brass shell cases are made, there are two problems—the copper in the pickling wastes and wash waters, and the oil in the wastes from the hot rolls. A survey was made of the wastes from an ordnance plant of this type in Chicago. Weirs were installed, samples collected every 15 minutes and composited according to flow. The results of flow measurements and analyses were as follows:

Measurement and Analyses of Wastes from Brass Ordnance Works

Date 1943	Flow, C.F.S.		Copper, P.P.M.		pH		Oil, P.P.M.	
	Day	Night	Day	Night	Day	Night	Ethyl Ether	
							Day	Night
May 27	2.175	2.128	27.0	2.0	3.0	5.4	54	61
28	2.007	2.093	18.6	14.2	4.4	4.8	101	58
29	2.204	2.053	21.4	20.8	5.2	6.0	123	63
30	1.241	1.938	23.7	11.5	4.5	5.1	21	33
June 1	2.230	2.312	10.3	15.3	4.0	6.1	70	64
2	2.321	2.354	21.4	16.6	7.0	7.0	120	111
3	2.347	2.343	22.0	18.0	4.0	3.8	599	220
4	2.313	2.372	26.1	13.5	3.8	4.0	117	137
8	2.314	2.197	28.4	14.9	4.6	5.1	215	128
9	2.279	2.368	44.3	13.2	6.5	6.3	242	159
10	2.394	2.297	31.5	42.5	4.5	2.9	244	186
11	2.273	2.345	50.6	45.6	2.7	2.9	119	146

The average discharge of copper was 277 lb. per 24 hr. and of oil 1,744 lb. per 24 hr. The oil discharge varied from a minimum of 243 lb. on Sunday, May 30th, to a maximum of 5,188 lb. on Thursday, June 3rd. The high oil content was present in spite of a number of large proprietary oil separators through which the wastes flowed. The average oil content was 146 p.p.m.

The loss of copper from this plant was too small to affect the West Side Imhoff tanks, where the volume of sewage treated averages 400 m.g.d. However, other instances have been reported (10) where copper wastes have almost completely inhibited gas production in sludge digestion plants. As little as 1 p.p.m. in the sewage is objectionable, because of the concentration of the copper in the sludge by precipitation. The only remedy therefore appears to be either diversion of the wastes from the sewage treatment works, or disposal of the sludge by incineration. It is doubtful whether the copper can be removed to a sufficient degree by lime, and lime precipitation is very expensive. The use of sodium or calcium sulfide for reducing the solubility of copper in the digestion tank liquor has been suggested in the Eighth Report of the Connecticut State Water Commission (11), but no tests of this procedure have been reported for full plant-scale operation.

Copper-bearing wastes have long been known to be toxic to biological processes of sewage treatment or sludge disposal, and particular care should be taken to investigate the waste waters from copper mills prior to installation of sewage treatment works.

Airplane Motors and Parts.—The use of aluminum and magnesium for airplane motors has introduced new types of pickling waste—a chromic acid bath for pickling and anodyzing aluminum, and a hydrofluoric acid bath for magnesium. Waste solutions of both types are to be discharged from the reportedly largest airplane motor plant under one roof in the U. S., in Chicago, but the volume of wastes and amounts

of acids involved are not large. It has been recommended that a waste solution of caustic soda, used for cleaning magnesium castings, be used for neutralizing the acid wastes, with the caustic solution properly strengthened by additional solid caustic soda. This appears desirable, in spite of somewhat increased cost over the use of lime or limestone, especially for the hydrofluoric acid, inasmuch as the lime or limestone might be rendered ineffective by a coating of calcium fluoride. The company agreed that caustic soda would be preferable, and its use also will be more convenient.

New Industries

Oil Refining.—The production of high-octane gas has introduced more complex operations in oil refineries, including catalytic crackers of various types. The clarification of refinery wastes has been given considerable attention by the American Petroleum Institute, which has issued a manual (12) giving basic data for the design of the so-called "A.P.I. Separator." A number of these separators have been installed, including one at a refinery near Chicago. This plant has a small catalytic cracker. The A.P.I. separator was installed in 1941, and careful records have been kept of the results of daily determinations of the oil content of the effluent. The basin is greatly oversize for the present flow of 1,000 gal. per minute, having been installed for an expected flow of 4,000 g.p.m. The average oil content of the effluent has been approximately 35 p.p.m., and only rarely has the content been as low as 15 p.p.m. The latter concentration is frequently cited as the result obtained by this type of separator, which is generally agreed to be one of the best, for the purpose. Detention periods of one hour or more are recommended, and baled straw is used in the second tank of the separator for final, rough and rapid straining of the effluent.

Ethyl Alcohol.—The use of alcohol in the manufacture of smokeless powder had created a demand for increased production even before Pearl Harbor, but when the requirements of the synthetic rubber industry became known, the alcohol production quotas were again greatly increased. The requirements for various uses in 1943 and 1944 are as follows (9), as compared with use in 1942:

Ethyl Alcohol Consumption
Millions of Wine Gallons, 190 Proof

	1942	1943	1944
Direct Military and Lend-Lease	49.4	94.8	115
Synthetic Rubber	—	22.6	265
Chemical Mfgr.	74.0	76.0	80
Anti-freeze	36.6	27.8	40
All other	94.1	50.9	50
Total	254.1	272.1	550

The shortage in receipts of molasses in 1942 resulted in the conversion of many alcohol plants to the use of corn, but the Commodity Credit Corporation restricted this use of corn, and technologists then adapted the process to the use of wheat, and later wheat grits, which do

not include the bran, germ and other non-starch constituents of the wheat. Thus about 20 lb. of the 56 lb. bushel of wheat can be recovered for feed, and not discharged to the sewer. The yield of alcohol is reported to be 2.8 wine gal. per 56 lb. bushel of the wheat grits.

More recently, however, it appears that molasses may return to use, inasmuch as there is enough molasses in storage in the West Indies to produce 150 million wine gallons of alcohol, as much as was made in 1942 from this source. In the estimates for 1944, only 40 million gallons are based on this source, but if shipping facilities improve, this estimate may prove to be low.

The significance of this increase of alcohol production on stream pollution is tremendous. According to the U. S. Public Health Service (13), 5,000 gal. per day of 100 proof spirits produces still slop with a population equivalent of 55,000 to 60,000. The fermentation alcohol in the 1944 program (9) is estimated at 40 m.g. from molasses, 160 m.g. from industrial alcohol plants (new) and 235 m.g. from whiskey and other liquor distilleries, all 190 proof. This totals 1,192,000 gal. 190 proof, or 2,265,000 gal. 100 proof spirits per day, which gives a population equivalent of $\frac{2,265,000}{5,000} \times 60,000 = 27,180,000$, if no evaporation or other recovery of still slop were practiced. Fortunately a number of evaporator plants have been installed, but far from enough to reduce the population equivalent to a large degree. For example, distilleries and alcohol plants at Peoria, Ill., are estimated to discharge wastes with a population equivalent of possibly 1,500,000. This enormous waste discharge threatens to wipe out all fish next summer in the Illinois River below Peoria. A few trips by Sanitary District chemists in the summer of 1943 showed the dissolved oxygen below Peoria to be much lower than in any previous summer on record. Results farther downstream, obtained by the Illinois Sanitary Water Board, are even lower, approaching complete deoxygenation.

To cope with this problem of alcohol wastes, evaporators have been installed in some cases, including one small new plant at Peoria, plants at Omaha, Kansas City, Frankfort and Louisville, each with a capacity of from 10,000 to 20,000 bushels of wheat per day (2.5 wine gal. alcohol per bushel). It is to be hoped that the evaporators have been allocated to the plants where they will do the most good in abatement of stream pollution.

Sulfite Pulp.—The production of ethyl alcohol from waste sulfite liquor of pulp mills is being advocated as preferable to the use of grain, at least during the war. A plant is in operation at Thorold, Ont., with a capacity stated to be around 800,000 gallons of alcohol per year. The 1941 production of 80 sulfite mills in the U. S. (9) was 2.9 million tons of pulp, which at 12 gal. alcohol per ton is equivalent to 35 million gallons of alcohol. As only the larger plants could hope to support this process, it is estimated that only 17 mills would be involved, with a capacity of 1.4 million tons pulp per year, or 16.2 million gallons of alcohol.

The process ferments only the sugars present in sulfite liquor leaving the lignin still discharged to streams. The possibilities of alcohol production for utilizing the wood sugars, followed by the Howard Process for removing lignin, deserve study.

Investigations have been under way for some time at Appleton, Wis. (14), on methods of treatment of sulfite wastes, recently including operation of a 15 ft. trickling filter and study of methane fermentation, contact aeration and ponding with stream-flow control. It is gratifying to note the increasing interest in the study of this major problem of stream pollution.

Synthetic Rubber.—The manufacture of ethyl alcohol for making butadiene is the most important source of wastes in the synthetic rubber industry. Butadiene made from petroleum does not produce wastes much different from those of the usual refinery, and styrene manufacture also is analogous to refinery operation. However, the co-polymer plants, where the butadiene and styrene are polymerized in a soap bath in contact with a catalyst, followed by discharge of the spent soap solution, may have considerable significance from the standpoint of wastes. It is estimated that 200 million pounds of soap or equivalent fatty acids will be used in this process in 1944. Information is needed concerning the polluting effect of these wastes. Co-polymer plants are installed as follows (15), with the estimated tons per year and percentages of the total program:

Co-polymer Plants, Synthetic Rubber

Location	Thousand Long Tons per Year	Percentage
Northeast		
Naugatuck, Conn.	30	4.1
Institute, W. Va.	90	12.2
Akron, Ohio	60	8.2
Sarnia, Ont.	30	4.1
Louisville, Ky.	90	12.2
Total	300	40.8
Southwest		
Borger, Tex.	45	6.0
Baytown, Tex.	30	4.1
Houston, Tex.	60	8.2
Port Neches, Tex.	120	16.4
Lake Charles, La.	60	8.2
Baton Rouge, La.	30	4.1
Total	345	47.0
Pacific		
Los Angeles, Cal.	90	12.2
Total	735	100

Apparently the stream pollution problems may not be of serious importance in view of the comparatively few plants and their locations, in some cases, on large rivers.

Dehydration of Food.—The dehydration of food products has had considerable development during the war, for obvious reasons of logistics. The wastes from a potato dehydration plant in California have been measured, sampled and analyzed (17). Losses of dry solids average about 20 per cent of the original content, with a corresponding 5-day B.O.D. of 40 lb. per ton of potatoes, amounting to a population equivalent of 240 per ton of potatoes per day, or 1,200 per ton of dehydrated potatoes, dry.

The quota of dehydrated potatoes to be produced in the U. S. in 1943 is 136 million pounds, or 187 tons per day. Wastes from this production would have a population of about 224,000.

The total quota of dried vegetables in 1943 is 356 million lb., of which potatoes comprise 136 million, sweet potatoes 39, cabbage 34.5, beets 26, onions 20, corn 20, tomatoes 18.5, and others in less amounts.

The quota for fruit is 51 million lb., of which the largest is 31.4 million lb. of lemons and 14.5 of apples.

Assuming losses for all fruits and vegetables to be as great as for potatoes, which is unlikely, the total population equivalent for the vegetable and fruit quota, spread over the entire year, would be only about 670,000. The effect during the brief canning season is of course much greater.

The meat dehydration quota is likewise low, totalling 120 million lb. of pork, and practically no beef. It is doubtful whether even the pork quota will be filled to any appreciable degree.

It is obvious that the waste problems of the food dehydration industry are insignificant for the country as a whole, although possibly troublesome for plants on small streams or lakes. This industry appears to be essentially a wartime necessity and it is generally agreed that it may again practically disappear after the war, plus a brief postwar period, as it did after the first World War. The quotas are low in comparison with the pack of the canning industry, and likewise the overall waste problem of the dehydrated food industry is not so important as that of the nation's canneries, whose quota for 1944 approximates 300 million cases of 24 cans each.

Industries with Increased Production Because of the War

Various industries normal in times of peace have required expansion because of war needs, and in some cases the increased volume and solids content of the liquid industrial wastes have affected the operation of sewage treatment works either detrimentally or by contributing increased organic loadings on the treatment process. For example the population equivalent of the West-Southwest Treatment Works of the Sanitary District of Chicago has increased by more than half a million since 1940, as shown in Fig. 1, based on flow and B.O.D. The largest population equivalent occurs each year in the winter, from November to January, when the kill at the stockyards is heaviest. There is a large difference in strength of week-day and Sunday sewage.

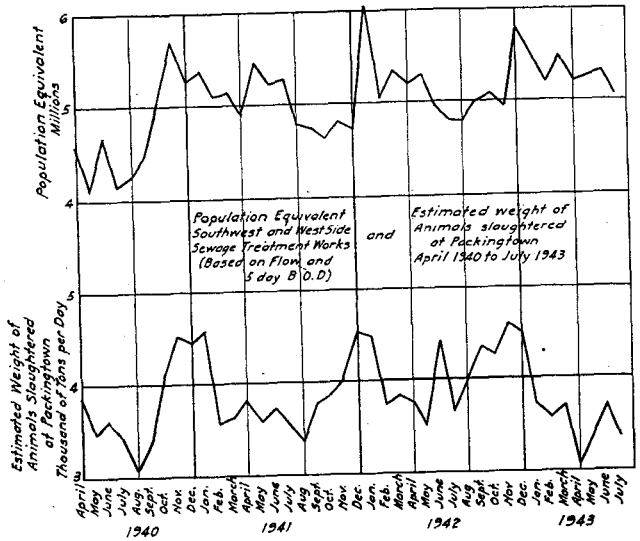


Fig. 1.

The corn products industry has suffered somewhat increased losses during the past several years, with production pressed to the limit of capacity and the necessity of using corn from various sources and of varying suitability for the separations involved. The losses of the Corn Products Refining Company at Argo, on the Main Channel of the Sanitary District of Chicago, have shown the increases shown in the table below for the years 1936 to 1943, inclusive:

Corn Products Refining Company Grind and Population Equivalent of Wastes

Year	Grind, Bu. per Day	Pop. Equiv. Wastes
1936	69,250	30,400
1937	71,820	41,000
1938	73,110	40,100
1939	69,690	49,200
1940	71,240	51,300
1941	85,460	56,100
1942	88,420	82,300
1943*	88,900	64,300

* Through September.

The iron and steel industry has undergone great expansion and increased production. There are many iron and steel plants in the

Sanitary District of Chicago, most of which pickle the metal in sulfuric acid. A survey of the steel mills in the Calumet area in 1938 indicated a loss of 1,400 tons of iron and 1,335 tons of sulfuric acid per year at that time. Now with production at 100 per cent of capacity, the losses are approximately 3,500 tons of iron and 3,340 tons of sulfuric acid per year. These wastes are discharged into the Calumet River and although of no significance with reference to health, the iron precipitates and forms sludge and the oxidation of the ferrous iron uses up some of the dissolved oxygen in the stream, equivalent to 63 c.f.s. river flow containing 8 p.p.m. dissolved oxygen.

The pickle liquor problem seems to be just about where it was during World War I, in spite of the large amount of work and money that has been spent on investigations of the recovery of disposal of the iron and acid (18).

One gratifying aspect of wartime industry, with reference to the effect of industrial wastes on streams, has been the fat recovery program of the WPB. A committee of the Chicago Section of the American Chemical Society (19) has been co-operating with the Industrial Salvage Branch of the WPB, for the purpose of promoting fat recovery and lending technical assistance to industries in which fats or oils are discharged to the sewers. Improved methods of testing catch basins in meat-packing plants have been developed (20) and standards suggested for good practice in recovery of fat. The WPB Consultant, Mr. Marcus B. Hinson of Chicago, has organized a program among packers to reduce their losses of fat by various salvage methods, in the plant and at the outlet sewer, and he estimates that 100 million pounds of fat could be recovered per year by adoption of efficient methods of salvage and skimming. The recovered fat has a glycerine content of around 10 per cent. The household fat recovery program has been helpful in keeping fat out of the sewers. A recent release of the Fat Salvage Committee of the Glycerine and Associated Industries stated that 150 million lb. of household fats has been salvaged during the past 12 months by the American housewives and the Army and Navy.

Recovery of salable grease from skimming tanks in sewage treatment works may be feasible during the war if the recovered grease is low enough in unsaponifiable matter, but in most cases mineral oil, waxes, and other contaminants so lower the value of the grease that it cannot be sold. However, New York City reports sale of recovered skimmings at 80 cents per 100 lb. and the Chicago Sanitary District has been offered 55 cents per 100 lb. for an estimated daily production of 14,000 lb. of skimmings at the Southwest Treatment Works. The cost of removal and loading must be investigated to determine the economics of the proposition. The unsaponifiable matter in the rendered grease averages 13 per cent, which is comparatively low, due to the presence of stockyards wastes in the sewage.

In view of the rather widespread increase in stream pollution by wartime industrial wastes, it is gratifying to report these various possibilities of diminution of the discharge of fats and greases to sewers, sewage treatment plants and streams.

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Discussion

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The problems discussed by Dr. Mohlman reflect in a striking manner the present war tempo of our nation. The writer will consider primarily the third aspect of the paper: "The effect of expanded industries on sewage treatment works operation."

Dr. Mohlman's reference to adequate stream dilution, where practical, for TNT wastes, hits a sound key for the war emergency, and in

planning peacetime disposal of other industrial wastes difficult of treatment. Manufacturers discharging such wastes should consider this in planning factory locations or expansions, and state sanitary officials should guide them along sound lines.

The acceptable discharge of pickling liquors and copper into the Chicago sewers also shows the advantage of high dilution. Such wastes discharged to a small municipal treatment plant or into a small stream might cause undesirable conditions, as I will show later.

The chromic acid bath for pickling and anodyzing the aluminum in airplane motor parts mentioned by Dr. Mohlman has been encountered at one large manufacturing plant in Connecticut. The sewage plant in question treats domestic sewage from the factory by plain settling, sand filtration and chlorination. Rinse waters from the chromic acid vats discharge, after limestone treatment, to the plant sewer. The pH of the raw sewage is about 7.5. The soluble chromium content of the raw sewage averages around 10 p.p.m. The settled sewage contains about 6 p.p.m. soluble chromium and the sand filter effluent 6 p.p.m.

The chromium reacts with ortho-tolidin giving a high color reaction which interferes seriously with the chlorine residual test. Studies to date indicate that ortho-tolidin testing for free chlorine will be unsatisfactory. It was considered possible that chromium, which is a poison, might accomplish satisfactory bacterial destruction without the use of chlorination. Bacterial samples recently collected have not supported this belief.

Good nitrification of the filtered effluent has continued through six months of operation, indicating so far no poisoning effects on the bacterial life in the filters.

While the rinse waters have not affected sludge digestion, a single discharge of the concentrated waste chromic acid liquors dropped the pH of the sludge materially, stopped gas production, and completely upset digestion. Future discharges of the strong liquors, relatively small in amount, will be diverted from the treatment plant.

The following remarks deal with the particular war industrial wastes that have affected municipal sewage treatment in this discussor's state. Our problem will be appreciated by stating that Connecticut, while standing only 46th in the nation in area, is first in dollars per capita for federal war contracts. Furthermore, of Connecticut's peacetime population, about 70 per cent is served by public sewers, of which over 75 per cent of the sewage is treated.

The four war industrial waste horsemen of Connecticut are:

CUTTING OIL; IRON; SULFUR; FIBER

CUTTING OIL

This is the oil used in machine shops. The increased volume of this oil used in Connecticut since the start of the war is tremendous. While most kinds of cutting oil mix with water, a percentage separates, forming a scum. So great has been its volume that the man hours required to remove it have increased over 400 per cent at some treatment plants.

Its effects on air diffusers, vacuum filter cloths, and sludge digestion activity have not been noticeably adverse. Its unsightly appearance and the manual labor involved in removing it have been the major difficulties.

Local communities are controlling the volume of such oil discharged into municipal sewers by the following methods:

1. Public education through newspaper releases, the radio and circular letters to manufacturing establishments.
2. Removal of the waste rancid oil at the factories in containers. The material is dumped or incinerated.
3. Wider use of oil clarifiers. One type of clarifier yields a heavy black sludge which is concentrated in volume and relatively easy to discard.
4. The source of oil, especially heavy oils, has been traced by daily inspection of floating white discs in key manholes. Offenders have offered little argument when confronted with the evidence.

IRON

Iron wastes discharged to one Imhoff tank plant blocked the tank slots, stopped sludge digestion, and produced a pasty-brown, slimy sludge, very difficult to dry. At another location iron fungus growths and sludge deposits have increased in the receiving stream, and chemical precipitation of the raw sewage was upset.

In the first community the use of Ferrisul for cleaning brass parts in the factory was discontinued, and a so-called Blakeslee degreaser using sulfuric acid, soap, and hot water was substituted. This eliminated the iron from the raw sewage, and also resulted in better cleaning of the brass.

In the second community a copperas recovery plant was being poorly operated by the offending factory. Conferences between the factory management, municipal officials and state authorities have resulted in operating improvements. Regular check-ups have been and will be necessary to produce satisfactory results.

Where iron wastes can be sufficiently diluted with domestic sewage, municipal treatment plants have been able to handle them.

SULFUR

Sulfur dyes from a textile mill dyeing army uniform cloth have raised the chlorine demand of the sewage at one large municipal plant far in excess of the chlorinator capacity. The normal domestic sewage demand of 10 to 12 p.p.m. has increased to 60 p.p.m. (500 lb. of chlorine per million gallons of sewage treated) and higher. One of the major difficulties with this waste has been the wide fluctuations in chlorine demand, making proper adjustment of the chlorine dose a physical impossibility. The first corrective step in this problem was the construction of concrete holding basins for the spent dye and first rinse from the dye jigs. Subsequent rinses are discharged directly to the sewer

as formerly. The strong liquids are bled from the lagoons into the sewer to even out the chlorine demand. While these basins should remove the peaks in the demand, it will be necessary to materially increase the chlorinator capacity at the treatment plant to obtain satisfactory residuals. Changes at the sewage plant were considered more practical from both an economic and operating standpoint than treatment of the dye liquors at the mill. Laboratory tests conducted by the Connecticut State Water Commission also showed that chlorine was the cheapest and most satisfactory oxidizing agent for the sulfur dyes.

Fiber Wastes

These wastes from textile and carpet mills were a problem with us long before the present war. Fine screening, mechanical scum stirrers in digestion tanks, and other specialized equipment have been employed at municipal plants in Connecticut to control the clogging and matting properties of this waste. The major difficulty with fiber wastes is the accumulation of a heavy thick scum in digesters. This scum resists digestion and increases in depth until no supernatant can be removed from the decanting pipes. Under war conditions, the quantities of these wastes have greatly increased in some communities.

One temporary remedy has been use of a fire hose for breaking up the scum. Use of supernatant liquor from the digesters rather than cold water is preferable. The liquid is introduced through manholes in the covers of digestion tanks. Not only does some of the scum thus settle out and digest, but sometimes it can be made fluid enough to draw off to sludge beds or vacuum filters.

Another remedy is the use of screens with ½-in. to 3/32-in. openings in the mill waste water channels. This is of material aid in reducing the quantities discharged to sewers. They are especially needed in wool scouring departments or where cotton or wool napping is washed.

A rather unusual occurrence at one sewage plant was the balling up of fiber in raw sewage sludge conditioned with ferric chloride and lime. The fiber could not be coagulated and its quantity was so great (about 50 per cent of the dry solids sludge weight) that it would not adhere to the vacuum filter drums. The material actually flowed like lava over the rim of the filter vats and along the filter operating floor. With the co-operation of the Connecticut State Water Commission, a detention tank of considerable proportions equipped with a series of screens of various size openings was installed at the offending mill for retaining the bulk of the fiber.

In another city where screens have been installed in woolen mills with wastes tributary to the sewerage system, it has required periodic visits to the mills to see that the screens to remove wool fiber are kept in place and regularly cleaned. It is evident from our experience that some supervising agency must check the operation of mill installations or they will be neglected due to the press of other work.

Other Wastes

Plating solutions have caused us some concern, as a great deal of industrial metal plating is done in Connecticut. Fortunately, however, to date the concentrations of the spent wastes from these processes have been below any detrimental amounts. The soluble copper and chromium quantities in municipal sludge digestion tanks have been below 10 p.p.m. in the digesting sludge, and no reduction in gas production or appreciable increase in digestion time has been noted. It is a situation, however, that warrants periodic testing at plants subject to such wastes.

At the East Street plant of the City of New Haven, Conn., large amounts of copper are present in the raw sewage. This was known years before any treatment was given this sewage, and I believe that Dr. Mohlman had a great deal to do with the original investigations that were made. Therefore the plant vacuum filters and incinerates a raw sludge without digestion because of the digestion difficulties that would surely occur.

As a peacetime note, our war experience indicates the need of careful surveys by a designing engineer of the industrial waste load on a proposed treatment plant in communities now discharging raw sewage to watercourses. Such a survey is worth while in avoiding the possible deleterious effects of certain wastes on the proposed treatment units.

The four war horsemen of Connecticut: oil, iron, sulfur and fiber, are not riding as high and handsome as they were a year ago. In most cases we had them with us before the war and it is a question of volume and concentration when dealing with wastes of this character. The steps that have been taken to control the oil, iron and fiber have involved just that—reduction in their amounts to a point where they can be handled with domestic sewage. Our sulfur problem will require oxidation with chlorine.