PB-233 116

CHARACTERIZATION OF WASTEWATERS FROM THE ETHICAL PHARMACEUTICAL INDUSTRY

GULF SOUTH RESEARCH INSTITUTE

PREPARED FOR

NATIONAL ENVIRONMENTAL RESEARCH CENTER

JULY 1974

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1. REPORT NO. EPA-670/2-74-057	2.	3. RE[CIPIENT'S ACCESSION NO.] PB 233 116
4. TITLE AND SUBTITLE CHARACTERIZATION OF WASTEWATERS FROM THE ETHICAL PHARMACEUTICAL INDUSTRY		5. REPORT DATE July 1974; Issuing Date
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) James H. Mayes		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Gulf South Research Institute, 8000 GSRI Avenue, Baton Rouge, LA 70808 for the Pharmaceutical Mfgrs. Association, 1155 15th Street, N.W., Washington, D.C. 20005		10. PROGRAM ELEMENT NO. 1BB036;ROAP 21AZQ;TASK 09
		11. CONTRACT/GRANT NO. R-801159
12. SPONSORING AGENCY NAME AND ADDRESS National Environmental Research Center, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report presents a first attempt to categorize the ethical pharmaceutical industry on the basis of manufacturing processes and resulting effluent characteristics. The available information allowed a breakdown into (1) pharmaceutical (formulation) plants, (2) pharmaceutical and chemical (synthesis) plants, and (3) all others (those using fermentation, biological preparation, extraction, and combinations).

Analysis of the collected raw effluent data indicated tha sanitary wastes were a major contributor in pharmaceutical plants. The wastes of the other categories were more dependent on specific operations and were, consequently, more variable. Fermentation wastes were, as expected, very high in biodegradable organics and usually were the predominant contributor in complex plants.

Conventional biological treatment, both in-plant and at central facilities, is widely used and appears capable of achieving 90% removal of degradable organics. Advanced technology appears to be limited in application to specific wastes not amenable to biological treatment.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Drugs Pharmaceuticals Industrial wastes Waste water Waste treatment	Water pollution sources Waste water disposal Chemical wastes Waste water treatment Water pollution control	13B

18. DISTRIBUTION STATEMENT Release to public	19. SECURITY CLASS (This Report) UNCLASSIFIED	21. NO. OF PAGES
	20. SECURITY CLASS (This page) UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (9-73)

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EPA-670/2-74-057
July 1974

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FROM THE
ETHICAL PHARMACEUTICAL INDUSTRY

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for

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Project No. R-801159
Program Element No. 1BB036

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The National Environmental Research Center - - Cincinnati has reviewed this report and approved its publication. Approval does not signify that the comments necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes that interplay between the components of our physical environment--air, water, and land. The National Environmental Research Center provides the multi-disciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and

- a search for ways to prevent contamination and to recycle valuable resources.

The goals of this study were to characterize the wastewaters being generated by the ethical pharmaceutical industry, identify current treatment methods and their effectiveness, and define technology needed to upgrade the industry's wastewater management practices over the coming years.

In collecting, compiling, and analyzing the data for this report, the subcontractor found it necessary to incorporate considerable professional judgement. The reader is urged to bear this in mind and use discretion when exercising his professional prerogative by making further interpretations or forming additional, quantitative conclusions.

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Director
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Research Center, Cincinnati

ABSTRACT

Effluents from the ethical pharmaceutical industry have been evaluated based on three categories. The following two tables indicate the weighted averages of the reported values. However, variations in the observed values were large. The companies reporting represent three-fourths of the industry's sales.

Table 1

PLANT SUMMARY

Item	Pharmaceutical Plants	Chemical Plants and Pharmaceutical/ Chemical Plants	All Other Plants
Total Plants Reporting	27	17	30
Reporting Plants With Usable Data	17	13	26
Total Employees In Plants With Usable Data	17,724	10,855	36,546
Total Treatable Effluent in Plants With Usable Data (Gallons Per Month)	85,764,000	149,235,000	615,713,000
Effluent Per Employee (Gallons Per Month Per Employee)	4,840	13,750	16,850
Number of Plants Self Treating With Usable Data	3	4	12
Treatment Cost (Dollars Per Year)	$114,850	$674,660	$7,311,500
Treatment Cost (Dollars Per 1000 Gallons of Treatable Effluent)	$1.52	$0.97	$2.28

Table II

EFFLUENT SUMMARY FOR SELF TREATING PLANTS

Weighted Averages		Pharmaceutical Plants Self Treating		Chemical Plants and Pharmaceutical/Chemical Plants Self Treating		All Other Plants Self Treating	
		In Raw Effluent	In Treated Effluent	In Raw Effluent	In Treated Effluent	In Raw Effluent	In Treated Effluent
BOD_5	Pounds Per Month Per Employer	3.18	.29	687	85	291	35
	Pounds Per 1000 Pounds Raw Mat'l	5.2	.47	134	16.7	123	15
COD	Pounds Per Month Per Employee	7.4	.66	1,620	670	882	183
	Pounds Per 1000 Pounds Raw Mat'l	53.3	3.8	175	73	276	57
Suspended Solids	Pounds Per Month Per Employee	←INSUFFICIENT DATA→				75	8.6
	Pounds Per 1000 Pounds Raw Mat'l	←INSUFFICIENT DATA→				42.7	4.9
Percent BOD Removal		91		88		83	
Percent COD Removal		90		59		79	
Percent SS Removal		-		-		84	

All companies reported no pathogens in the effluent and only infrequent indications of heavy metals (mercury, chromium, lead, zinc) being present in low concentrations (Tables VI, VIII and X).

This report was submitted in fulfullment of Grant No. R801159 to the Pharmaceutical Manufacturers Association (PMA) by the Office of Research and Development of the U. S. Environmental Protection Agency (EPA). The PMA subcontracted with Gulf South Research Institute (GSRI) of New Orleans, Louisiana, for the investigation.

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TABLES

I CONCLUSIONS

1. The industry was segregated into three types of plants according to the nature of their manufacturing operation.

   (a) Pharmaceutical Plants
   (b) Chemical Plants and Pharmaceutical/Chemical Plants
   (c) All Other Plants

2. Since the industry manufactures many and varied product mixes, frequent process changes (job shop operations) generate industry wastes which may be cyclical, intermittent, and highly variable in nature, thus adding to the complexity of the treatment problems.

3. The majority of the plants in this industry discharge their effluents into municipal sewage collection systems with subsequent public treatment.

4. Pharmaceutical plants generate effluents largely sanitary in nature and readily treatable in a biological facility.

5. The "All Other Plants" category includes processes such as fermentation, extraction, pharmaceutical, biological, chemical, or a combination of these. Where fermentation is an integrated part of the manufacturing procedure, its high BOD and suspended solids loadings usually predominate the nature of the raw effluent.

6. Fermentation processes are usually conducted in a plant along with other processes such as chemical, pharmaceutical, biological and natural products extraction, or a combination of these. The raw fermentation effluent is characterized by a high BOD and usually high suspended solids.

7. Several self-treating plants reported high pounds of dissolved solids in their effluents which may be attributed to the dissolved solids present in their intake once-through cooling water.

8. Based on the data available, the treatability of the plant effluents is comparable to the levels normally associated with a regional biological facility's influents.

9. Specifications and standards in "The Good Manufacturing Practices Regulations" place severe restrictions on the ability to reuse and recycle process effluents because of cross-product contamination considerations.

II RECOMMENDATIONS

A number of factors need to be considered to allow more complete characterization of the industry. These are.

1. Better definition of the effluents from each manufacturing process;

2. Determination of economics and feasibility of recovery, recycle and disposal methods for specific waste streams;

3. Identification of areas where transfer of treatment technology within the industry or from other industries is possible;

4. More in-depth evaluation of existing operations to identify those plants using the most practical treatment technology.

5. Fermentation should be extracted, and separate data obtained.

III INTRODUCTION

Over the past several years, the Environmental Protection Agency (EPA) has been striving to establish effluent guideline levels for contaminants from all industrial and domestic point sources. As part of this program, 27 major industry categories have been identified in Public Law 92-500 and are now being investigated in depth by checking and surveying the member plants and obtaining data on selected contaminants, average plant discharge rates, treatment costs, and other pertinent factors.

Since the pharmaceutical industry can be expected to be investigated at a later time, the Pharmaceutical Manufacturers Association (PMA) has been following the procedures of EPA in anticipation of the need for information on the effluents from the pharmaceutical industry. It is the intention of PMA to take an active part in the study of the industry and to assist the EPA in developing meaningful information from which satisfactory effluent guidelines can be established. To support such a cooperative effort, the PMA and the EPA agreed to jointly sponsor an industry study to collect preliminary data. This data is to be used to aid the EPA in eventually setting these initial effluent standards and to define areas where additional research related to waste treatment is needed.

Although there are over 1,300 producers of ethical pharmaceuticals in the United States, 115 of these are responsible for 95 percent of the industry's sales. The PMA represents these 115 manufacturers, and thus is the logical agency to represent and coordinate the effort to evaluate the effluents from the ethical pharmaceutical industry. The companies which are not members of the PMA are very small in terms of sales and employees, and consequently the plant effluents are usually very small and are discharged directly to municipal facilities. As will be explained later, these small companies are also regulated by the Food and Drug Administration (FDA). The FDA guidelines for good manufacturing plant practices are a check on plant effluent contaminant loadings.

IV GOOD MANUFACTURING PRACTICES

Actually, the pharmaceutical industry has been under a form of pollution control for a number of years. Certain cleanliness, hygienic, sanitation, and process control standards are matters of particular importance to this industry because of its concern for product quality. As a result of these considerations, the pharmaceutical industry has, as a matter of course, practiced usually good manufacturing and housekeeping procedures as they apply to both processes and personnel. In addition, the pharmaceutical industry has for years been subject to certain manufacturing and operational restrictions and inspections pertaining to the regulations of the Federal Food and Drug and Cosmetic Act. Periodically, FDA personnel will call on a pharmaceutical manufacturer for an unannounced in-plant inspection covering some of the above factors. Good manufacturing practices regulations promulgated by the FDA have been in force, with modifications, since 1963.

Through action by the entire industry, in cooperation with the FDA and other governmental agencies, the industry took action in 1969 to strenghten the overall manufacturing procedures described in FDA's Good Manufacturing Practices Regulations.

In the Federal Register of August 22, 1969 (34 F.R. 13553), a notice was published proposing a revision of sections 133.1 to 133.4 to clarify, strengthen and make more specific these regulations which, if put into effect, will reduce potentials for water contamination.

The Good Manufacturing Practices Regulations covered the following areas.

Section 133.1	Definitions
Section 133.2	Finished pharmaceutical manufacturing practice
Section 133.3	Buildings
Section 133.4	Equipment
Section 133.5	Personnel
Section 133.6	Components
Section 133.7	Master production and control records Batch production and control records
Section 133.8	Production and control procedures
Section 133.9	Product containers and their components
Section 133.10	Packaging and labeling

Section 133.11	Laboratory controls
Section 133.12	Distribution records
Section 133.13	Stability
Section 133.14	Expiration dating
Section 133.15	Complaint files

Several of the sections have significant impact on the control of effluent contamination from a raw material, intermediate, or product standpoint. For example.

Section 133.8 Production and Control Procedures

"Production and control procedures include all reasonable precautions, including the following, to insure that the drugs produced have the safety, identity, strength, quality, and purity they purport to possess:

1. Each significant step in the process, such as the selection, weighing, and measuring of components, the addition of ingredients during the process, weighing and measuring during various stages of processing, and the determination of the finished yield, shall be performed by a competent and responsible individual and checked by a second competent and responsible individual.

2. All containers, lines, and equipment used during the production of a batch of a drug shall be properly identified at all times to indicate accurately and completely their contents and, when necessary, the stage of processing of the batch."

These good manufacturing procedures promulgated by the FDA indicate that the processing operations are more closely controlled than other industries. With such a close check on raw materials and products, it should be possible to determine the degree of contamination in the contact cooling and process water. In addition, since inventories are closely watched and checked, inadvertent spills and batch discharges are completely monitored and housekeeping practices are kept at the optimum.

V INITIAL WORK PLAN

In one of the initial meetings of the PMA, EPA, and Gulf South Research Institute (GSRI), it was decided to categorize the pharmaceutical industry into five processing categories so that these individual areas could be examined from a segregated effluent viewpoint with the attendant types and concentrations of contaminants, as well as flow volumes and rates. The five categories originally agreed upon at that time were:

1. Pharmaceutical
2. Chemical
3. Fermentation
4. Biological
5. Natural Product Extraction

It was felt that by initially identifying these five separate manufacturing categories, the contaminant loadings of the respective effluents could better be defined.

During the course of site visits and subsequent evaluations of data submitted by member firms of the PMA, it was realized that the actual identification and categorization of each effluent discharged from the above processing categories would be difficult at this time since many firms do not have the historical documentation needed.

As a result, the final data was tabulated in the following three general categories.

Pharmaceutical

Chemical plants and pharmaceutical/chemical plants

All other plants consisting of a combination of two or more of the above listed process categories.

Even though the data was evaluated in the above three categories, it was felt that an examination of the individual processes would be of importance in evaluating treatment practices and would aid in establishing the overall industry's present level of effluent treatment.

VI SOURCES OF EFFLUENT CONTAMINATION

Pharmaceutical Plants

Production Techniques and Typical Effluents

The products which come under this category are primarily (a) ethical pharmaceuticals sold on prescription and (b) ethical over-the-counter preparations. Also included in this category may be certain of the following: (c) proprietary medicines (advertised directly), (d) diagnostic agents, (e) animal health products, and (f) miscellaneous products.

The majority of pharmaceutical manufacturing firms are compounders, special processors, formulators, and product specialists. Their primary objective is to convert the desired prescription to tablets, pills, lozenges, powders, capsules, extracts, emulsions, solutions, syrups, parenterals, suspensions, tinctures, ointments, aerosols, suppositories, and other miscellaneous consumable forms. These operations can be classified as labor intensive and low in waste production.

In respect to the ingredients going into the end product, two factors are of importance:

a. The industry requirement that the weight of all components going into a specific application be recorded at all separate intervals during the process; and

b. The fact that each ingredient is usually expensive and any loss is reflected in company profits where close quality and raw material control is not practiced.

There are several sources within a manufacturing plant which can contribute to effluent contamination:

a. Plant personnel sanitation wastes;
b. Plant and equipment washdowns and cleanouts;
c. Oily wastes from operating machinery and various maintenance facilities;

d. Inadvertent raw material, intermediate and product spills;
e. Normal process and utilities operations;
f. Off quality material; and
g. Laboratory facilities.

The current manufacturing practices established by industry and codified by the FDA have insured a number of safeguards with regard to several of these items.

a. It has become standard plant practice to insure adequate hygienic and sanitation facilities for personnel.
b. Tableting, pill, encapsulating, and powder preparation areas are segregated with air control to remove airborne particles through adequate recovery systems.
c. Bulk chemical preparation areas involving aqueous solutions are generally curbed and guttered so that spills and washdowns can be directed to the proper treatment system.
c. Generally, pharmaceutical operations are under roof so that storm water contamination does not present a problem.
e. Generally, pharmaceutical operations utilize vacuum and vent scrubbing systems. Thus, seal and scrubber water can be discharged to the proper drain system for appropriate treatment.

Plants engaged in the manufacture of pharmaceutical items fall into two categories: (1) those which treat their own plant effluent, and (2) those which discharge their untreated combined plant effluent directly to a public collection system for subsequent central treatment. There are some plants that partially treat their effluents and then discharge to a central system.

Self-treatment of pharmaceutical wastes generally consists of a mixing system where the various plant effluents (including sanitary wastes) are collected for pre-settling prior to treatment in a bio-oxidation unit. This unit can either be a trickling filter or activated sludge. The overflow may then go to sand filter beds, post-chlorination and discharge.

None of the plants investigated exhibited any unusual types of treatment of their plant effluent. Conventional treatment methods are capable of reducing contaminant loadings to specific levels. Many plants utilize incineration or steam sterilization to treat certain wastes.

Some plant production lines do generate wastewaters containing dissolved inorganic salts. When mixed with effluents from other plant operations, the concentration of such salts usually does not present any difficult treatment problems. The technique presently used most frequently for such material is dilution with other effluents to concentrations which do not interfere with conventional treatment.

Chemical Plants

In most cases, chemical processing is part of a manufacturing complex and the resulting waste streams are combined with other plant streams so that the total plant effluent can be treated centrally or, if compatible with domestic sewage, discharged to a regional facility.

In general, the chemical processing area of a plant is made up of a number of batch reactors followed by intermediate product storage and purification steps, such as crystallization, distillation, filtration, centrifugation, solvent extraction, and other well known unit operations, singularly or in combination. Since some equipment may be common to several product needs, careful equipment cleaning is necessary to avoid cross-contamination.

To meet rigid quality standards for subsequent use in pharmaceutical preparations, all intermediate and finished chemical production steps and procedures are well defined and monitored by production, technical and laboratory personnel.

This segment of the pharmaceutical industry probably generates the most difficult to treat effluent when compared with the others. Because of the many batch type operations and chemical reactions including nitration, amination, halogenation, sulfonation, alkylation, etc., the processing may generate wastes containing high COD, acids, bases, solvents, cyanides, refractory organics, suspended and dissolved solids, and many other specific contaminants. As an example, one class of pharmaceutical chemicals produced is bacteriostats, disinfectants, and compounds used for sterilizing public facilities, hospitals, etc. Certain formulations containing phenolics have been effective in this area. Since these products are, by nature, disinfecting, a biological treatment system may be deactivated if the raw effluent from such a manufacturing sequence is directly charged to the treatment system at too high a concentration. Thus, it may be necessary to equalize or chemically treat the process effluents. This treated effluent in certain circumstances may then be acceptable for treatment in a conventional central system. Solids, precipitates and sludges are usually disposed of at designated landfills. It should be realized that the quantity of pollutants is small and these effluents are relatively minor when compared to the main plant effluents.

In some instances, process solutions and vessel washwater may also contain residual organic solvents. A number of companies maintain solvent stripping facilities where the solvent is recovered and recycled. Others concentrate the organic wastewaters by evaporation to the point where they may be effectively incinerated. This method is particularly effective where an animal testing facility is operated in the same complex. The test animals may be disposed of in the same properly designed incineration system, and thus a two-fold purpose is served.

Usually the entire chemical processing and production operations are carried out in buildings constructed specifically for these purposes. In most instances, the buildings are multi-storied and the process flow can then be from top to bottom making intermediate transfers simple and easy to handle. Most process areas are designed to direct spills to a designated holding system from which they are then added at a controlled rate to the central treatment system.

Since the usual batch procedure requires equipment cleaning for the next product, considerable washing is necessary. The washings follow the drainage system, and can thus be collected for subsequent treatment. Where a solvent is necessary in the cleaning steps for a vessel cleanout, the vessel will be closed and cleaned by recirculation of the solvent through a pump system. The contaminant solvent may then be discharged to a tank for purification by stripping and subsequent recovery. The tars or sludges are usually incinerated or hauled to a landfill. In some very small production facilities, the solvent may be disposed of to an approved disposal firm.

Where solvents are used for cleaning, one of the primary concerns is plant safety. It is extremely important not to let any of the water insoluble solvents get into the plant drains as a simple spark could create a major catastrophe. Plant safety is of constant concern and fire hazards are to be avoided as much as possible. Consequently, plant safety measures contribute to elimination of gross discharges of such organics although low concentrations remain in dissolved, dispersed or emulsified form and require subsequent treatment.

Several plants practice deep well disposal of certain chemical plant effluents. Pre-treatment usually consists of neutralization and suspended solids settling followed by filtering prior to injection.

Fermentation Plants

Fermentation is an important production process in the pharmaceutical industry. This type of process is the basic method used for producing most antibiotics (penicillin, streptomycin, aureomycin) and many of the steroids (cortisone, etc.).

The major waste of the fermentation process, and the one most likely to be involved in water pollution problems, is spent beer, although purification and clean-up wastes also exist. The beer is the fermented broth from which the valuable fraction, antibiotic or steroid, has been extracted usually by the use of a solvent. Spent beer contains the residual food materials such as sugars, starches, and vegetable oils not consumed in the fermentation process. Discharging this high BOD, concentrated effluent to a receiving stream without eliminating or drastically reducing dissolved and suspended solids could only result in a serious water pollution problem.

Methods for treating the liquid fermentation waste are generally biological in nature. Although fermentation wastes, even in a highly concentrated form, can be satisfactorily treated by biological systems, it is much better and less likely to upset the system if these wastes are first diluted to some degree by addition of other waste streams. One such recommended method is to combine it with large volumes of sanitary effluents. No further nitrogen, phosphorus or trace elements is generally needed to carry out a satisfactory biological reduction of the contaminants in the combined wastes.

In a number of fermentation operations, it is possible to recover the suspended mycelia and nutrients present in the spent beer. They can then be concentrated, dried, and sold as an animal feed supplement. Of course, the utilization of these solids in such a manner is dependent on the nature of the fermentation waste which must be free of hazardous components. Designated landfill areas for such solids are employed by some companies when reuse is not feasible.

The waste beer from these fermenters makes an excellent dilution medium for several selected industrial and domestic effluents. The mixing with domestic effluents has been described previously. In another regional treatment operation, the filtered spent beer is combined with the waste liquors from a paper mill for joint treatment with the community sanitary wastes. The treatment plant personnel have proven that this combination of effluents requires no additional nutrients for satisfactory bio-oxidation to reduce the contaminant loadings to meet local effluent specifications for BOD, SS and possibly COD. Other waste sources of fermentation manufacturing include equipment washdown, filter backwashes, and solvent recovery operations. These are customarily combined with the major waste stream since all pollutants generated are believed to be relatively easily biodegradable.

Biological Plants

One of the first significant efforts to utilize animals for pharmaceutical purposes was the recovery of serum from horses for use in manufacturing tetanus and diptheria anti-toxins and typhoid vaccines. During World War II, the need for protecting American armed forces overseas caused this segment of the industry to be greatly expanded. Large quantities of gas-gangrene anti-toxin, tetanus toxoid, typhus and influenza vaccines were produced from the serums extracted from certain animals.

There are two primary sources of pollution from a facility housing live animals for the purpose of isolating serums. Where there is a need for large amounts of serum, the number of animals housed at one location may require several hundred acres. The two basic sources of pollutants are: (1) the used hay and waste animal feeds which are generally impregnated with animal wastes, and (2) the water soluble runoff which also is rich in animal wastes.

Treatment of such wastes is quite conventional and really does not need much elaboration. The animal waste impregnated bedding material is usually picked up by front loaders and removed to a landfill location or spread on farm land as a fertilizer supplement. The liquid runoff is usually collected and either discharged to a regional treatment plant or discharged to an in-plant treatment system. In either case, the effluent can be reduced to what have been acceptable levels of BOD and SS by conventional treatment. Sludge may be removed and also used as landfill.

Conversion of the crude animal isolates to consumable products generates negligible effluent contaminants.

Natural Product Extraction Plants

Perhaps the classic process which typifies this segment of the industry is the extraction of insulin from animal glands. In this category, the raw waste would be high in the solid residues from the animal organs or plant tissues and the washwaters containing some residual organic solvents. Most of these extraction processes do practice solvent recovery and recycle; the degree of contamination remaining in the stripped wash water depends on the extent of the recovery facilities and the efficiency of operations.

It should be pointed out the amount of suspended solids and total effluent is not particularly large. A plant capable of extracting several million pounds annually of animal organs and plant tissue would be one of the large natural products extraction businesses in operation in this country.

The used organs, plant tissues and still bottoms may be incinerated. Used organs may be isolated and sold as animal feed supplement. Landfill is the most widely used method of handling plant tissue. Therefore, these wastes seldom enter the washwater stream.

VII PLANT EFFLUENT EVALUATION SCHEME

After the initial meeting, it was felt that a field investigation of selected processing plants in the previously described manufacturing categories would help in developing firsthand knowledge of the treatment systems in operation at the present time. In addition, through on-site discussions with engineers, ideas might be developed on technology which might be forthcoming in the years ahead to resolve persisting problems. These site visits were to be followed by requesting PMA member firms to submit data on the quantity and quality of their raw process effluents. Data on treated effluents and methods of treatment were also requested. Seventy-four plants of member firms acknowledged the request for data.

There were 56 plants which submitted usable data on effluents from various plant areas at corresponding levels of contaminant loadings. Based on the identification of these plants, the PMA has estimated that companies represented by the 56 responding plants constitute more than three-fourths of the gross sales generated by the industry. As an approximation, it may be assumed that these 56 plants are responsible for a major percentage of the effluents discharged by the industry.

After making the initial site visits, it became apparent that it was not going to be possible to distinguish between effluent types being discharged in terms of the five categories originally designated. The reason for this is that while there are some manufacturers who have pharmaceutical operations at a single location, and some who have chemical operations at a single location, there are no individual fermentation, extraction or biological processors of any consequence at any one manufacturing location. The number of plants reporting by process categories is shown in Table III.

Table III

PLANTS RESPONDING BY PROCESS CATEGORIES

Category	Number of Plants	Pharmaceutical	Chemical	Fermentation	Extraction	Biological
A*	27	X				
B**	8		X			
	9	X	X			
C***	3	X		X		
	3	X				X
	3	X			X	
	4					X
	2				X	
	4		X	X		
	4	X	X	X		
	1		X	X	X	
	2	X	X	X	X	
	2	X	X		X	
	1			X	X	X
	1	X			X	X
Total	74					

*A Pharmaceutical Plants

**B Chemical Plants and Pharmaceutical/Chemical Plants

***C All Other Plants

VIII PRESENTATION OF PLANT EFFLUENT DATA

To develop the information obtained from the PMA member firms and establish the levels of effluent treatment being accomplished by the industry, a tabulation was made of the various parameters of the raw and treated effluents. After reviewing all of the available responses, it was decided to divide the industry into three categories; (1) pharmaceutical processors only, (2) chemical plants and pharmaceutical/chemical plants, and (3) all other plants (Table IV).

A breakdown of the raw effluent characteristics for all the company responses is listed in Tables V, VII and IX. The PMA firms supplied the number of plant personnel and the pounds of raw material. The data has been normalized on these two bases in an endeavor to find a correlatable base.

The information requested also included a section covering the types of effluent treatment practiced by each of the operating plants. The various types of treatments within the plants are also summarized in Tables V, VII and IX. As indicated in these tables, the various types and sequences of effluent treatments present no new and variable technology except for the use of pure oxygen activated sludge in one case not shown by code due to the confidentiality of the survey.

While there was a variation of pH of the final effluent, all reported values were within the nominal 6.5 - 7.5 range. No excessive discharge temperatures were noted with the average being less than 95°F.

Information on the heavy metals content of the raw effluent was also requested. Tables VI, VIII, and X report the levels of Hg, Cr, Pb and Zn in both ppm and pounds per month.

All companies reported that no pathogens were present in their wastewater discharges.

Table IV

RESPONSES ACCORDING TO
FINAL PROCESS CATEGORIES

Category	Responses	Responses Where Raw Effluent Could Be Evaluated		
		Total	Effluent to Municipal Treatment	Effluent Self-Treated
Pharmaceutical Plants	27	17	15	3
Chemical Plants Pharmaceutical/ Chemical Plants	17	13	9	4
All Other Plants	30	26	13	12
Totals	74	56	37	19

Table V

PHARMACEUTICAL PLANT RAW EFFLUENT CHARACTERISTICS

Company Code	Employees	Pounds of Raw Material Per Mo	Gallons/Mo Treatable Effluent	Gallons/Mo Once Through Cooling	Pounds BOD_5 Per Employee Per Mo.	Pounds BOD_5 Per 1000# Raw Material	Pounds COD Per Employee Per Mo.	Pounds COD Per 1000# Raw Material	Pounds D.S. Per Employee Per Mo.	Pounds D.S. Per 1000# Raw Material	Pounds S.S. Per Employee Per Mo.	Pounds S.S. Per 1000# Raw Material	Type of Effluent Treatments
0792	900	2,772,000	3,956,000	2,569,000	1.5	0.5	-	-	11.2	3.7	0.2	.07	Primary settling, solids removal, municipal treatment
1016	660	750,000	2,750,000	1,000,000	8.1	7.1	9.5	8.4	14.0	12.3	3.5	3 1	Municipal treatment
1234C	145	340,000	1,020,000	200,000	6 2	2.6	-	-	-	-	6 3	2 7	Segregation, incineration, municipal treatment
1234F	530	320,000	1,080,000	. -	23.6	39.0	-	-	17.0	28.0	8.5	14.0	Segregation, activated sludge, landfill, incineration, post Cl_2
1256A	2,500	2,000,000	4,250,000	3,000,000	3.6	4.5	8.5	10.6	-	-	-	-	Segregation, neutralization, municipal treatment
1690	40	5,170	182,000	87,000	10.9	84.0	11.4	87.5	24.0	185.0	0.3	2.3	Municipal treatment
1695	900	1,330,000	1,777,000	10,583,000	1.8	1.2	3.1	2.1	1.1	0.75	2 9	2.0	Sedimentation, bio-oxidation, post Cl_2, chemical coagulation, sand filtration, segregation
1712B	1,200	400,000	2,870,000	1,400,000	1.9	5.7	3.0	9.6	2.0	6.0	1.3	3.9	Municipal treatment
2467B	638	348,400	1,413,000	-	5.0	9.2	9.0	16.5	-	-	-	-	Segregation, bio-oxidation, settling
3524B	385	103,000	2,297,000	-	2 1	7.8	4.7	17 6	19 5	73.0	2 7	10.1	Segregation, municipal treatment
3897A	2,400	1,833,000	23,200,000	330,000,000	11.4	14.9	14.4	18.9	18.1	23.7	1.1	1.4	Municipal treatment
3897D	976	2,000,000	8,800,000	-	12 1	5.9	51.0	25 0	31.0	15.1	14 4	7.0	Municipal treatment
4064	2,000	1,470,000	21,600,000	1,400,000	6 7	9.1	-	-	-	-	-	-	Municipal treatment
4934B	1,350	1,700,000	1,700,000	500,000	2.6	2.1	5.7	4.5	3 1	2.5	3.2	2.5	Municipal treatment
8297B	1,400	128,000	3,100,000	-	3 2	35.0	9.4	103	-	-	-	-	Segregation, activated sludge, landfill, flotation, post Cl_2, ponding
9370-1	750	1,645,000	1,654,000		1 4	.64	3 3	1.5	5.4	2.5	2.3	1.1	Evaporation, segregation, municipal treatment, incineration, recycle
9435B	950	900,000	4,115,000		3 2	3.4	5.0	5.3	36.0	38.0	10.3	10.9	Separation, segregation, municipal treatment, recycle

Table VI

PHARMACEUTICAL PLANT RAW EFFLUENT CHARACTERISTICS

(Heavy Metals)

Company Code	Hg		Cr		Zn		Pb	
	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.
0792	-	-	.005	0.16	.09	3.0	.03	1.0
1016	← NOT DETECTABLE →							
1234C	0	0	-	-	-	-	0	0
1234F	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
1256A	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
1690	NIL	-	NIL	-	.045	.07	.05	.08
1695	0	0	0	0	0	0	0	0
1712B	-	-	-	-	-	-	-	-
2467B	-	-	-	-	-	-	-	-
3524B	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
3897A	0	0	NIL	NIL	NIL	NIL	0	0
3897D	0	0	0	0	0	0	0	0
4064	-	-	-	-	-	-	-	-
4954B	0	0	.01	.14	0.4	5.6	.04	0.56
8297B	-	-	-	-	-	-	-	-
9370-1	-	-	-	-	-	-	-	-
9435B	-	-	-	-	-	-	-	-

NIL - Is as reported by plant
O - Is as reported by plant
Is as reported by plant and is interpreted to mean not detectable.

Table VII

CHEMICAL PLANTS AND PHARMACEUTICAL/CHEMICAL PLANTS RAW EFFLUENT CHARACTERISTICS

Company Code	Employees	Pounds of Raw Material Per Mo.	Gallons/Mo. Treatable Effluent	Gallons/Mo Once Through Cooling	Pounds BOD_5		Pounds COD	
					Per Employee Per Mo.	Per 1000# Raw Material	Per Employee Per Mo.	Per 1000# Raw Material
0947	175	300,000	257,000	-	1.8	1.0	4.1	2.4
1234G	120	1,400,000	766,000	-	135.0	11.6	200.0	17.1
1712A	500	800,000	5,950,000	15,000,000	300.0	187	425.0	266.0
2662	700	275,000	4,225,000	3,800,000	33.0	84.0	34.0	87.0
3524A	1,600	300,000	9,200,000	9,200,000	15.0	80.0	23.0	123.0
3897B	325	750,000	1,700,000	210,000,000	8.8	3.8	12.4	5.4
4954A	-	1,800,000	64,000,000	-	-	21.0	-	30.0
5722A	3,500	6,660,000	43,400,000	-	215.0	113.0	359.0	189.0
5722B	150	3,300,000	47,350,000	185,000,000	3,500.0	159.0	5,750.0	261.0
6165	1,500	550,000	11,400,000	6,500,000	12.0	32.7	29.0	79.0
7794A	1,400	1,600,000	5,600,000	4,200,000	12.6	11.0	26.0	22.8
7794B	135	795,000	3,060,000	-	580.0	99.0	910.0	155.0
8442	750	5,000,000	16,327,000	60,830,000	80.0	12.0	160.0	24.0

Table VII (continued)

CHEMICAL PLANTS AND PHARMACEUTICAL/CHEMICAL PLANTS RAW EFFLUENT CHARACTERISTICS

Company Code	Pounds D.S.		Pounds S.S.		Type of Effluent Treatment	Process Type C PC
	Per Employee Per Mo.	Per 1000# Raw Material	Per Employee Per Mo.	Per 1000# Raw Material		
0947	3.8	2.2	2.2	1.3	Production Control, Segregation, municipal treatment	PC
1234G	308.0	26.4	10.6	0.9	Neutralization, aeration lagoon, landfill Coagulation, sedimentation, post Cl_2	C
1712A	-	-	12.5	7.8	Neutralization, coagulation activated sludge Segregation, sedimentation, landfill, post Cl_2	C
2662	20.0	51.0	1.3	3.3	Municipal treatment	PC
3524A	40.0	214.0	0.6	3.2	Municipal treatment	PC
3897B	-	-	-	-	Self treatment not defined	C
4954A	-	18.0	-	2.0	Primary treatment, Municipal treatment	PC
5722A	680.0	358.0	4.0	2.1	Municipal treatment	C
5722B	1,190.0	54.0	795.0	36.0	Solvent recovery, recycle, Segregation, dilution	C
6165	2.2	6.0	2.4	6.5	Neutralization solvent recycle Settling, incineration, municipal treatment	PC
7794A	27.0	23.6	1.8	1.6	Neutralization, incineration, Municipal treatment, segregation, landfill	C
7794B	-	-	-	-	Segregation, evaporation, recycle, Settling, incineration, activated sludge, Landfill Cl_2	C
8442	1,120.0	168.0	43.0	6.4	Settling, coagulation, aeration, lagoon, Floatation, clarification, landfill, Cl_2	C

C Chemical

PC Pharmaceutical and Chemical

Table VIII

RAW EFFLUENT CHARACTERISTICS
CHEMICAL PLANTS AND PHARMACEUTICAL/CHEMICAL PLANTS

(Heavy Metals)

Company Code	Hg		Cr		Zn		Pb	
	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.
0947	NIL	NIL	0	0	0	0	0	0
1234G	-	-	1.28	8.2	-	-	-	-
1712A	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
2662	0	0	0	0	0	0	0	0
3524A	0	0	0	0	0	0	0	0
3897B	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
4954A	0	0	.01	5.4	.07	37.8	.023	12.4
5722B	.02	7.9	.05	19.8	.6	237.0	.01	3.9
6165	0	0	0	0	0	0	0	0
7794A	.003	0.14	.06	2.8	.6	28.0	.04	1.9
7794B	.01	0.25	0.15	3.75	2.8	70.0	0.1	2.5
8442	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
8632	.01	1.4	.6	84.0	1.0	140.0	2.0	280.0

Nil - Is as reported by plant
O - Is as reported by plant
\- - Is as reported by plant and is interpreted to mean not detectable

Table IX

ALL OTHER PLANT RAW EFFLUENT CHARACTERISTICS

Company Code	Employees	Pounds of Raw Material Per Mo.	Gallons/Mo. Treatable Effluent	Gallons/Mo Once Through Cooling	Pounds BOD_5		Pounds COD		Pounds D.S.		Pounds S.S.	
					Per Employee Per Mo.	Per 1000# Raw Material	Per Employee Per Mo.	Per 1000# Raw Material	Per Employee Per Mo.	Per 1000# Raw Material	Per Employee Per Mo.	Per 1000# Raw Material
0347	6,000	6,700,000	22,500,000	420,000,000	111.0	99.0	-	-	189.0	170.0	50.0	45.0
0526	675	330,000	4,500,000	100,000	13.9	28.4	16.6	34.0	435.0	892.0	16.6	34.8
0979	-	2,750,000	36,000,000	50,600,000	-	230.0	-	460.0	-	230.0	-	276 0
1088	480	400,000	2,700,000	-	22.0	26.0	29.0	35.0	28.0	34.0	2.8	3.4
1234A	4,500	1,153,000	38,000,000	21,000,000	101 0	394.0	-	-	-	-	20.0	78.0
1234B	2,300	2,500,000	21,500,000	154,000,000	204.0	188.0	-	-	74.0	67.0	12.0	11.0
1234D	824	10,000,000	33,000,000	124,700,000	1,200.0	98.0	3,000.0	246.0	1,100.0	94.0	70.0	6.0
1234E	417	2,200,000	60,200,000	125,000,000	1,830.0	340.0	4,280.0	810.0	835.0	158.0	597.0	109.0
1256B	400	742,000	320,000	320,000	2.0	1.0	-	-	-	-	-	-
3559	650	477,000	10,000,000	-	31.0	42.0	-	-	-	-	44.0	62.0
3897C	280	226,000	14,100,000	900,000	79.0	97.0	-	-	-	-	-	-
5092	2,500	730,000	6,615,000	9,400,000	5.0	17.1	8.0	27.4	8.0	27.4	3.0	10.3
5722C	450	5,000,000	50,400,000	244,000,000	2,400.0	216.0	5,330.0	480.0	4,500.0	406.0	232.0	21.0
5722D	400	6,700,000	25,200,000	300,000,000	1,460.0	87.0	2,920.0	174.0	4,360.0	260.0	352.0	21.0
5722E	3,250	768,000	14,000,000	-	20.0	84.0	48.0	203.0	28.0	119.0	10.0	42.0
5921	1,350	470,000	2,100,000	14,660,000	17.0	48.0	22.0	63.0	12.0	34.0	0.4	1.1
6301A	1,000	863,000	40,500,000	2,000,000	114.0	145.0	163.0	186.0	-	-	21.0	24.0
6301B	800	3,050,000	33,000,000	60,000,000	550.0	138.0	280.0	73.0	480.0	125.0	53.0	14.0
7457	750	600,000	1,930,000	14,000,000	10.5	13.0	24.4	30.0	7.4	9.2	4.0	5.5
8266A	275	1,000,000	18,810,000	14,530,000	211.0	58.0	259.0	71.0	434.0	119.0	18.0	4.9
8266B	235	2,700,000	11,200,000	45,200,000	1,700.0	147.0	3,860.0	333.0	5,580.0	482.0	846.0	73.0
8297A	975	2,000,000	11,574,000	-	31.0	15.0	100.0	49.0	244.0	119.0	69.0	34.0
8599A	5,500	22,000,000	165,000,000	-	180.0	45.0	800.0	200.0	37.0	9.3	1,250.0	313.0
9125C	350	250,000	714,000	900,000	1.9	2.7	-	-	-	-	6.6	9.3
9435A	185	750,000	1,850,000	300,000	8.4	2.1	-	-	-	-	-	-
9949	2,000	7,000,000	26,000,000	-	6,000.0	1,710.0	-	-	-	-	6,500.0	1,570.0

Table IX (Continued)

ALL OTHER PLANT RAW EFFLUENT CHARACTERISTICS

Company Code	Type of Effluent Treatment	Process Type
0347	Solvent recovery, landfill, filtration, neutralization, incineration, sterilization, seg., act. sludge, chlorination	F-C-P
0526	Same as Above	B-P-E
0979	Filtration, concentration, landfill, act. sludge, seg.,solvent recovery, incineration, municipal treatment	F-C-P-B
1088	Seg., solvent recovery, incineration, odor control, concentration recycle, landfill, act. sludge	F-C-P-E
1234A	Evaporation, landfill, incineration, neutralization, municipal treatment	P-E
1234B	Seg., recycle, municipal treatment, neutralization, reuse	F-P
1234D	Neutralization, sedimentation, solvent recovery recycle, seg., coagulation, act. sludge, aerated lagoon	F-C
1234E	Solvent recovery, evaporation, concentration, neutralization, burning, incineration, act. sludge, landfill	F-C
1256B	Chemical coagulation, settling, neutralization, municipal treatment	P-E
3559	Seg., odor control, aerated lagoon, landfill, settling, neutralization, municipal treatment	E
3897C	Seg., incineration, municipal treatment	B
5092	Seg., sludge disposal, chlorination, sedimentation, bio-oxidation, sand filtration	B-P
5722C	Seg., solvent recovery, bio-oxidation, sedimentation, incineration, landfill, chlorination	F-C
5722D	Same as Above	F-C
5722E	Sedimentation, sand filtration, sea disposal, bio-oxidation, filtration	B-P
5921	Seg., recycle, incineration, landfill, chemical recovery, bio-oxidation, municipal treatment	F-P
6301A	Seg., landfill, sedimentation, septic tanks	P-E
6301B	Seg., chemical recovery, recycle, land disposal, chlorination, coagulation, sedimentation, neutralization, bio-oxidation	F-P
7457	Sedimentation, municipal treatment	P-C-E
8266A	Sterilization, solvent recovery, landfill, municipal treatment	P-C-E
8266B	Seg., bio-oxidation, settling, landfill, municipal treatment	F-C-E
8297A	Seg., settling, bio-oxidation, landfill, municipal treatment	F-C-P
8599A	Sterilization, landfill, seg., municipal treatment	F-C-P
9125C	Seg., landfill, bio-oxidation, post chlorination	B
9435A	Activated sludge, digestion, chlorination, landfill	B
9949	Solvent recovery, recycle, neutralization, municipal treatment	F-C-P

P Pharmaceutical
C Chemical
B Biological
F Fermentation
E Solvent Extraction

Table X

ALL OTHER PLANT RAW EFFLUENT CHARACTERISTICS
(Heavy Metals)

Company Code	Hg		Cr		Zn		Pb	
	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.
0347	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
0526A&B	.005	0.2	.063	2.2	0.31	11.6	0	
0979	NIL	NIL	NIL	NIL	NIL	NIL	NIL	-
1088	.001	.02	.09	2.0	.1	2.2	.005	0.1
1234A	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
1234B	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
1234D	0	-	NIL	-	0	-	0	-
2467A	-	-	-	-	-	-	-	-
3559	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
5921	.016	.28	.08	1.4	0.12	2.1	.01	0.2
6301A	0	0	0	0	0	0	0	-
6301B	0	0	0	0	0	0	0	0
7457	0	0	0	0	0	0	0	0
8266A	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
8266B	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
8599A	.0077	10.6	0	0	.745	1,020	.091	125
9125A	-	-	-	-	-	-	-	-
9125B	-	-	-	-	-	-	-	-
9125C	0	0	0	0	0	0	0	0
9435A	-	-	-	-	-	-	-	-
9949	0	0	0	0	0	0	0	0

Nil - Is as reported by plant
0 - Is as reported by plant
- - Is as reported by plant and is interpreted to mean not detectable

IX TREATED EFFLUENT CHARACTERISTICS

There was a total of 25 plants which practiced varying degrees of self-treatment of their effluent. Of these, only 19 presented sufficient data which could be intepreted with any certainty. These 19 reporting plants have been arranged by industry category and are shown in Table XI. The heavy metal concentrations and pounds in the treated effluent are shown in Table XII.

Here again, the data are presented in pounds of contaminant per-employee per-month and per-1,000 pounds of raw material in an effort to find a correlatable base. Concentrations and pounds are shown in Table XII.

Table XI

FINAL TREATED EFFLUENT LOADINGS PLANTS WITH SELF-TREATMENT

Plant Category and Company Code	Employees	Pounds of Raw Material Per Month	Pounds BOD		Pounds COD		Pounds D.S.		Pounds S.S.	
			Per Employee Per Mo.	Per 1000# Raw Material	Per Employee Per Mo.	Per 1000# Raw Material	Per Employee Per Mo.	Per 1000# Raw Material	Per Employee Per Mo.	Per 1000# Raw Material
Pharmaceutical Plants										
1695	900	1,330,000	0 23	0.16	0.34	0.23	0.18	0.12	1.2	0.7
24678	638	348,400	0 38	0.70	1.25	2.30	-	-	0.15	0.23
82978	1,400	128,000	0 28	3.2	0.6	6.6	0.1	1.1	0.46	5.0
Chemical Plants and Pharmaceutical/Chemical Plants										
1712A	500	800,000	13.9	8.6	-	-	-	-	-	-
38978	325	750,000	5.3	2.3	13 8	4.7	-	-		-
57223	150	3,300,000	520.0	26.0	2,600 0	118.0	1,200 0	55 0	270.0	12.3
77548	135	795,000	53 0	9.0	127.0	21.6	1,900 0	320.0	190.0	32.0
All Other Plants										
5092	2,500	730,000	0.44	1.5	1.2	4.1	8 5	29 0	0.3	1 0
9435A	185	750,000	0.9	.22	4.5	1.1	126.0	310.0	12.6	31.0
9125C	350	250,000	0.18	0.25	-	-	-	-	0.2	0 28
5772E	3,250	768,000	0.4	1.5	0.8	3.1	2.4	9.0	-	-
57220	400	6,700,000	242 0	14.4	434.0	29.3	4,500 0	268 0	104.0	6.2
12310	824	10,000,000	425.0	35.0	765 0	63 0	2,650 0	218.0	183 0	15 0
1231E	417	2,200,000	145.0	27.0	352 0	66 0	1,360 0	254.0	44 0	8.0
5772C	450	5,000,000	218.0	21.0	1,525 0	137.0	4,800 0	470.0	380.0	37 0
0347	6,000	6,700,000	6 3	5.7	9.5	8 6	6.3	5 7	3.2	2.9
0979		2,750,000	-	25.1	-	54.0	-	25.0	-	22.0
0526	675	330,000	1.0	2.0	2.0	4.1	45.0	91	3.7	7.5
63018	800	3,050,000	15 0	4 2	60.0	16.0	-	-	-	-

Table XII

FINAL TREATED EFFLUENT LOADINGS
PLANTS WITH SELF-TREATMENT
(Heavy Metals)

Plant Category and Company Code	Hg		Cr		Zn		Pb	
	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.	ppm	Pounds Per Mo.
Pharmaceutical Plants								
1695	0	0	0	0	0	0	0	0
2467B	-	-	-	-	-	-	-	-
8297B	-	-	0.05	1.25	0.15	3.7	-	-
Chemical Plants and Pharmaceutical/ Chemical Plants								
1712A	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
3897B	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
5722B	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
7794B	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
All Other Plants								
5092	0	0	0	0	0	0	0	0
9435A	-	-	-	-	-	-	-	-
9125C	0	0	0	0	1.3	7.8	0	0
5722E	-	-	-	-	-	-	-	-
5722D	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
1234D	0	0	0	0	0	0	0	0
1234E	NIL	NIL	NIL	NIL	0.9	450.0	NIL	NIL
5722C	NIL	NIL	NIL	NIL	7.8	3,270.0	NIL	NIL
0347	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
0979	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
0526	NIL	NIL	NIL	NIL	.06	2.4	0	NIL
6301B	0	0	0	0	0	0	0	0

X LEVELS AND COST OF EFFLUENT TREATMENT

The levels of pollutant removal for those plants practicing self-treatment are presented in Table XIII, along with the actual (or estimated) cost of treatment per 1,000 gallons. The data has been separated into the three individual process categories with weighted averages for each category. Treatment cost figures were furnished by PMA member companies and reflect both capital amortization and operating costs.

Table XIII

COSTS AND TREATMENT LEVELS PLANTS WITH SELF-TREATMENT

Plant Category and Company Code	Treatable Effluent Gals/Mo	Treatment Cost $/Year	Treatment Cost $/1000 Gals	BOD in Raw Treatable Effluent #/Mo	BOD in Treated Effluent #/Mo	Percent Reduction in BOD	COD in Raw Treatable Effluent #/Mo	COD in Treated Effluent #/Mo	Percent Reduction in COD	Percent Reduction in Suspended Solids
Pharmaceutical Plants										
1695	1,777,000	36,750	1.72	1,630	210	87	2,800	310	89	59.0
2467B	1,413,000	42,100	2.48	3,200	240	92	5,750	790	86	-
8297B	3,100,000	36,000	0.97	4,500	400	91	13,200	860	91	-
Weighted Average			1.52			91			90	-
Chemical Plants and Pharmaceutical/Chemical Plants										
1712A	5,950,000	43,460	0.61	150,000	6,940	95	212,000	-	-	-
3897B	1,700,000	200,000	9.80	2,870	1,760	39	4,040	3,510	13	-
5722B	47,350,000	390,000	0.69	520,000	79,000	85	854,000	395,000	54	67
7794B	3,060,000	41,700	1.12	79,000	7,160	91	124,000	17,150	86	-
Weighted Average			0.97			88			59	-
All Other Plants										
5092	6,615,000	65,000	0.81	12,500	1,100	91	20,000	3,000	85	90
9435A	1,850,000	10,500	0.48	1,555	167	89	-	835	-	-
9125C	714,000	8,000	0.93	650	60	91	-	-	-	96
5722E	14,000,000	-	-	64,000	1,300	98	154,000	2,600	98	-
5722D	25,200,000	450,000	1.49	585,000	97,000	83	1,170,000	194,000	83	70
1234D	33,000,000	1,365,000	3.45	1,000,000	350,000	65	2,500,000	630,000	75	-
1234E	60,200,000	1,728,000	2.39	765,000	61,000	92	1,789,000	148,000	92	93
5722C	50,400,000	340,000	0.56	1,080,000	98,400	91	2,400,000	687,000	71	-
0347	22,500,000	1,600,000	5.95	660,000	38,000	94	-	-	-	94
0979	36,000,000	1,650,000	3.82	600,000	69,000	89	-	-	-	92
0526	4,500,000	80,000	1.48	9,400	675	93	11,200	1,350	88	77
6301B	33,000,000	80,000	0.20	415,000	12,000	97	211,000	48,000	79	-
Weighted Average			2.28			88			79	84

XI DISCUSSION OF RESULTS BY INDUSTRY CATEGORY

Pharmaceutical Plants

Of the plant responses for data on their raw effluent, there were 27 which were exclusively pharmaceutical. The following table breaks down this industry category into several applicable areas.

Table XIV
PHARMACEUTICAL PLANTS

Pharmaceutical Plants	Pharmaceutical Plants
Number of Responding Plants	27
Number Discharging to Municipal	23
Number Self-Treating	4
Number With Data Breakdown on Raw Effluent	17

It became apparent during the plant visits and also was verified later through examination of the industry data that the dominant effluent from the pharmaceutical manufacturers was the sanitary loading generated by the employees during the daily production periods, as reflected in normal sanitary BOD loadings and low COD/BOD ratios.

Only 14 of those plants which discharged to a municipal system provided sufficient data for evaluation of raw effluent. Three of the four self-treating plants presented sufficient data for analysis.

One of the main reasons for regarding the effluents for pharmaceutical plants as primarily sanitary in nature is the correlation of contaminant loadings with the number of employees. If the contaminant loadings are normalized against the number of employees, the amount of deviation from the lowest to highest values is quite low. For example, in the case of BOD_5, the lowest reported value in the raw effluent is 1. 4 pounds of BOD_5 per employee per month, while the highest value is 25. 0. Nine out of the 17 reported values fall between 1. 4 and 3. 6. Typical sanitary loadings reported in the literature for industrial environments range between 0. 06 and 0. 1 pounds of BOD per person per working day. * Since there are approximately 20 working days per month, a typical sanitary load would vary between 1.2 and 2. 0 pounds of BOD per person per month.

With a large proportion of the pharmaceutical plants discharging to municipal treating systems, it is quite obvious that the local sewerage treating capabilities are the determining factor for treatment of these plant effluents.

Three of the four plants which practiced total in-plant effluent treatment responded to the request for effluent treatment data. The data have been examined and the results obtained for the pharmaceutical plant category are summarized in Table XIII. The treated effluent is fairly consistent, with the three companiès reporting self-treatment removal of BOD_5 averaging 90 percent, which is also in the range expected from public treatment plants. In addition, the BOD_5 per employee in the treated effluent is fairly constant, as previously discussed. The COD per employee also followed the same correlation as BOD_5. The ratio is reasonably low in the raw waste and COD removals of 90 percent were achieved. The data for dissolved and suspended solids were not sufficient to reach any conclusions. One company also showed some trace metals in their effluent, as shown in Table XII.

The various treatment sequences listed for these self-treatment plants present no unusual procedures. A typical system might be as follows: (1) grit removal, (2) bio-oxidation, (3) settling and sludge recycle, (4) sand filtration, (5) selected landfill, (6) post chlorination, and (7) discharge.

Chemical Plants and Pharmaceutical/Chemical Plants

There were a total of 17 plants responding which fell into this category.

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*1. Wastewater Engineering, Metcalf & Eddy, Inc., Collection, Treatment, Disposal, 1972.

2. Industrial Water Pollution Control, McGraw-Hill Series in Sanitary Science and Water Resources Engineering, 1966.

Table XV

CHEMICAL PLANTS AND PHARMACEUTICAL/CHEMICAL PLANTS

Plants	Chemical Plants and Pharmaceutical/ Chemical Plants
Number of Responding Plants	17
Number Discharging to Municipal	11
Number Self-Treating	6
Number With Data Breakdown on Raw Effluent	13

There was a wide variation in the raw effluent loadings, both per employee and per 1000 pounds of raw material. This would be expected since the contaminants present may vary widely. The average treatment efficiency (88% BOD removal, 59% COD removal) is not quite as good as those levels achievable in public treatment facilities and was considerably more variable. To establish dependable data for this segment of the industry, it will be necessary to gather additional information, both for the plants studied and also for other facilities.

All Other Plants

There were a total of 30 plants placed in this category. Actually, some of these performed only two of the five processing operations. In addition, there were several which did not generate significant wastes.

Table XVI
ALL OTHER PLANTS

Plants	All Other Plants
Number of Responding Plants	30
Number Discharging to Municipal	15
Number Self-Treating	15
Number With Data Breakdown on Raw Effluent	26

There was a wide variation in the amount of contaminants in both the raw and treated effluents when related to either the number of employees or the raw material input. Therefore, it will be difficult to establish any direct correlatable relationships. It will be necessary to find another basis for categorization for this segment and may, in fact, be necessary to subcategorize further to identify any correlations. However, at this time, insufficient information is available to make such a breakdown.

XII DISCUSSION OF WATER USAGE

It would appear that where the sanitary wastes dominate the day-to day effluent loadings of an operating plant, the removal of contaminants by conventional methods is adequate and conforms quite closely with that achievable by regional treatment systems.

There will always be some problems that will arise as a result of a special process. The washdowns and contaminated process waters from these operations may require other treatment approaches.

The entire industry generates an estimated average of 13,100 gallons of treatable effluent per employee per month, with a breakdown of usage by category as follows:

Table XVII

TREATABLE EFFLUENT BY CATEGORY

Category	Gallons of Treatable Effluent Per Month	Number of Reporting Employees Per Category	Gallons of Treatable Effluent Per Month Per Employee
Pharmaceutical Plants	85, 764, 000	17, 727	4, 840
Chemical Plants and Pharmaceutical/Chemical Plants	149, 235, 000	10, 855	13, 750
All Other Plants	615, 713, 000	36, 546	16, 850
All Plants	850, 712, 000	65,125	13, 060

Pharmaceutical Plants

It should be realized that most of the pharmaceutical plants operate on an eight-hour day and a five-day week. The usage of water is primarily limited to that period. The operation of the production plants during the working part of the day is quite compatible with the influent to a regional treatment facility.

The amount of treatable effluent for the pharmaceutical plants is quite low when compared with other industry categories. For example, in the petroleum refining and petrochemical industry, where operations are continuous and highly automated, the treatable effluent can run from 20, 000 to 100, 000 gallons per month per employee, while in this segment, the average is only 4, 850 gallons per month per employee.

Chemical Plants and Pharmaceutical/Chemical Plants

The amount of treatable effluent from this category is sharply higher than that for the pharmaceutical processors, reflecting the increased amounts of process water, vessel cleaning, contaminated cooling water, wash water, etc., in the manufacture of the intermediate chemicals.

A greater evaluation of this segment of the pharmaceutical industry is needed to better determine the most practical methods of effluent treatment. In certain specific areas individual process effluents need to be examined in-depth so that material balances can be determined for the overall raw effluent.

All Other Plants

This industry category utilizes the greatest amount of water per employee. This is primarily due to the larger processing units in the fermentation area and its water demand.

XIII EFFLUENT TREATMENT TECHNOLOGY

Since each industry category has different effluent characteristics and loadings, the degree of treatment will vary for the different categories.

Perhaps one area unique to this industry is the handling of possible pathogenic material and experimental animals, such as mice. In general, there are two methods for handling these wastes. With respect to the toxic materials, they are generally sterilized or incinerated. The animals are generally incinerated.

The research and development facilities are generally located adjacent to the central pharmaceutical plant. Where experimental work on the development of new drugs, serums, etc. is being carried out, the area is usually segregated and isolated by research type. In the case of research on a specific material with a toxic or contagious aspect, a great deal of effort is made to carry out the program in an atmosphere of isolation with physical communication checked by a security officer.

1. Pharmaceutical Plants

As previously discussed, the pharmaceutical plant effluents are predominently sanitary in nature and the majority have their wastes treated in a municipal system. Only some of the larger plants have opted to self-treat their effluent.

In the inspection of all the treatment practices of the pharmaceutical plants, there were no special techniques applied to effluent treatment.

Levels of treatment for this category should be comparable to levels achievable by a conventional municipal treatment plant. As a matter of fact, some consideration should be given to this category having its effluent treated in a joint public-industry facility. One of the main reasons would be the load factor; since the pharmaceutical plant operates during the day, the total treatment plant load would be comparable with the decreased daytime influent from domestic sources.

The washouts of the recipe kettles which are used to prepare the master batches of the pharmaceutical compounds do not appear to be a major problem. The types of contaminants present in these washouts are primarily inorganic salts, sugar, syrup, etc. The surges in effluent resulting from these washout volumes are well within the capacity of the central in-plant or public treatment facility. Where a more exotic compound is involved, the raw materials are so expensive that care is taken to reduce the loss in the master kettle to a minimum.

2. Chemical Plants and Pharmaceutical/Chemical Plants

In those plants which carry out chemical or a combination of pharmaceutical and chemical processes, it is obvious that chemical operations can contribute some undesirable contaminants to the plant effluents. As mentioned earlier, the chemical products are obtained through amination, alkylation, chlorination, sulfonation, etc. The purification steps usually involve one or more conventional chemical engineering unit operations, all of which may generate wastewater containing organic intermediates, solvents, catalysts, etc.

There are several areas of possible major pollution sources. If the reaction is carried out in a batch kettle or autoclave, then the washout solutions will be high in contaminant loadings. If distillation is done with vacuum, the process vacuum jet water will be saturated with the lighter components of the reaction mix. If filtration is involved, two possibilities exist. If the filter cake is the undesirable, then there is a solids disposal problem. If the filtrate is the unwanted material, this portion usually goes to the process sewer where it is either treated separately or combined with the main effluent for subsequent treatment. Unless material balances are obtained and more careful analyses of manufacturing processes is possible, it is impossible to identify major sources of pollution.

Since chemical reactions frequently involve acids or bases, an effluent needing pH adjustment may result. Reactor effluent will sometimes contain emulsions from which the oil may be separable by pH adjustment.

Where solvents are used, both for process and vessel cleaning, a number of plants practice solvent recovery. A few plants also strip weak organic solutions to reduce contaminant loadings further. The stripping operation is carried to the point where the organic solution can safely be combined with other process wastes.

A number of the plants have evaporation and incineration units to aid in their disposal of specific organic wastes which might be difficult to treat biologically.

3. All Other Plants

A great deal or organic matter is present in the spent beers in the fermentation operation. Some of the plants involved have developed ways to reduce this organic matter to a material which can be incinerated or used as a possible source of animal feed supplements. In some cases, however, toxic residues prohibits its use as a food supplement.

If the plant involved is self-treating and does not filter out the solids for sale or burning, then a considerable landfill operation is sometimes carried out.

In reality, none of the problems involved in spent beer wastes require a technology which must be expanded to any great degree. Perhaps additional data on this segment of the pharmaceutical industry need to be obtained so that the loadings to be assigned are well established. Since the raw effluent loadings are quite high, this additional information is all the more important.

Further information should be obtained with regard to the solvent recovery for the natural product extraction processors. At present, this segment of the industry is a relatively small contributor to plant effluent loadings. If information is desired on the extent of this processing category's contribution, then it will have to be developed in a later program.

Even less quantitative information is available concerning the wastes derived from the biological segment of the industry. Additional time and manpower would be necessary to develop the needed data concerning process and purification wastes. Known technology such as land disposal of solids and animal wastes and biological treatment of liquid wastes appears adequate to meet current and immediately anticipated standards.

XIV NEW TECHNOLOGY

According to the observations of GSRI, there are a few processing sequences in several of the categories which might be investigated for improvement.

1. Pharmaceutical batch vessel cleaning

In general, the conventional approach is used in cleaning a vessel for the next manufacturing operation. The mix is transferred to a holding tank through a bottom cone. As a result of the cone draw-off, minimum residual is retained. The walls are then washed and the rinse goes to the process sewer. It would be logical to conduct a study of the possibility of utilizing a small holding tank to collect wash water from previous similar operations for recycle. Eventually the solids or solute levels would rise to a point where the washwater could be added to the master batch going into production. Of course, the possibility of cross-contamination is an ogre hanging over the producer of pharmaceuticals. One contaminated batch can incur the possibility of law suits and possible criminal action. A thorough investigation of this area of water reuse by individual plants would have to be undertaken to increase water conservation, yet not jeopardize the integrity of the industry and its ability to supply quality products.

2. Chemical

Most of the materials coming from the chemical area are intermediates used in making final pharmaceutical products. As explained earlier in this report, there are always a number of chemical engineering unit operations associated with the manufacture of such chemical intermediates. With so many batch processes involved, it should be possible for individual plants to study these areas for water conservation. Holding tanks for recycle of contaminated wash water, further solvent stripping, and process water decontamination should be areas for investigation.

No doubt, as planned regional treatment plants inform various industries of their proportion of capital and the subsequent processing charges, many manufacturers will re-evaluate their water reuse programs and raw effluent loadings.

3. Fermentation

Investigations of the sterilization of spent beer and its solids might reveal the possibility of making this a constant source of animal feed supplements, even when biologically active or toxic components are initially present. Some experimental work has shown that the vitamin and nutrient content of spent beer would aid in animal growth.

Further thought needs to be given to basic physical-chemical treatment systems for the further reduction of contaminant levels. Such development work might be given processes such as ion exchange, carbon adsorption, air flotation, reverse osmosis, etc. Various sequences of these treatment methods might also be important both from an economic and a technical standpoint.

Carbon in Raw Material

One other effort was made to correlate the amount of contamination with another measurable parameter connected with plant operations. The companies were asked to estimate the percent of elemental carbon in their raw material. This number was then correlated with the pounds of BOD_5 and presented in Tables XVIII, XIX, and XX.

The degree of variation was less for the pharmaceutical plants than for the other two categories. Normalizing the pounds of BOD_5 or COD per 1000 pounds of carbon in the raw material does show some consistency although there are ratios in each of the three categories which are extreme. There are several obvious explanations for this. If a company were manufacturing a very common over-the counter item high in carbon such as cough syrup it could do so on a highly automated basis with minimum personnel. Thus, their raw material carbon content and raw effluent loadings versus personnel would be extremely high. On the other hand, another company manufacturing an inorganic antacid could also do so on a highly automated basis with minimum personnel. Their corresponding carbon content in the raw material and effluent loadings versus employee would be minimal.

The actual data for the categories reflects the variation in such operations as illustrated. Comparison of BOD and COD relative to carbon in raw material versus total raw material weight shows the latter to be somewhat more consistent, although only slightly more so. The correlation for both is, in general, very poor.

Table XVIII

PERCENT CARBON IN RAW MATERIAL VERSUS CONTAMINANTS IN RAW EFFLUENT

Pharmaceutical Plants

Pharmaceutical Plants	Percent Carbon In Raw Material	Pounds BOD_5 In Raw Effluent Per 1000# Carbon In Raw Material	Pounds COD In Raw Effluent Per 1000# Carbon In Raw Material
0792	40	1.23	-
1256A	27	16.7	39.3
3524B	80	9.8	22.0
3897D	35	16.9	71.5
4954B	35	6.0	12.9
8297B	40	87.0	257.0
9435B	60	5.7	8.8

Table XIX

PERCENT CARBON IN RAW MATERIAL VERSUS CONTAMINANTS IN RAW EFFLUENT

Chemical Plants and Pharmaceutical/Chemical Plants

Chemical Plants and Pharmaceutical/Chemical Plants	Percent Carbon In Raw Material	Pounds BOD_5 In Raw Effluent Per 1000# Carbon In Raw Material	Pounds COD In Raw Effluent Per 1000# Carbon In Raw Material
0947	14	7.2	17.1
1712A	50	374.0	532.0
3524A	40	200.0	308.0
5722A	25	452.0	756.0
5722B	25	636.0	1,044.0
6165	36	91.0	220.0
7794A	15	73.0	152.0
7794B	54	183.0	287.0

Table XX

PERCENT CARBON IN RAW MATERIAL VERSUS CONTAMINANTS IN RAW EFFLUENT

All Other Plants

All Other Plants	Percent Carbon In Raw Material	Pounds BOD_5 In Raw Effluent Per 1000# Carbon In Raw Material	Pounds COD In Raw Effluent Per 1000# Carbon In Raw Material
1234B	72.0	260	-
1234E	17.0	2,000	4,760
5092	25.0	19	30
5722C	25.0	864	1,920
5722D	34.0	256	512
5921	13.0	369	485
7457	47.0	28	64
8266A	37.5	154	189
9949	20.0	8,550	-

ACKNOWLEDGEMENTS

The collection and compilation of data for this project was completed by the Environmental Technology Department of Gulf South Research Institute under the general supervision of Dr. James H. Mayes.

The contributions of Dr. Herbert S. Skovronek, EPA Project Officer, and members of the Environmental Control Committee of the Pharmaceutical Manufacturers Association, as well as the individual member companies' technical representatives, are gratefully acknowledged.

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Appendix A

DATA GUIDE FOR PHARMACEUTICAL INDUSTRY WASTE WATERS SURVEY

GENERAL INSTRUCTIONS

Be sure to include the confidential company identification number on each information sheet to be submitted.

In filling in the several forms (tables 1. 1, 2. 1, etc.), give specific information whenever available. Otherwise use good estimates and put the estimated figures in parentheses. If a given datum is not applicable, place a dash in the space. Where a value is unknown and no estimate can be made, leave the space blank. If it is known to be negligible, use a "nil"; use "0" if it is known to be zero.

Whenever enough room is not available on a given form, use the notation "over" in the applicable space and use the back of the form. Alternatively, use a second (identical) form and call attention to it by writing "see additional form" at the bottom of the first form. Separate blank sheets may also be used for additional information. In such cases staple addendum sheets to the original.

Terms used in the questionnaire are defined below to insure a clear understanding of the information desired. Following these definitions are specific instructions for responding to each section of the questionnaire. Be sure to read all of the instructions before starting to complete the form. For clarification of any specific items in the form, contact GSRI (Dr. James Mayes - (504) 766-3300 or Dr. Elias Klein or Dr. Ralph Rawls - (504) 283-4223).

DEFINITIONS

Manufacturing Process - A single or series of operations required in going from raw materials to final product, or from a semifinished product to a ready-for-market product -- including all measures normally considered to be good manufacturing practice. Five categories have been selected which, it is believed, adequately describe manufacturing in the pharmaceutical industry. These are defined below. A manufacturing process should not be confused with a unit operation. It may be a unit operation, a series of unit operations, or an entire production line.

Fermentation Processes - All those manufacturing processes including all steps for the recovery of the fermented products, which employ the use of microbial action in producing a product.

DEFINITIONS (continued)

Chemical Synthesis Processes - All those manufacturing processes which primarily employ chemical changes in producing a product including all product recovery steps.

Natural Products Extraction Processes - Those processes making use of preferential solubility to remove constituents from plant or animal substances in producing a product including all product recovery steps.

Biological Processes - All those manufacturing processes making primary use of animal fluids and tissue cultures in producing a product including all product recovery steps.

Pharmaceutical Processes - All those processes used in the formulation of the finished dosage form. (Mixing of ingredients, drying, tableting, encapsulating, coating, sterilization, and packaging are examples.)

Waste Treatments - Those operations utilized solely for the purpose of reducing the quantity or changing the character of wastes produced by a manufacturing process. For the purposes of this questionnaire, "treatment" means the use of some specific operation such as filtration, evaporation, incineration or anaerobic digestion, subsequent to primary manufacturing steps.

Raw Materials - All materials exclusive of process, non-contact and solution waters consumed each year in a given Manufacturing Process Category.

Process or Contact Water - That water which comes into contact with the materials utilized in a manufacturing process.

Non-Contact Water - That water which does not come into contact with the materials being processed. Cooling water is the major example.

Raw Wastes - Leftover materials at the end of a manufacturing process which have had no waste-treatment procedures applied to them.

Treated Wastes - Materials remaining after waste-treatments have been applied to raw wastes.

SPECIFIC INSTRUCTIONS FOR COMPLETING
THE DATA GUIDE

TABLE 1.1 PROCESSED RAW MATERIALS

Line A: For each of the five types of processes in your plant, and for the cumulative plant indicate the current annual consumption (thousands-of-pounds) of raw materials on a dry basis.

Line B: Show the highest monthly utilization of raw materials for each of the five processes. Leave B-60 blank.

Line C: Write in under each process category the source of water used in that process. If a single source is used for all processes, note this amount under the total and leave the other spaces blank.

Line D: If your water presents special purification problems, indicate this in these spaces, on the back of table 1.1 or on a separate sheet.

Line E: Indicate the current annual consumption of non-contact cooling water, by process category. If central services require cooling water, include this in total figure. (Mark this total figure with an asterisk if you have included such non-contact usage cooling water.)

Line F: Indicate the maximum usage of cooling water in any single month. (Treat last column as in line E.)

Line G: Indicate the current annual usage of process water for each category. Count only in-take; do not count recycled water here. No non-contact water should be included. Column 60 should show the cumulative total usage.

Line H: Indicate the maximum monthly usage of process water for each category, and the maximum monthly usage by the entire plant site. (Column 60 will not necessarily equal the sum of columns 10 through 50, unless maximum process water usage by each category occurs in the same month.)

TABLE 2.1 EFFLUENTS FROM MANUFACTURING PROCESSES

Note: The information for Table 2.1 should be reported in terms of the specifications shown in "Standard Methods for the Analysis of Water and Waste Water," 13th edition published by American Public Health Association, unless indicated otherwise.

Fermentation Processes

Column 11: Indicate the average monthly volume and composition of the raw waste effluents from all fermentation reactors, prior to any waste treatment steps. The flow should be in terms of average monthly values during which production occurs, and the analyses should correspond to this flow.

Column 12: Indicate the average monthly volume and composition of waste water after waste treatment or controls are carried out on the fermentation effluents shown in column 11. If you do not take any control or treatment measures in this process area, show a "0" and include the effluent in column 81 of Table 2.2 unless you discharge to a public sewer system.

Column 13: If you use a municipal or regional sanitary disposal system for fermentation wastes, indicate the volume and composition in this column.

Column 14: Indicate the appropriate parameters for water used to cool fermentation processes.

Chemical Synthesis Processes

Column 21: Indicate the average monthly volume and compositions of the raw waste effluents from all chemical synthesis reactors, wash downs, neutralizations, etc. from chemical synthesis processes--prior to any waste-treatment steps. The average monthly flow (line A) should be in terms of average monthly values during the time in which production occurs, and the analyses should correspond to this flow.

Column 22: Indicate the average monthly volume and composition of waste water after waste treatment or controls have been carried out on the chemical synthesis effluents shown in column 21. If no waste treatment or control measures are taken within the chemical synthesis process areas, show a "0" in the spaces and include these effluents in column 81 (Table 2.2) unless discharge is to a public sewer system.

TABLE 2.1 (continued)

Column 23: If chemical synthesis process wastes are discharged to a municipal or regional sanitary disposal system, show the volume and composition in this column.

Column 24: See Column 14

Natural-Products Extraction Processes

Column 31: Show the average monthly volume and compositions of the raw waste effluents from all solvent-extractors and associated extraction processes--prior to any waste treatment or waste control steps. The flow (line A) should be in terms of average monthly volumes during the time in which production occurs, and the analyses should correspond to this flow.

Column 32: Indicate the average monthly volume and composition of waste water after waste treatment and/or waste control measures have been carried out on the extraction process effluents shown in column 31. If no waste treatment or control measures are carried out within the extraction process areas, show a "0" in these spaces and include these effluents in column 81 of Table 2.2--unless discharge is to a public sewer system.

Column 33: If natural product extraction wastes are discharged to a municipal or regional sanitary disposal system, show the volume and composition in this column.

Column 34: See Column 14

Biological Processing

Column 41: Show the average monthly volume and composition of raw biological wastes prior to any waste treatment or waste control measures. If a major portion of the effluent load is due to animal wastes, place the word "over" on line A (Avg. monthly flow)--below the number which represents average monthly volume of raw biological wastes--and give an explanation on the back of the form. The flow (line A) should be in terms of average monthly volumes during the time in which production occurs, and the analyses should correspond to this flow.

TABLE 2.1 (continued)

Column 42: Indicate the average monthly volume and composition of waste water after waste treatment or control measures have been taken for biological effluents as shown in column 41. If no waste treatment or control measures are carried out within the biological processes, show a "0" in these spaces and include these effluents in column 81 of Table 2.2--unless discharge is to a public sewer system.

Column 43: If biological process wastes are discharged to a municipal or regional sanitary disposal system, show the volume and composition in this column.

Column 44: See Column 14

Pharmaceutical Processes

Column 51: Show the average monthly volume and compositions of the raw waste effluents from all pharmaceutical processes (see definitions) such as, for example, dry mixing, blending, formulating, packaging--prior to any waste control measures. The average monthly flow (line A) should be in terms of average monthly volumes during the time in which production actually occurs, and the analyses should correspond to this flow.

Column 52: Indicate the average monthly volume and composition of waste water after waste treatment or control measures are taken for pharmaceutical processes effluents as shown in column 51. If no waste treatment or control measures are carried out on pharmaceutical processes wastes, show a "0" in these spaces and include these effluents in column 81 of Table 2.2--unless discharge is to a public sewer system.

Column 53: If pharmaceutical processes wastes are discharged to a municipal or regional sanitary disposal system, show the volume and composition in this column.

Column 54: See Column 14

TABLE 2.2 TOTAL WASTE EFFLUENTS FROM ENTIRE PLANT

Column 60: Show the average monthly volume and composition of waste water originating with operations which service the entire plant area, such as boiler and/or cooling tower blow-down, demineralizers, etc. If more than one such waste stream exists and these are not combined, use more than one Table 2.2 form.

Column 70 If once-through, non-contact, cooling water is combined from all manufacturing processes and discharged, use this column to show the combined volume and the analyses of the combined stream at the point of discharge. If more than one such waste stream exists and these are not combined, use more than one Table 2. 2 form.

Column 81 If two or more process waste streams are combined and sent to an on-site treatment facility (either before or after process-area, treatment), use this column to show the total volume of such waste streams and their analyses. If two or more on-site treatment facilities are used, use more than one Table 2. 2 form and label each according to the figure 3 codes appropriate to the treatment facility which it represents.

Column 82: Show the average monthly volume and analyses of the waste stream which results from collecting wastes from various process categories and sending them to a public sanitary disposal system.

Column 83: Show the average monthly volume and analyses of the waste stream which results from collecting wastes from various process categories and sending them to deep-well injection.

Column 84: Show the average monthly volume and analyses of the waste stream leaving the plant-site treatment facility. The facility referred to in this column should be the same as the one referred to in column 81.

Column 85: If non-treated water from any source is combined with effluents from the treatment facility referred to in columns 81 and 84, show the total average monthly volume and analyses of the flow resulting from this combination.

TABLE 2.2 (continued)

Column 90 — If any waste streams from your manufacturing plant are sent to a public sanitary disposal system, obtain the available analyses of this discharge for an average month during which your plant is discharging to this facility.

Section 3. Waste Flow Relationships

1. Provide on separate sheets a waste flow sketch showing the relationship between each manufacturing category (fermentation, extraction, etc.) and other sources of waste effluents, and waste treatment and/or waste control measures. Up to eight waste stream sources should be shown (the five manufacturing categories plus utility effluents, once through cooling and sanitary wastes).

2. The diagram attached is an example.

3. Identify the sample points which correspond to various columns in Tables 2.1 and 2.2. For example, "Column 11, Table 2.1" should be used to identify the point in the diagram which corresponds to the analyses shown in Table 2.1 for raw fermentation process effluents prior to any treatment. "Column 81, Table 2.2" should be used to identify the point in the diagram which corresponds to the analyses shown in Table 2.2 for the total combined process effluents to main plant site treatment. It is not expected that there will be a point in the diagram to correspond to every column heading in Tables 2.1 and 2.2, since many of the columns may not be applicable to a given plant's operations.

4. Use the code numbers given in figure 3 to identify process/waste control measures, waste treatment measures, and disposal measures. If, for example, the wastes from a fermentation process are disposed of by spray irrigation, an arrow should terminate with the code number 904. List only these waste treatment and waste control measures which contribute a significant reduction in effluent volumes, concentrations or temperatures.

5. In cases where a code ending in 9--"not defined above"--is used, provide enough of an explanation to identify what measure has been taken.

TABLE 2.2 (continued)

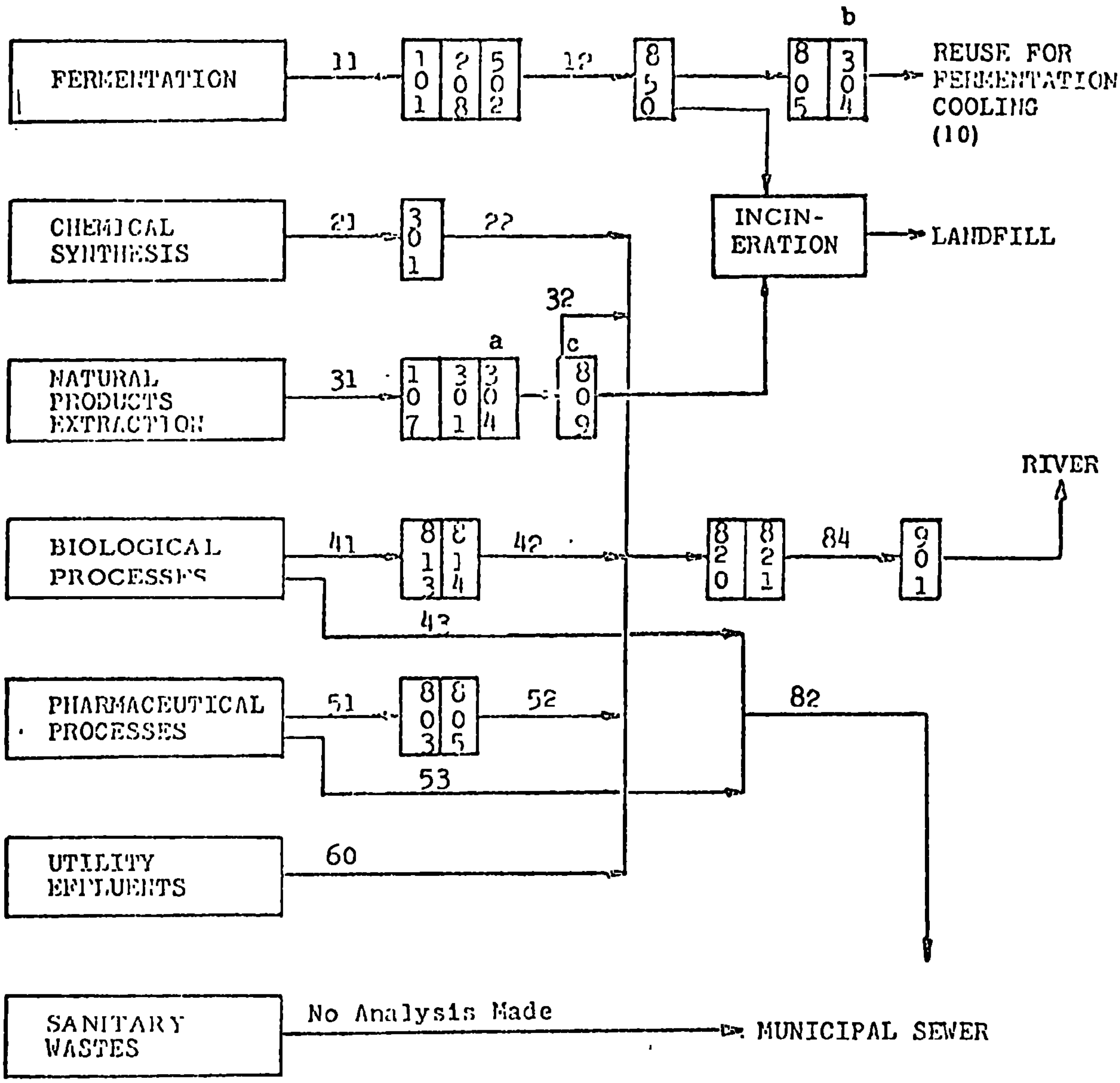
6. In all cases indicate the eventual disposal of wastes, even if they are not contributions to water pollution. Where wastes are dried and then incinerated, for example, indicate this code 850 followed by an arrow leading to the word "incineration". Another such disposal method which is not associated with water pollution is, for example, land fill usage.

7. Use code 304--"recycle or reuse of water"--to indicate usage of both process contact water, and non-contact cooling water. However, provide a reference mark and an explanation to distinguish between the two.

8. Label the sheets used in preparing diagrams with your assigned company I. D. number in the upper right-hand corner.

EXAMPLES OF WASTE-FLOW DIAGRAMS

Company ID Code:__________________



NOTES: a. Non-contact cooling water
b. Process-contact water
c. Air drying

A-10

FIGURE 3 CODES

IN-PROCESS CONTROL MEASURES

100 SERIES-ENGINEERING DESIGN CONSIDERATIONS

101 Installation of separate drainage systems
102 Segregation and collection of specific wastes
103 Use of surface condensers in place of barometric condensers
104 Use of various water conservation measures and facilities
105 Emergency storage facilities
106 Countercurrent use of chemicals and/or washwaters
107 Use of pumps and valves with special seals to minimize leakage
109 Not defined above

200 SERIES-PROCESS DESIGN MODIFICATIONS

201 Use of reaction chemicals or feed stocks producing minimum waste
202 Continuous vs batch processes
203 Chemical regeneration
204 Downgraded use of chemicals
205 Elimination of air blowing and water washing
206 Physical separators
207 Change in design basis for chemical recovery facilities
208 Modifying operating conditions
209 Not defined above

300 SERIES-RECOVERY & UTILIZATION

301 Recovery of material for reuse in process
302 Downgraded use of spent chemicals in other processes
303 Use or sale of wastes as raw material for other processes
304 Recycle or reuse of water
305 Heat recovery
309 Not defined above

400 SERIES-LOCAL PRETREATMENT OR DISPOSAL

401 Local separators and traps
402 Evaporation and incineration of noxious liquid wastes
403 Use of emulsion prevention chemicals
409 Not defined above

500 SERIES-OPERATION CONTROL

501 Automatic vs. manual process controls
502 Control of production to minimize losses
503 Administrative control of wastewater discharge
504 Monitoring sewer effluents
505 Management follow-up on losses
509 Not defined above

WASTEWATER DISPOSAL MEASURES

700 SERIES-DISCHARGE TO TREATMENT FACILITY

701 Private facilities
702 Public facilities
703 Cooperative facilities
704 Contract disposal
705 Transportation to more receptive environment
706 Storm water drainage
709 Not defined above

WASTEWATER TREATMENT UNIT OPERATIONS

800 SERIES-PHYSICAL TREATMENT

800 Equalization
801 Screening
802 Pre-aeration
803 Sedimentation
804 Flotation
805 Temperature control
809 Not defined above

810 SERIES-CHEMICAL TREATMENT

810 Neutralization
811 Primary chemical coagulation
812 Chemical treatment
813 Odor control
814 Nutrient addition
819 Not defined above

820 SERIES-BIOLOGICAL TREATMENT

820 Stabilization basins
821 Activated sludge
822 Trickling filter
823 Aerated lagoon
824 Anerobic contact (6 to 12 hours)
825 Anerobic pond (3 to 30 days)
826 Denitrification
827 Aerobic or anaerobic digestion of solids
829 Not defined above

830 SERIES-SLUDGE HANDLING

830 Thickening
831 Lagooning or drying bed
832 Centrifugation
833 Vacuum filtration
834 Dry combustion
835 Wet combustion
836 Land disposal
837 Sea disposal
839 Not defined above

840 SERIES-TERMINAL SECONDARY TREATMENT

840 Biological sedimentation
841 Final chemical coagulation and sedimentation
842 Sand filtration
843 Diatomite filtration
844 Chlorination
849 Not defined above

ADVANCED WASTE TREATMENT

850 SERIES-TEMPERATURE CHANGE PROCESSES

850 Evaporation
851 Freezing
852 Distillation
853 Eutectic Freezing
854 Wet Oxidation
855 Process Residue, Handling and Disposal
859 Not defined above

860 SERIES-ALL OTHER

860 Adsorption 870 ACTIVATED CARBON
861 Electrodialysis
862 Ion Exchange
863 Solvent Extraction
864 Reverse Osmosis
865 Foaming
866 Chemical Treatment
867 Electrochemical Treatment
868 Process Residue, Handling and Disposal
869 Not defined above

900 SERIES-TREATED WASTEWATER DISPOSAL

901 Controlled discharge
902 Surface storage and evaporation
903 Deepwell disposal
904 Surface (spray) irrigation
905 Ocean disposal
906 Surface discharge
909 Not defined above

Company ID. Code: ________________

1. Materials Input.

Table I. 1 PROCESSED RAW MATERIALS

READ INSTRUCTIONS CAREFULLY BEFORE PREPARING THIS FORM. PAY PARTICULAR ATTENTION TO DEFINITIONS.

	10. Fermentation Processes	20. Chemical Synthesis Processes	30. Natural Product Extraction Processes	40. Biological Processes	50. Pharmaceutical Processes	60. Totals
A. Annual Dry Weight						
B. Maximum Dry Weight/Mo.						
C. Water Source (river, purchased well, recycled, etc.)						
D. Special Problems *						
Cooling Water Usage: E. Annual						
F. Max. /Mo.						
Process Water Usage: G. Annual						
H. Max. /Mo.						

* If a special problem or consideration exists for a given source of water, place a number (1, 2, . . . 5) in the appropriate space next to "Special Problems". Use these as reference numbers and give a brief explanation. (Use the back of this form or extra sheets if necessary).

Table 2.1 EFFLUENTS FROM PROCESS AREAS - READ INSTRUCTIONS CAREFULLY BEFORE PREPARING THIS FORM. Company ID. Code: ________

PAY PARTICULAR ATTENTION TO DEFINITIONS

PROCESS:	FERMENTATION PROCESSES				CHEM. SYNTH. PROCESSES				NATURAL PRODUCT EXTRACTION PROCESSES				BIOLOGICAL PROCESSING				PHARMACEUTICAL PROCESSES			
ANALYSES PARAMETERS	(11) Raw Process Effluent Prior to Any Treatment	(12) Process Effluent After Fermentation Area Treatment	(13) Process Effluent to Public Sewer	(14) Cooling Water once-through (Non-Contact)	(21) Raw Process Effluent Prior to Any Treatment	(22) Process Effluent After Chem. Synth. Area Treatment	(23) Process Effluent to Public Sewer	(24) Cooling Water once-through (Non-Contact)	(31) Raw Process Effluent Prior to any Treatment	(32) Combined Process Effluent After Extraction Area Treatment	(33) Process Effluent to Public Sewer	(34) Cooling Water once-through (Non-Contact)	(41) Raw Process Effluent Prior to Any Treatment	(42) Combined Process Effluent After Biological Area Treat.	(43) Process Effluent to Public Sewer	(44) Cooling Water once-through (Non-Contact)	(51) Raw Process Effluent Prior to Any Treat.	(52) Process Effluent After Pharmaceutical Area Treatment	(53) Process Effluent to Public Sewer	(54) Cooling Water once-through (Non-Contact)
A. Avg. Monthly Flow (1000 Gals.)																				
B. Sp. Gr. @ 60° F																				
C. Temp (°F)																				
D. pH																				
Oxygen Demand. E. BOD_5 ppm/wt.																				
F. COD ppm/wt.																				
Solids ppm/wt. G. Total Solids																				
H. Dissolved Solids																				
I. Suspended Solids																				
J. Tot. Org. Carbon																				
Heavy Metals. K. Hg ppm/wt.																				
L. Cr ppm/wt.																				
M. Zn ppm/wt.																				
N. Pb ppm/wt.																				

Table 2.2 TOTAL WASTE EFFLUENTS FROM ENTIRE PLANT Company ID. Code: __________

READ INSTRUCTIONS CAREFULLY BEFORE PREPARING THIS FORM.
PAY PARTICULAR ATTENTION TO DEFINITIONS.

DESIGNATED WASTE FLOW STREAMS ANALYSES PARAMETERS	(60) Utility Effluents: Boiler and/or Cooling Tower Blow-down, Demineralizers, etc.	(70) Once-through Cooling Water: (Non-Contact)	(81) Total Combined Process Effluents to Main Plant-Site Treatment	(82) Total Process-Area, Effluents to Public Sewer	(83) Total Combined Process-Area Effluents to Deep Well Injection	(84) Total Combined Process Effluents Leaving Main Plant-Site Treatment	(85) Combined Total Treated Effluent Plus By-Passed Untreated Water to Receiving Stream	(90) Average Public Treatment-Plant Effluent
A. Avg. Monthly Flow (1000 Gals.)								
B. Sp. Gr. @ 60° F								
C. Temp. (°F)								
D. pH								
Oxygen Demand:								
E. BOD_5 ppm/wt.								
F. COD ppm/wt.								
Solids.ppm/wt.								
G. Total Solids								
H. Dissolved Solids								
I. Suspended Solids								
J. Tot. Org. Carbon								
Heavy Metals:								
K. Hg ppm/wt.								
L. Cr ppm/wt.								
M. Zn ppm/wt.								
N. Pb ppm/wt.								

Company ID. Code:___________

NARRATIVE QUESTIONS

3.1 Please identify unit operations (for waste water load reduction) which you feel should be developed to meet special needs of this industry, and for which your company has no practicable technology available. (Note: This question is very important in determining the future availability of Federal demonstration funds to meet needs specific to our industry. Please be detailed; your responses are coded and confidential.)

3.2 Estimate your annual operating budget for your waste water treatment operations. If you allocate costs to each of the five manufacturing areas, please do so. Otherwise, give total costs. Please distinguish chemical costs, operating cost (labor, overhead, power); do not include capital amortization.

Note: Include those waste treatment operations early in your process, which reduce loads to your central treatment plant.

Company ID. Code:___________

NARRATIVE QUESTIONS (continued)

3.3 Give the average number of employees at your plant site. Include office personnel, R & D., etc.

3.4 It is believed that some rational parameter for the measurement of waste loads per unit of plant throughput is needed. For example, waste loads per employee, or waste loads per dollar volume of product have been used in the past. The data requested in the earlier sections will yield waste loads per unit of raw material input for each process category. A possible alternate might be the expression of waste load per pound of organic carbon processed. This could be a measure of the efficiency of processing in a given industry.

Please estimate the organic carbon percentage in the raw materials shown on line A, Table 1.1. If your plant processes non-carbonaceous materials, indicate another element as the "marker" and give its percentage.

3.5 Pathogens.

If any of your manufacturing processes include the use of pathogenic organisms, briefly describe how they are removed from inclusion in your waste streams.