Environmental Protection Agency

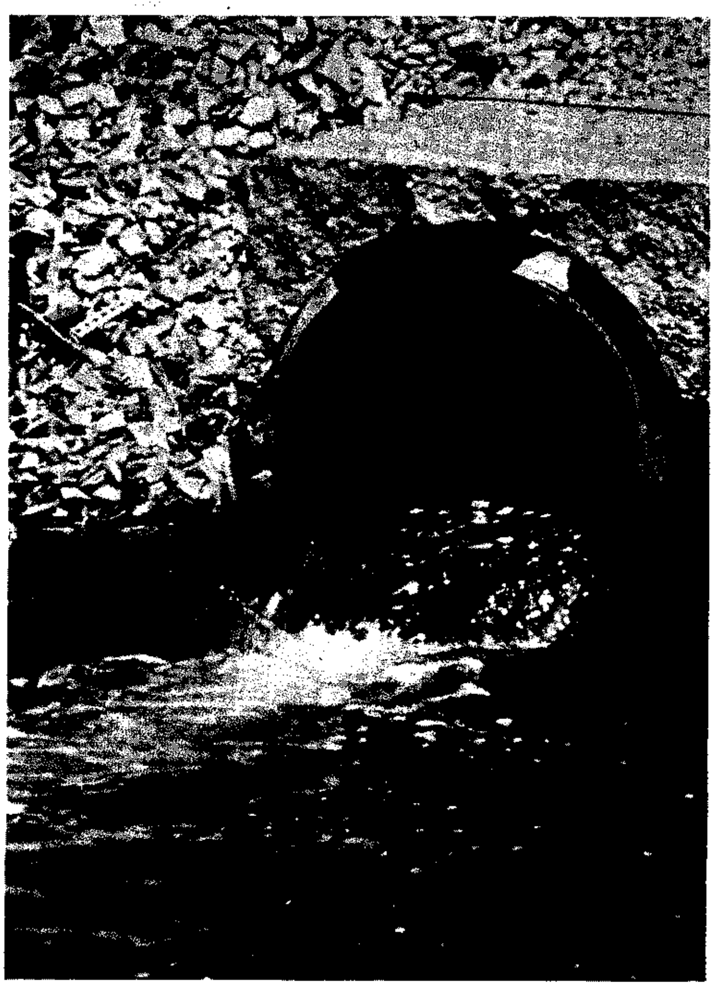
June 1980

Office of Research and Development

EPA

Research Summary

Industrial Wastewater



In 1746 Benjamin Franklin wrote "when the well's dry, we know the worth of water." In those days, people were primarily concerned with finding a reliable source of water, its quality was often taken for granted. The quantity of pollutants contaminating our water resources was relatively small, and those pollutants were removed through natural processes. Increasing population, growing industry, and rapidly developing technology since the industrial revolution have sorely tested nature's capacity for maintaining clean water. Increased water use and wastewater discharge have added impurities to water which overload natural cleansing processes, either because of the amount or the chemical complexity of the impurities. Hence, we are compelled to turn to technology to protect our water supply.

Water is a resource we cannot afford to have in short supply—a resource we cannot take for granted. It is necessary that we know the worth of water now, and that we take steps to protect it before the well becomes dry, or polluted.

Stephen J. Gage

Assistant Administrator
for Research and Development

This brochure is one of a series providing a brief description of major areas of the Environmental Protection Agency's research and development program. Additional copies may be obtained by writing to:
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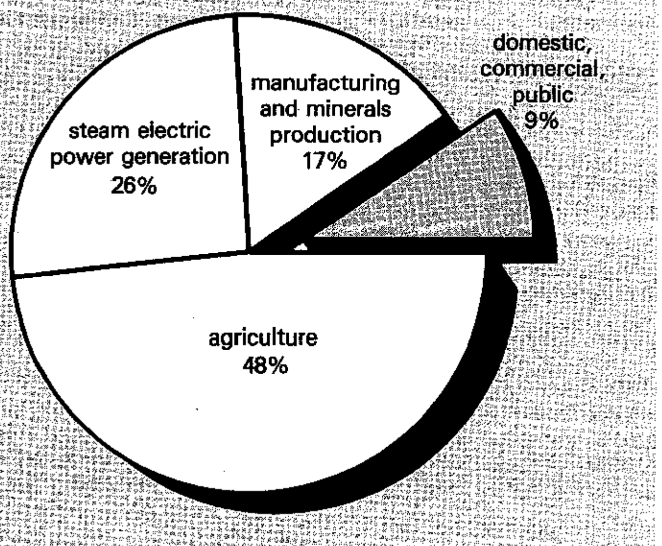
industrial wastewater

More than 300 billion gallons of water are withdrawn from our Nation's lakes, rivers, and streams each day. Of this quantity 91 percent is devoted to industrial use, an amount of water roughly equal to 75 percent of the daily flow of the Mississippi River at its mouth.

While some water is evaporated, or is incorporated into the product itself, most is discharged back to its source. The U.S. Department of Commerce estimates that major industrial water users discharged approximately 285 billion gallons of wastewater daily in 1975.

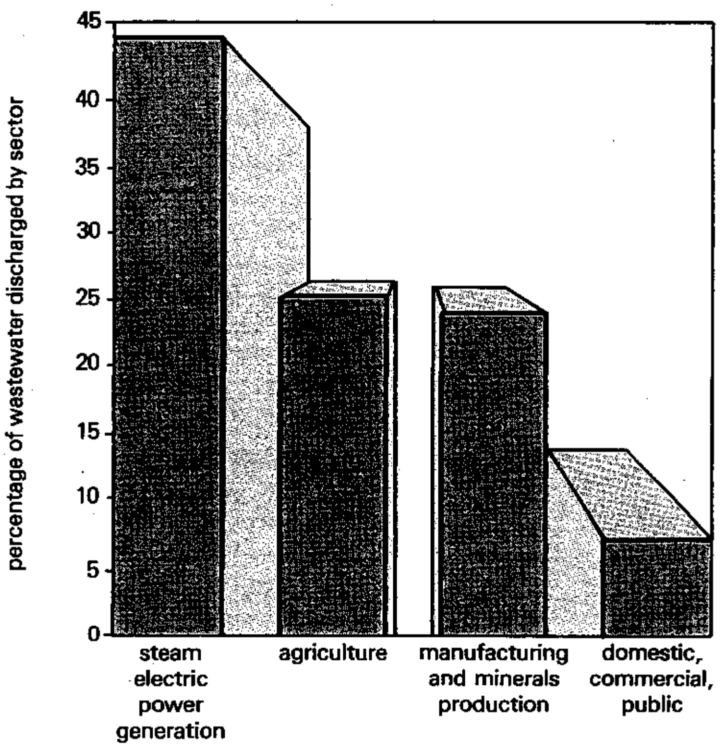
This water, usually altered considerably in the industrial process, may contain contaminants which degrade water quality and pose a threat to human health. Degradation of water quality comes about with the addition of large amounts of nutrients, suspended sediments, bacteria, and oxygen-demanding matter. The possible addition of toxic pollutants is even more serious. These pollutants are particularly important because of their persistence, harmful effects at low concentrations, and ability to enter the food chain.

percentage of water withdrawn from national sources by sector



source: U.S. Department of Commerce

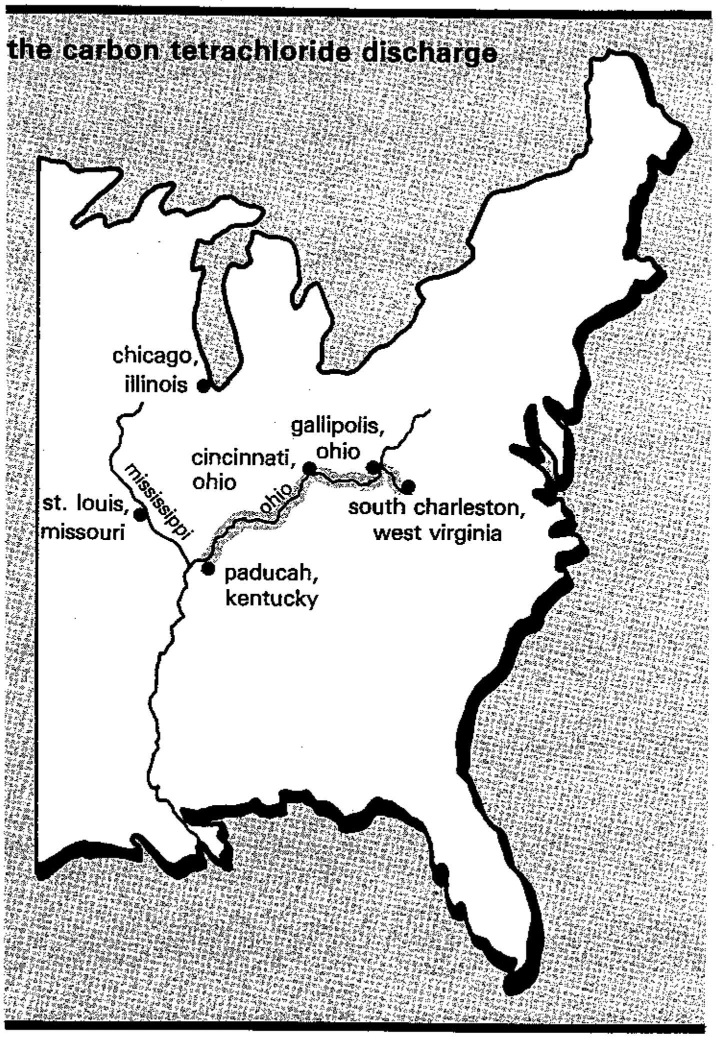
U.S. wastewater discharges



source: U.S. Department of Commerce

Past water use and discharge practices have levied their toll on the Nation's water supply. A particularly severe example, illustrating the potential hazards associated with uncontrolled discharge, occurred in South Charleston, West Virginia, in 1977. A 5,000-pound discharge of carbon tetrachloride into an Ohio River tributary contaminated the river for more than 600 miles—from Gallipolis, Ohio, to Paducah, Kentucky. Since carbon tetrachloride is a carcinogen, and can cause damage to the liver, kidneys, lungs, and central nervous system, this contamination was a matter of great concern. EPA, through its sampling and analysis program, was able to detect the contamination and notify cities on the Ohio River to close their water treatment plant intake gates, thereby protecting drinking-water supplies along the river's course. The map below shows the areas that were affected by the spill.

The effects of past use and discharge practices are increasingly in evidence; from the contamination of New York's Hudson River by polychlorinated biphenyls (PCB's), to the presence of Kepone in the James River in Virginia. Such incidents are particularly alarming in light of documented evidence that some organisms can ingest, accumulate, and bioconcentrate toxicants such as these to lethal levels.



federal legislation

In recognition of the need for industrial wastewater control measures, Congress enacted the 1972 Federal Water Pollution Control Act Amendments identifying several major environmental goals for the nation. The elimination of pollutant discharges or "zero discharge" into navigable waters by 1985 highlighted the Act, with the preservation of water quality providing for fishable and swimmable waters by 1983 as an interim goal.

To meet these goals with respect to industrial wastewater, the Act mandates the establishment and imposition of discharge limitations based on protection of receiving water quality, toxicity, and technological practicability. The latter regulatory effort requires the definition and achievement of Best Practicable Control Technology Currently Available (BPCTCA), and Best Available Technology Economically Achievable (BATEA). Best Practicable Control Technology levels require industries to use the best broadly demonstrated technology available while the Best Available Technology levels require the use of the best technology available.

NRDC consent degree

From 1972 to 1976, EPA concentrated on developing Best Practicable Control Technology and Best Available Technology limitations for conventional pollutants such as suspended solids, biochemical oxygen demand (BOD), and chemical oxygen demand (COD). BOD is a measure of the oxygen required to biologically decompose organic matter in water, while COD is a measure of the oxygen required to chemically oxidize both organic and oxidizable inorganic compounds in water. As such, both BOD and COD are used to determine the degree of pollution in an effluent.

In June 1976, in settlement of a suit with the Natural Resources Defense Council (NRDC), EPA agreed to devote more attention to potentially toxic substances in industrial wastewater. The resulting NRDC Consent Decree required EPA to promulgate regulations for 65 classes of toxic pollutants associated with 21 industrial categories—updated in 1979 to 34 industrial categories. The 65 classes represent 129 specific substances referred to as "consent decree priority pollutants" or simply "priority pollutants." The Clean Water Act of 1977 (PL 95-217), which further amends the Federal Water Pollution Control Act, incorporates substantial portions of the NRDC settlement and broadens regulations to improve water quality and the control of potentially toxic pollutants.

Other Federal legislation related to industrial wastewater treatment and control includes: the National Environmental Policy Act, the Toxic Substances Control Act, the Ocean Dumping Act, the Safe Drinking Water Act, the Resource Conservation and Recovery Act, and the Clean Air Act.

regulatory responsibility

Federal responsibility for promulgating and enforcing industrial wastewater control regulations is held by EPA. The National Pollution Discharge Elimination System (NPDES), a national permit program administered through EPA, was created under the Federal Water Pollution Control Act Amendments of 1972 to control the discharge of pollutants into waterways from all point sources including industrial, municipal, and commercial facilities. Under the law, it is illegal to discharge pollutants into the Nation's waterways without a permit. Through this system EPA regulates what may be discharged and in what quantity by imposing the discharge limitations described above.

the research program

EPA's Office of Research and Development (ORD) supports the Agency's regulatory activities by producing the scientific data and technology necessary for development of effective pollution control strategies and environmental standards. This research falls under two major categories:

- Treatment, and
- Reuse and recycling and other process modifications.

Researchers at ORD's Industrial Environmental Research Laboratories in Cincinnati, Ohio, and Research Triangle Park, North Carolina, and the Robert S. Kerr Environmental Research Laboratory in Ada, Oklahoma, perform EPA's inhouse research. The majority of the industrial wastewater control research, however, is performed extramurally through contracts, grants, and cooperative agreements with universities, research foundations, trade associations, professional societies, and industrial companies.

ɩRDC consent decree — ɩ4 industrial categories

ɩdhesives
ɜather tanning and finishing
ɩoaps & detergents
ɩluminum forming
ɩattery manufacturing
:oil coating
:opper forming
ɩlectroplating
oundries
ron & steel
ɩonferrous metals
ɩhotographic supplies
plastics processing
porcelain enamel
gum & wood chemicals
paint & ink
printing & publishing
pulp & paper
textile mills
timber
coal mining
ore mining
petroleum refining
steam electric
organic chemicals
pesticides
pharmaceuticals
plastic & synthetic materials
rubber
auto & other laundries
mechanical products
electric & electronic components
explosives manufacturing
inorganic chemicals

ɩRDC consent decree — ɩ5 toxic pollutant classes

ɩcenapthene
ɩcrolein
ɩcrylonitrile
ɩldrin/dieldrin
ɩntimony and compounds
ɩrsenic and compounds
ɩsbestos
ɩenzene
ɩenzidine
ɩeryllium and compounds
:admium and compounds
:arbon tetrachloride
:hlordane
:hlorinated benzenes
:hlorinated ethanes
:hloralkyl ethers
:hlorinated phenols
:hloroform
ɩ-chlorophenol
:hromium and compounds
:opper and compounds
:yanides
DDT and metabolites
dichlorobenzenes
dichlorobenzidine
dichloroethylenes
2, 4-dimethylphenol
dinitrotoluene
diphenylhydrazine
endosulfan and metabolites
endrin and metabolites
ethylbenzene
fluoranthene
haloethers
halomethanes
heptachlor and metabolites
hexachlorobutadiene
hexachlorocyclopentadiene
hexachlorocyclohexane
isophorone
lead and compounds
mercury and compounds
napthalene
nickel and compounds
nitrobenzene
nitrophenols
nitrosamines
pentachlorophenol
phenol
phthalate esters
polychlorinated biphenyls (PCBs)
polynuclear aromatic hydrocarbons
selenium and compounds
silver and compounds
2,3,7,8,-tetrachlorodibenzo-p-dioxin (TCDD)
tetrachloroethylene
thallium and compounds
toluene
toxaphene
trichloroethylene
vinyl chloride
zinc and compounds

treatment

Treatment technologies reduce or eliminate industrial waste water pollutants, thereby producing an effluent that can either be discharged into a nearby waterway without threatening environmental quality, or can be accepted by a local municipal treatment plant without disturbing treatment processes.

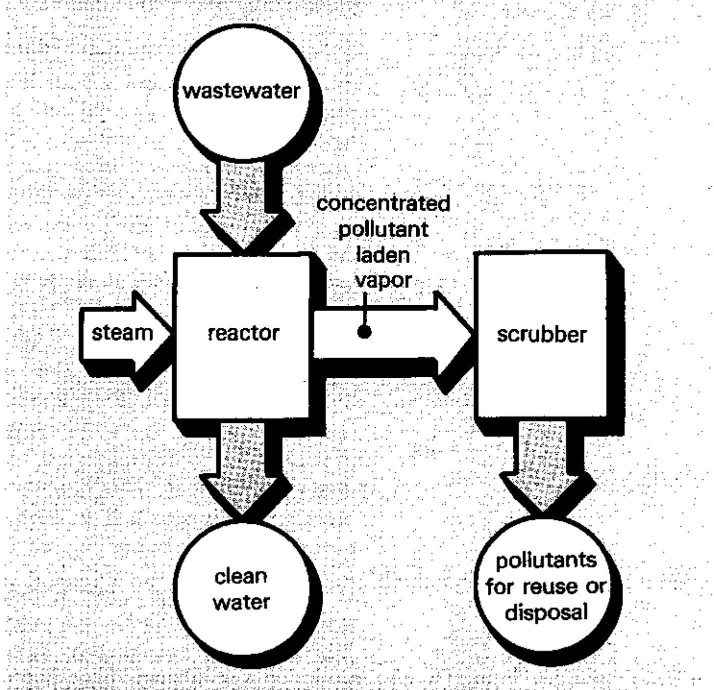
testing and evaluation facility

In March 1979, the Environmental Protection Agency (EPA) opened a wastewater Test and Evaluation Facility in Cincinnati, Ohio. The facility both increases EPA's capacity for in-house research on pollution control technologies, and enhances its capability to evaluate the health and environmental impacts of these controls.

Through a cooperative agreement with EPA, the City of Cincinnati is providing the land for the facility for 20 years at no cost. A sewage treatment plant, located adjacent to the facility, provides the industrial and municipal wastewaters and sludges needed for research efforts. The Test and Evaluation Facility is especially suited for research on techniques to remove or treat toxic and hazardous materials in industrial wastewaters.

Three technologies for removal of toxic materials from wastewater currently being tested are carbon adsorption, activated sludge, and steam stripping. Carbon adsorption removes toxic organic compounds through adsorption, or attraction and accumulation, onto the surface of activated carbon. Activated sludge processes essentially duplicate

steam stripping



natural stream purification mechanisms through biological degradation of water pollutants by bacteria and other microorganisms. The principal difference is that treatment is carried out in a controlled environment with high concentrations of bacteria and microorganisms, thereby speeding up and increasing the efficiency of the process. Steam stripping involves the removal of certain volatile organic pollutants from wastewater through distillation. Limited information exists concerning the efficiency of carbon adsorption, biological treatment, and stream stripping in removing priority pollutants from industrial plant wastewater streams. Research, development, and demonstration of these treatment technologies will answer important questions such as: Can these technologies be made more energy efficient and cost effective? And can they be broadly applied?

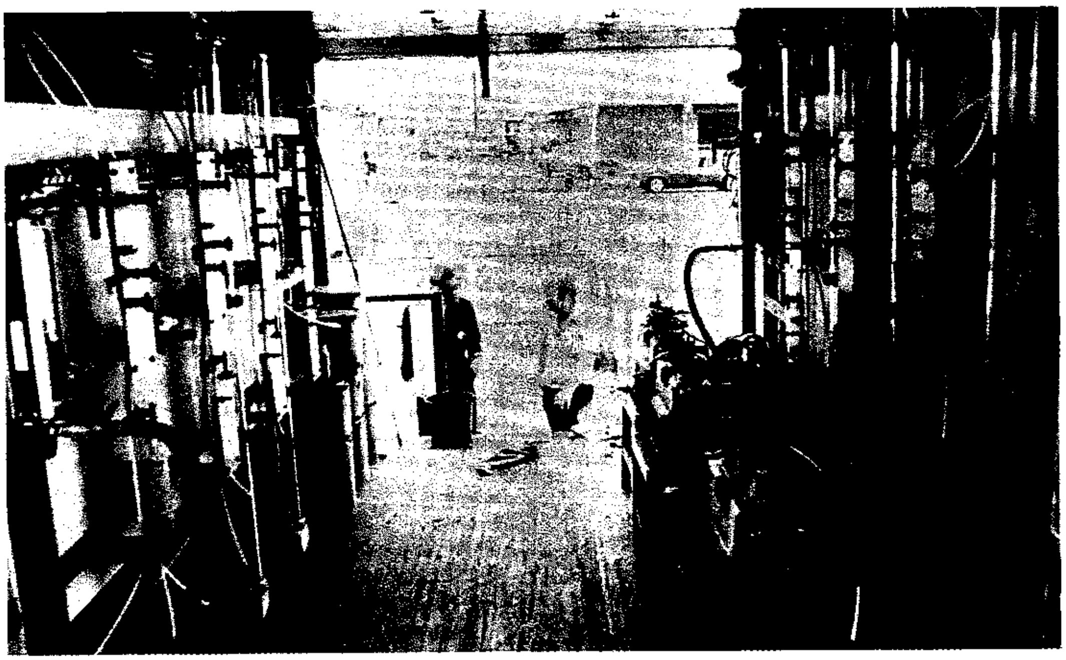
Due to the wide variability in industrial wastewater discharges, wastewater treatment research must be performed on an industry-by-industry basis. The discussion that follows focuses on several major U.S. industries requiring use of wastewater control technologies.

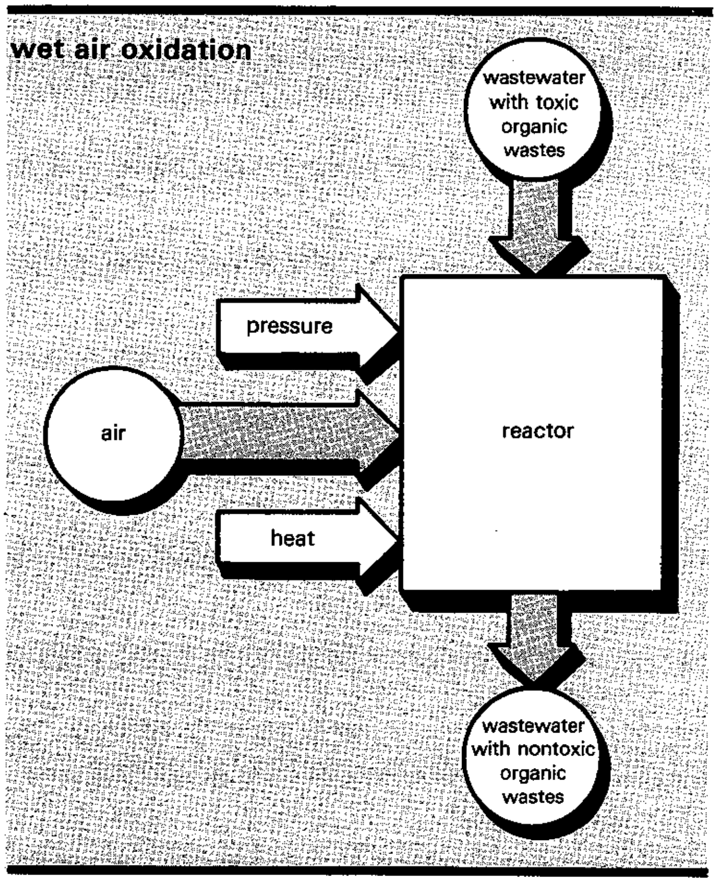
›rganic chemicals

Projects in support of research and development in the organic chemical industry are conducted largely through EPA's Industrial Environmental Research Laboratory in Cincinnati, Ohio (IERL-Cincinnati). The organic chemical industry is exceedingly complex. There are thousands of companies involved in the manufacture of a multitude of products from such organic chemical sources as petroleum, coal, and natural gas. Typical industry products include synthetic detergent bases, fuel additives, solvents, plastics, resins, and synthetic fiber bases.

The wastewater produced during the manufacture of these products is frequently heavily contaminated with toxic substances that require specialized treatment. ORD has initiated several research projects to look into the technical and economic aspects of various treatment technologies for these wastewaters. Both activated carbon treatment and wet air oxidation treatment are receiving particular attention As stated earlier, activated carbon is a highly adsorbent form of carbon to which specific pollutants adhere. After removing pollutants from water, the carbon can be changed, or cleaned and used again. ORD is assessing activated carbon technology through the use of four mobile pilot plants. These plants have small-scale activated carbon treatment systems wholly contained within trailers. Wastewaters from organic chemical plants are treated in the mobile units and analyzed in an accompanying mobile laboratory. When testing and analysis is completed, the mobile trailer units can be easily relocated to other plants.

A second process, wet air oxidation, is being investigated through a cooperative agreement with the Michigan Technological University. This process involves exposing toxic organic wastewaters to high temperatures and pressures while they are confined in a reactor. These conditions cause the oxidation and conversion of toxic organic substances into nontoxic forms. The resulting effluent is suitable for discharge directly to a waterway or to a nearby municipal wastewater treatment facility.





The data obtained through these efforts will provide EPA's regulatory offices with a basis for evaluation of the Best Available Technology Economically Achievable for wastewaters from the organic chemical industry.

petrochemicals

The petrochemicals industry produces wastewaters rich in chemicals which can be extremely hazardous. One chemical that has an especially deleterious ecological impact is caprolactam, used in the manufacture of nylon. Biological treatment of wastestreams containing caprolactam has not been successful. Steam stripping, while somewhat more successful, requires large amounts of energy and is costly to apply. In order to develop a more inexpensive, energy-conserving technology to treat chemical wastestreams, ORD has been examining the use of a new solvent to extract caprolactam from industrial wastewaters. After removal, the caprolactam can be extracted from the solvent and recovered for reuse. Research is also being conducted on the use of powdered activated carbon in combination with biological treatment to treat petrochemical industry wastewaters. ORD is conducting a full-scale demonstration of a powdered activated carbon treatment system at an operating chemical plant in New Jersey. The demonstration system will treat a 40 million gallon-per-day wastestream and will represent the first application of powdered activated carbon in a large industrial wastewater facility.

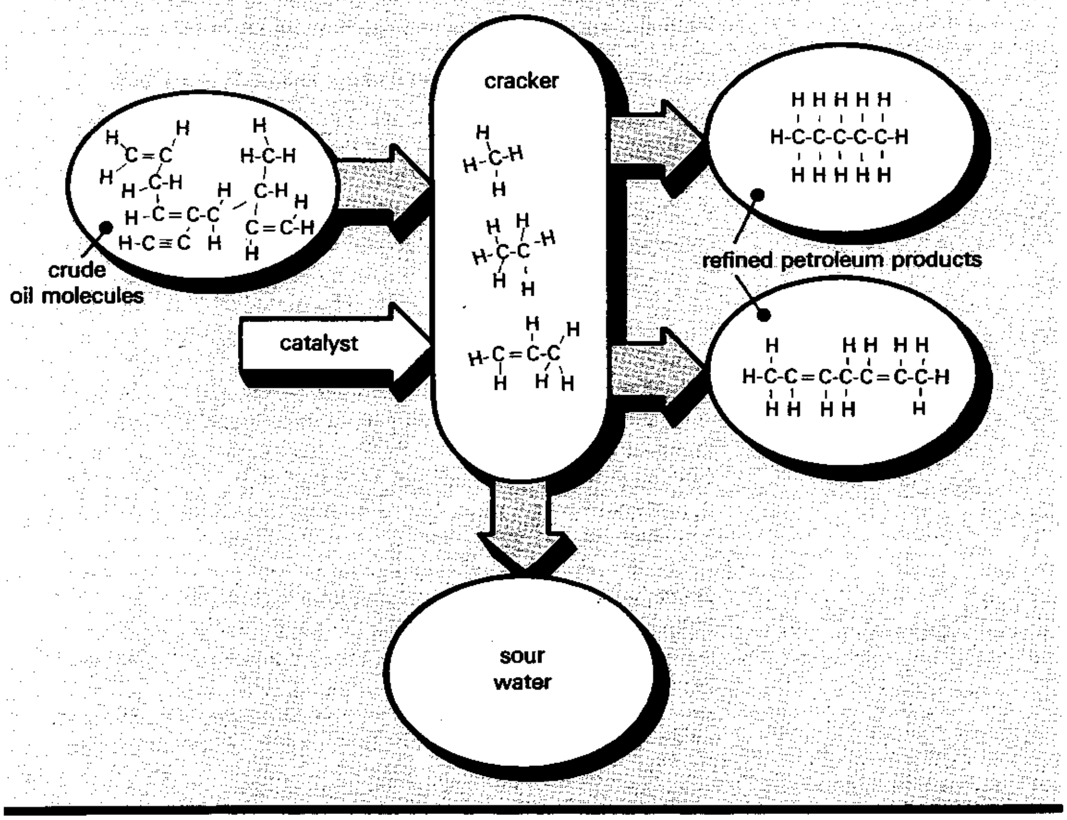
petroleum refining

The petroleum refining industry, one of the five largest industrial wastewater dischargers in the nation, requires large volumes of water to produce its products. Sour water, which results from some of its refining processes, contains high concentrations of sulfur and cyanide compounds, and ammonia. Treatment techniques employ a form of steam stripping known as sour water stripping. This process offers the benefit of recovering ammonia and sulfur which can later be sold. Unfortunately, the sour water stripping process has not been as efficient in removing high concentrations of ammonia as predicted. Apparently, other constituents in the sour water are preventing removal of the ammonia.

ORD, along with the American Petroleum Institute, is conducting studies to determine the feasibility of using wastewater from several industrial stripping operations to determine what constituents in sour water prevent efficient stripping. The results of this project will assist engineers in predicting the concentrations of sour water constituents that can be stripped, and in designing more effective stripping systems.

Research efforts in the petroleum refining industry are also being directed at the catalytic cracking process, a major source of sour water. Catalytic cracking involves splitting large crude oil molecules into smaller molecules, as described schematically in the figure below.

catalytic cracking



EPA, in cooperation with the Oil Refiners Waste Control Council and Oklahoma State University, is characterizing and treating effluents from catalytic cracking operations. Through intensive treatment of the effluents from these operations, the cost of "end of pipe" treatment for wastewaters from the entire petroleum refining process can be reduced.

Pilot plant testing of treatment methods is underway at an operating petroleum refinery which is currently using biological treatment. If these treatment methods prove to be effective in treating wastewaters from catalytic cracking operations, then recycle/reuse techniques may be applied throughout the petroleum refining industry.

pesticides

The manufacture of pesticides involves substantial production of toxic chemicals. In conjunction with treatability research, the EPA is developing a guideline document to review best available technology to support 1984 effluent limitations and standards. The document will concentrate on identifying pesticides industries and evaluating wastewater control and treatment technologies. In support of this effort, the Environmental Monitoring Systems Laboratory in Research Triangle Park (EMSL-RTP) is developing analytical procedures for measuring pesticide and priority pollutant levels in wastewaters.

In a recent study, the Industrial Environmental Research Laboratory in Research Triangle Park (IERL-RTP) investigated the treatability of three herbicides and one fungicide. Pesticide wastewaters were sampled, analyzed, and treated using small-scale activated sludge and activated carbon adsorption systems. To determine the effectiveness of treatment, measurements were made on several parameters: removal of pesticides, levels of biological and chemical oxygen demand, and color. Research is currently underway to assess the treatment of five additional pesticides through similar chemical and biological characterizations.

inorganic chemicals

The inorganic chemical industry comprises about 1,600 plants, produces 110 million metric tons of products annually, and generates 40 million metric tons of wastes per year. Large quantities of water are used for cooling, processing, product washes, waste transport, and other production purposes. Resulting wastewaters contain heavy metals and cyanide, suspended solids, fluoride, iron, ammonia, and have a high chemical oxygen demand. Although many plants operate sophisticated treatment systems capable of producing high quality effluents, the inorganic chemical industry continues to have significant water pollution problems which are difficult and expensive to solve.

Projects in support of research and development in the inorganic chemical industry are conducted at IERL-Cincinnati. Researchers are currently assessing the industry to identify research and development needs for solving major air, water, and land pollution problems.

battery manufacturing

Low concentrations of toxic metals such as lead, arsenic, cadmium, and antimony are often contained in battery manufacturing wastewater discharges. Wastewater treatment technology is expensive, both in terms of high costs and large land requirements. Since most battery manufacturing operations are inside cities, neither land nor money to purchase high-priced land, is available for building large treatment facilities.

ORD is involved in the development and demonstration of a microfiltration treatment system for battery manufacturing wastewater that is both compact and inexpensive to operate. The system filters out heavy metals which remain in the suspended solids after primary treatment, thereby producing a final effluent suitable for discharge into waterways or to local municipal treatment plants. Results of a one-year demonstration at a battery manufacturing plant show that the microfiltration system is successful in producing a final effluent that more than meets the regulatory requirements for this industry.

metal finishing

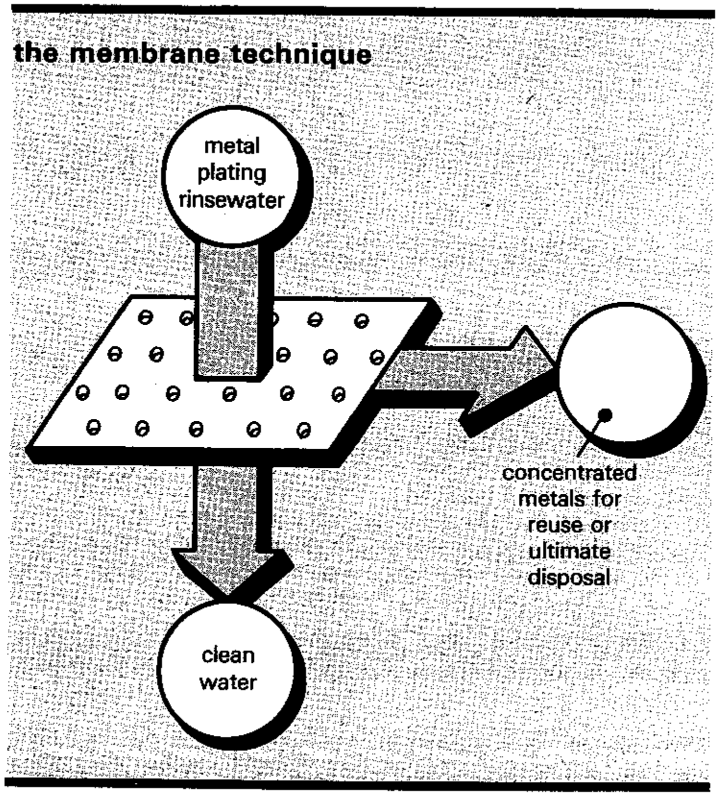
Metal finishing operations daily produce more than 1 billion gallons of wastewaters containing toxic heavy metals and cyanide. Metal finishing processes add a protective metal coating or plating to metal surfaces such as precision instruments and tools, or to nonmetallic surfaces such as plastics.

An object is plated by being submerged first in a plating tank and then in a series of rinse tanks. The concentration of heavy metals declines in each consecutive bath until the product is essentially "clean." As the concentration of metals increases in the rinse baths after extended use, the bathwater must be discharged and replaced.

Over the past several years, ORD has assisted in developing several methods for the cost effective treatment of waste rinsewaters from metal finishing plants. The most promising methods involve membrane and electrochemical techniques, and centralized waste treatment.

Using membrane techniques it is possible to concentrate rinsewater pollutants on the membrane through which the rinsewater is passing while simultaneously generating an effluent stream which is relatively pollutant free. The effluent can then be discharged, or reused in the process, while the concentrated pollutants can be returned to the plating bath or treated by chemical means. Major benefits of membrane technologies are that they recover reagents used in the process, do not require the addition of treatment chemicals, do not generate sludge, and are low in energy consumption.

Recently ORD, in cooperation with the Metal Finishers Foundation, initiated a full-scale demonstration of an electrochemical reactor at an operating metal plating plant. This reactor removes heavy metals and cyanide from the rinse tank water through electrical attraction, thereby preventing accumulation. In the process of removing toxic pollutants



from wastewater, heavy metals may also be recovered for possible reuse.

The electrochemical reactor occupies minimum floor space, can be used within the metal finishing process, and has the potential for not generating sludge if the metals recovered can be reused. A full-scale demonstration of this reactor will be undertaken to verify reductions in wastewater flow, pollutant concentrations, chemical use, and costs.

Although inexpensive treatment technologies for metal finishing wastewaters are being developed, the total cost of pollution control will be high because of the enormous number of metal finishing plants in the U.S. It is estimated that there are currently about 20,000 electroplating plants in operation. Although some plants will not suffer financially from implementing wastewater treatment technologies, EPA predicts that some plants in the metal finishing industry may be forced to close because of the high cost of installing and operating treatment systems. Clearly, the need exists for an alternative to individual plant onsite treatment that will remedy wastewater problems without debilitating a significant portion of the industry.

One method is centralized waste treatment. Centralized treatment of wastes is possible where industries producing similar types of waste are located in close enough proximity to allow the economical transportation of waste materials. Wastes can either be treated at one centralized location, or individual plants can exchange wastes and treat those for which they are best technologically suited. The Federal Republic of Germany has successfully used this concept of industrial wastes treatment for many years, and the Office of Research and Development is examining its feasibility in the United States.

To investigate the technical and economic feasibility of centralized treatment of metal finishing wastewaters, EPA is studying five geographical areas with the highest densities of metal finishing facilities.

Centralized Waste Treatment systems are being conceptualized for these five areas and one case study has been chosen for detailed analysis and design of a facility which will be considered for future demonstration. The information generated from this project will be useful in making decisions about broad U.S. utilization of the centralized treatment concept.

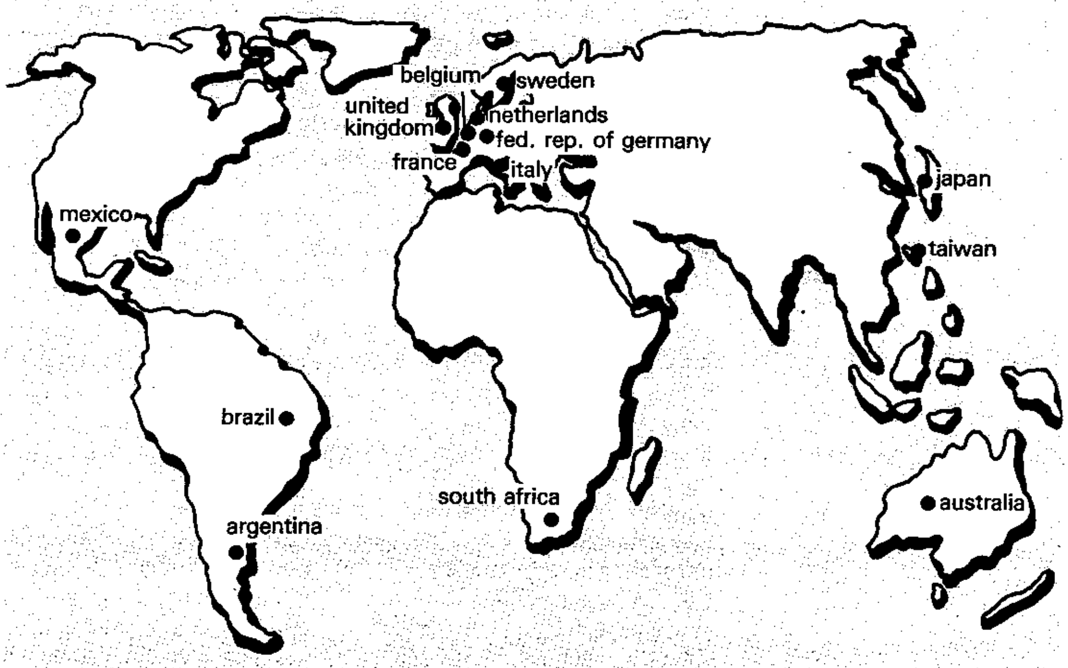
iron and steel

Water pollution is among the major environmental problems associated with the iron and steel industry. The largest single industry in the U.S., it has an annual production capacity of approximately 150 million metric tons. Wastewaters from steel plants contain such pollutants as suspended and dissolved solids, oils and greases, phenols, cyanides, ammonia, sulfide, and have a high biochemical oxygen demand.

ORD is using two mobile wastewater treatment systems to investigate the effectiveness of advanced wastewater treatment technologies for steel plant effluents. The systems house equipment for advanced physical/chemical treatment, as well as biological treatment.

Initial studies using mobile wastewater treatment systems have focused on coke plant and blast furnace wastewaters, two of the most contaminated wastewaters found in steel plants. Additional work will be carried out over the next few years on wastewaters which the Agency considers to be

foreign countries surveyed



most important. Data from these studies will support development of effluent limitations and standards for the industry as well as provide information to help industry meet established requirements. Efforts are also underway to evaluate foreign water pollution control technologies for treating coke and blast furnace effluents. Significant technological advancement in the control of pollutants has been made in recent years in both domestic and foreign iron and steel industries.

To accumulate the most current information on the state-of-the-art of water pollution control in the iron and steel industry, ORD scientists are visiting plants in the 14 countries in Europe and the Far East highlighted on the map above. Sampling and analysis of plant effluents is performed at local laboratories, and analyses are made for applicable conventional, nonconventional, and toxic pollutants at various treatment stages.

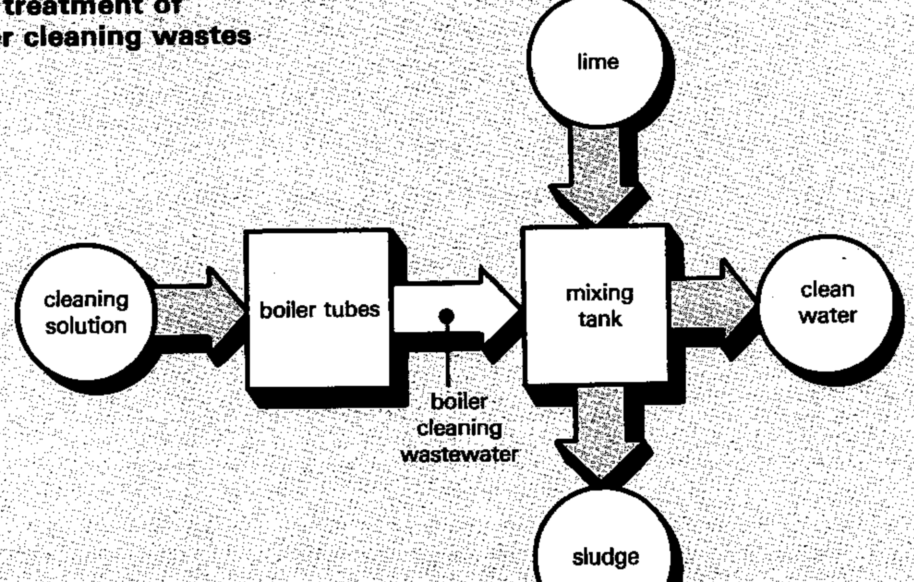
After sampling results are analyzed, the best foreign technologies will be ranked according to the cost and efficiency of contaminant removal. Where foreign technologies are found to be superior to domestic technologies, their applicability to domestic industry will be determined. The results of this research will aid U.S. industry and State and Federal regulatory agencies in developing water pollution control technologies for iron and steel plants.

steam electric power

Large quantities of water are used by the steam electric power industry, but most is used for steam generation, or cooling, and is returned to its source containing few pollutants. However, boiler cleaning operations at these power plants result in wastewater containing toxic pollutants. During operation, corrosion products accumulate in the boiler tubing and, if uncontrolled, cause the power plant to become less efficient. These corrosion products contain heavy metals such as iron, copper, zinc, and nickel. Strong chemicals are used to dissolve the corrosion products in the cleaning process. As a result, the heavy metals previously contained in the boiler tubing are put into a solution which ultimately becomes a toxic industrial discharge.

The Industrial Environmental Research Laboratory in Research Triangle Park (IERL-RTP), in cooperation with the Utilities Water Act Group, which represents the steam electric power industry, is conducting numerous laboratory studies to assess the effectiveness of lime treatment in precipitating and removing heavy metals in boiler cleaning solutions. The diagram below illustrates this treatment concept. Boiler wastewaters from six steam electric power plants using different boiler tube cleaning methods are presently being treated and analyzed. The results of this project will demonstrate which boiler cleaning methods used in conjunction with lime treatment can achieve the highest quality wastewater, and will provide EPA with the data on which to base effective effluent limitations and standards.

lime treatment of boiler cleaning wastes

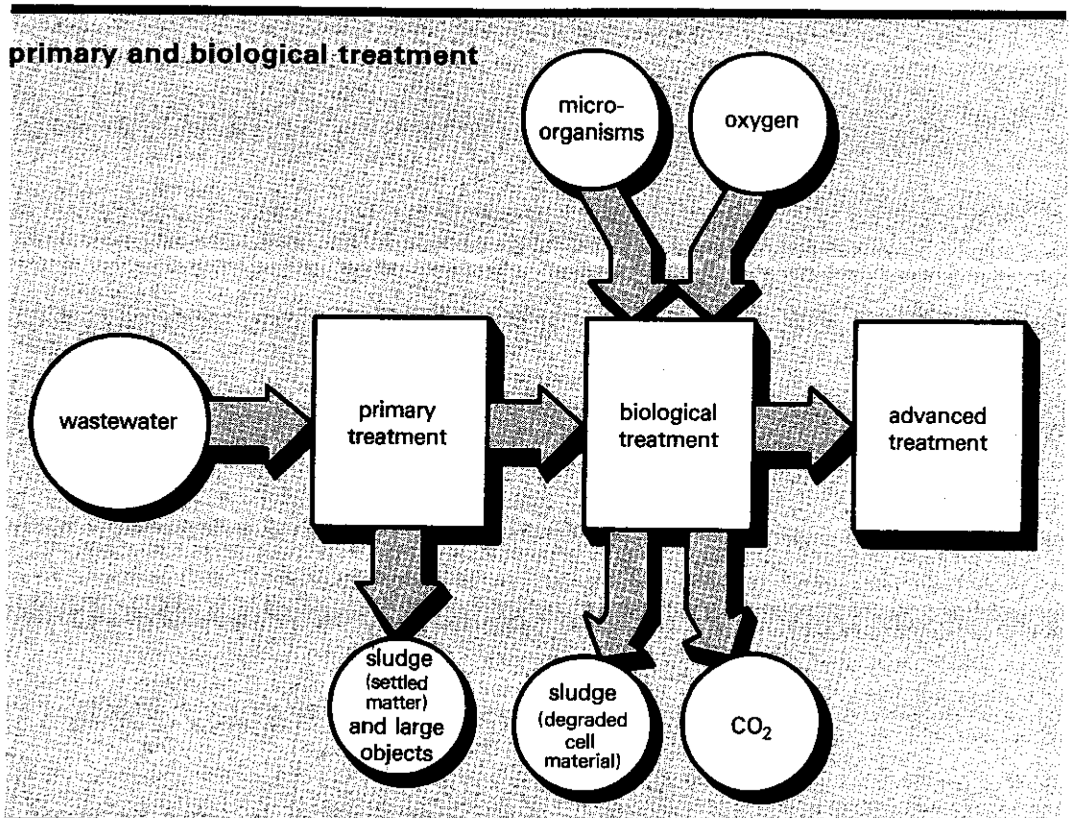


textiles

Wastewater from textile mills presents an environmental problem in several regions of the U.S. due to the large volume and the widely varying and specialized character of the wastes. Textile processing plants utilize a variety of dyes and chemicals such as acids, bases, salts, detergents, and finishes. Many of these are not retained in the final textile product but are discarded in wastewaters after they have served their purpose.

A study initiated in 1974 is being conducted jointly by EPA, the American Textile Manufacturers Institute (ATMI), the Carpet and Rug Institute (CRI), and the Northern Textile Association (NTA) to gather sufficient technical and economic data to identify the BATEA for removing priority pollutants from textile wastewaters. To evaluate the Best Available Technology, two mobile pilot plants have been constructed for treatment studies. During the first phase of the study, seven advanced treatment processes were evaluated at 23 textile plants.

The second, and current, phase of the study addresses the reduction in toxicity and priority pollutant concentrations achieved by those technologies. There are three major levels of wastewater treatment: primary treatment to remove pollutants which will settle or float; biological treatment, to speed up the breakdown of degradable organic pollutants; and advanced treatment, for further removal of pollutants



when biological treatment is inadequate. Results to date have shown that in cases where acute toxicity is observed in fish and algae exposed to textile plant effluents which have received biological treatment, advanced treatment often results in a nontoxic effluent. Data from this study and other information collected by EPA's regulatory offices will be used to propose 1983 effluent limitations and standards for the textile industry.

leather processing

Water is used extensively to process leather in cleaning, tanning, and dyeing operations. Cleaning is required to remove flesh and fat from the inside of animal skins. Tanning involves soaking the skins in chemicals to produce a flexible, long lasting product. And dying involves numerous chemicals to color the hides. Consequently, the process effluents are high in BOD and suspended solids, rich in process chemicals, and noticeably colored.

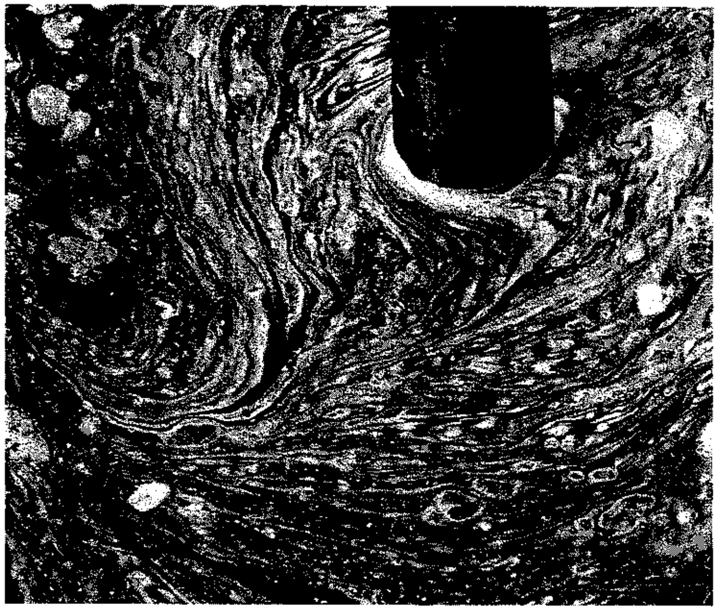
Wastewater from leather processing is treated to settle suspended solids. The resulting water does not, however, meet effluent guidelines. In 1976 EPA initiated a full-scale demonstration of the use of an oxidation ditch in which many of the pollutants in wastewater can be biologically degraded by bacteria and other microorganisms. After extended full-scale operation, it has been shown that this treatment method is successful in producing water which meets effluent limitations. This treatment technique represents not only the best available technology for the leather tanning industry, but the most cost effective method available as well.

The success of this project has encouraged EPA's support of further research and development at the tannery. The new phase of the project involves full-scale demonstration of the addition of powdered activated carbon (PAC) to the oxidation ditch system to further reduce priority pollutants which remain in the effluent in very low concentrations. The project will result in data on the costs, personnel requirements, and operational problems of PAC/biological treatment on which to base future technological developments.

paper

More than 7 billion gallons of wastewater are discharged daily by pulp and paper mills across the country. Soap-like resins and the fatty acids of pulp and paper manufacturing effluents are suspected of contributing to foam problems on rivers, streams, and lakes receiving mill effluents. In Maine, the threat to the aesthetic quality of the Androscoggin River due to unsightly mounds of foam, was first brought to the public's attention by local duck hunters. Four pulp and paper mills occupying sites along the river were the target of complaints by area residents. However, since municipalities and other industries line the river's banks, and since the river has its own natural foam, the blame could not be fairly placed entirely on the pulp and paper industry.

EPA, in cooperation with Maine's Department of Environmental Protection, recently initiated a study to look into ways of eliminating foam from pulp and paper mill effluents. Three river surveys are being conducted on the Androscoggin River



Doug Wilson/EPA-Documerica

to determine which chemicals are causing the foams, and to develop foam removal techniques and mill effluent treatment systems.

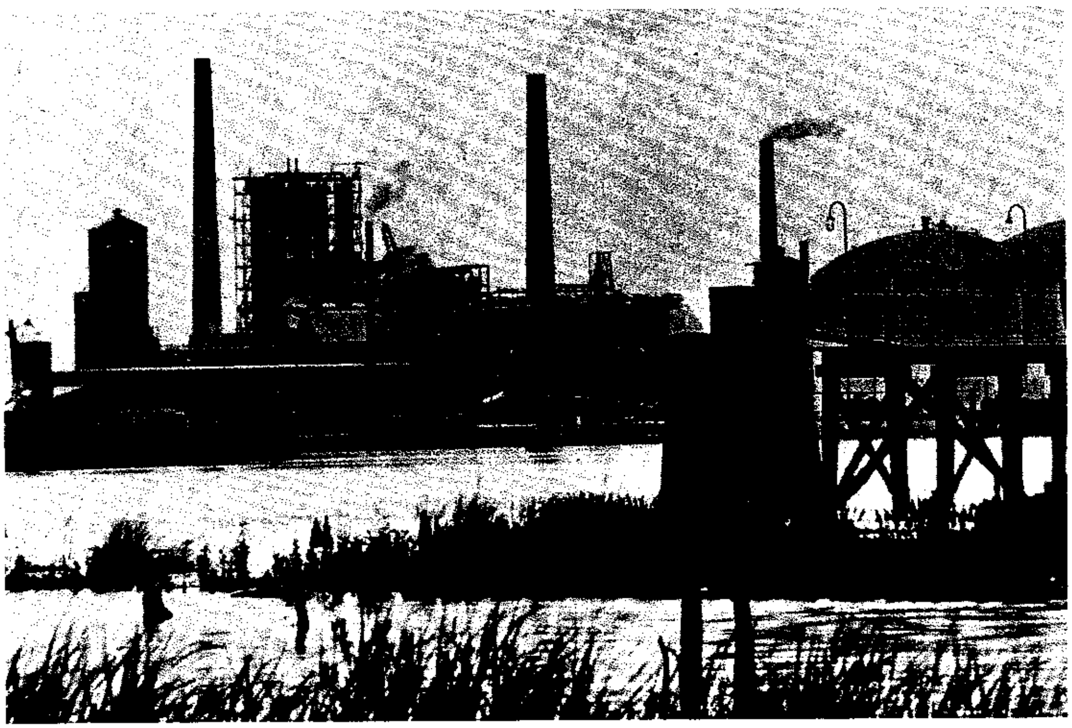
Treatment technologies involving the elimination of foam through recovery of resin and fatty acids, technologies currently employed in Southern mills, are a prime consideration for use in Northern manufacturing plants. Foam separation and chemically assisted treatment techniques are also being evaluated in this study.

environmental fate studies

The fate of priority pollutants in the biological treatment of wastewaters from the wood preserving, pharmaceuticals, petrochemicals, petroleum refining, pesticides, and rubber industries is the focus of much research at ORD's Robert S. Kerr Environmental Research Laboratory in Ada, Oklahoma. A major objective of this research is to determine whether the priority pollutants that are removed from wastewater in biological treatment are degraded to an innocuous state, or if they are transferred to another medium such as the air, or to sludge where they create new pollution problems.

Observations from sampling and analysis at industrial sites have shown that biological treatment is generally very successful in removing priority pollutants from wastewaters. However, some priority pollutants are removed from the wastewater but appear in significant quantities in air emissions and sludges. Compounds not originally present in the untreated wastewater are also appearing in air emissions and sludges. Apparently, additional compounds are generated in the biological treatment of industrial wastewaters.

ORD has initiated several studies to further examine the fate of priority pollutants in industrial treatment systems and to determine the origin of these "new" compounds. Researchers are conducting tests using several technologies to treat wastewaters from the pharmaceuticals, organic chemicals, and electronics industries. A complete analysis of air emission, sludge, influent, and effluent at each site for each treatment will provide the data which may lead to new industrial wastewater control theories.



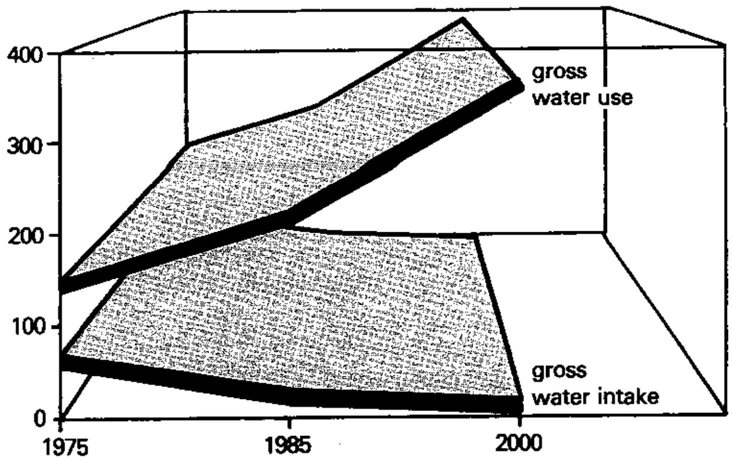
reuse, recycle and process modifications

Water use practices in industry have undergone radical changes in recent years. Whereas early water pollution control measures focused on "end of pipe" treatment to reduce the hazardous potential of industrial discharges, recent legislation, which has a goal of zero pollution discharge by 1985, has encouraged recycle/reuse alternatives. As shrinking fresh water supplies become an increasing problem, recycle/reuse systems are gaining attention as water conserving techniques. In California, for example, repeated cycles of drought and flooding have prompted the State to enact a law allowing allocations of fresh water only if manufacturing facilities can prove they cannot operate on, or cannot locate, used water. Industrial wastewater recycle/reuse systems offer the additional advantage of allowing reagent and by-product recovery and reuse.

Major benefits of recycle/reuse systems include: reduction of wastewater volume; reduction of intake water and related harmful effects to aquatic life; improved treatment efficiency; conservation of water, raw materials, and other natural resources; and containment of conventional and toxic pollutants. Water reuse can bring about intake reductions by reusing the effluent of one process or plant in the same, or another, process or plant. Treatment of each effluent must be tailored to its contaminants and its next use. Effluent from another process may be used directly in processes which do not require pure water. In contrast to water reuse, water is recycled in a closed loop and is continuously applied to one production process. Such a cycle usually includes a treatment system to remove contaminants from the process water to a degree suitable for reuse.

Continued research on wastewater treatment technology is essential because treatment will not only remain a major method for pollution control for many years to come, but is also an inherent part of any recycle/reuse system. Industry involvement in EPA's program is encouraged for the benefit of the program and for the benefit of industry as well. The fact that industrial water intake has been falling dramatically while gross water use has been steadily rising is indicative of this increasing industrial awareness of recycle/reuse technologies. This trend in water use is expected to continue at least through the rest of the century, according to U.S. Department of Commerce projections.

projected manufacturing water use patterns



source: U.S. Department of Commerce

recycling in steam electric power plants

Recycle/reuse efforts are gaining attention in the steam electric power industry. Water-cooled power plants are well known for their abundant water use. The water coming into the plant must first be treated to ensure that suspended and dissolved solids will not settle, clog the cooling system, and reduce its efficiency. In a coal-fired power plant, fly ash produced in the combustion process is sluiced or flushed from the system. As a result, the treated water regains dissolved solids from the fly ash as it passes through the cooling system. In the past, water involved in the cooling process was used on a once-through basis to prevent the buildup of fly ash solids and subsequent cooling system clogging.

In an effort to reduce water intake requirements and achieve zero wastewater discharge in coal-fired plants, IERL-RTP is building a mobile pilot plant which will be able to remove dissolved solids in water from a wet sluicing operation so that the water can be recycled in the power generation process. Pilot plant demonstrations will be carried out at three operating power plants.

closed loop fiberglass production

Large volumes of water are used in the production of fiberglass, particularly in the cooling process. To melt the glass and form the fibers, high temperatures are required. Once the fibers are formed, they are cooled with water. One fiberglass textile industry plant, through an EPA grant, has implemented a closed loop system for the reuse of process water. Prior to the initiation of this project in 1973, approximately 350 gallons of water per minute were discharged from the plant following primary and biological treatment. To obtain water of suitable quality for reuse, a three-stage advanced treatment system was added to the facility. The first stage, sand filtration, removes biological solids; the second stage, carbon adsorption, removes organic chemicals; and finally, chlorination provides adequate disinfection. Under present operating conditions, an 80 percent discharge reduction to approximately 70 gallons of water per minute has been achieved. It is expected that zero wastewater discharge will be achievable in the very near future.

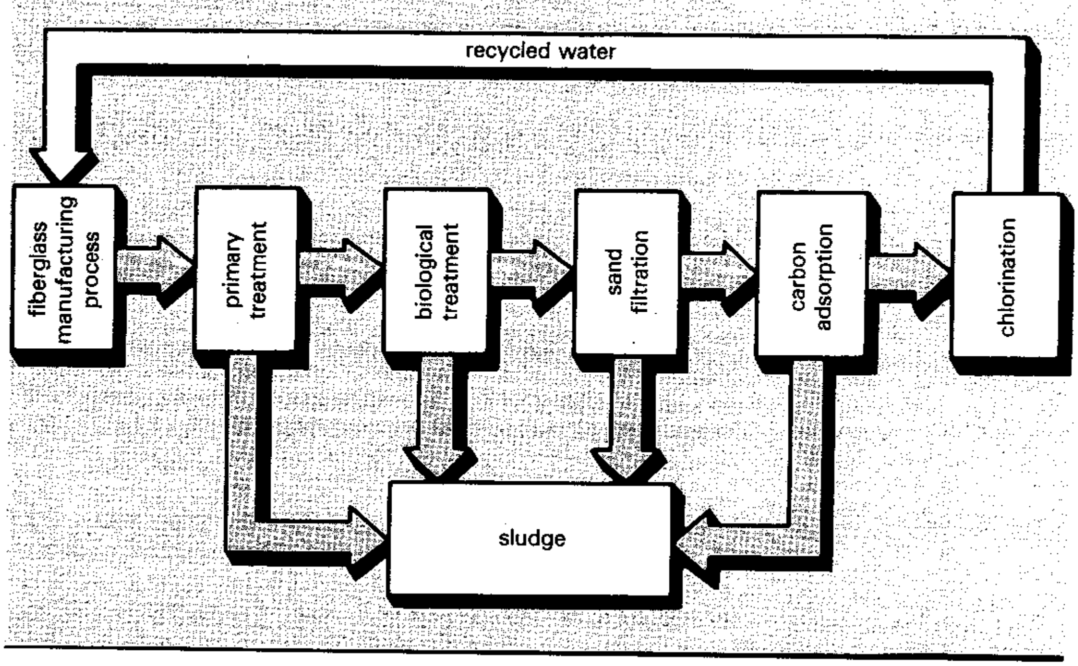
When the system is complete, the only intake water required by the industry will be that needed to compensate for evaporation and other small losses. This intake water should amount to approximately 130 gallons per minute—a considerable reduction from the 1,000 gallon-per-minute requirements of many fiberglass plants prior to implementation of recycle/reuse programs. A schematic view of the closed loop system is shown in the figure below.

closed cycle dyeing

In textile operations, dyes, and chemicals used to set dyes, are typically diluted with effluent from the rest of the plant. The effluent is then treated and discharged. Since pure water for dyeing is necessary for obtaining high quality colored fabrics, dye water is typically used on a once-through basis. As a result, industries must make large expenditures to treat and remove the color from water which they never use again.

In an effort to eliminate dye water discharges from textile plants, reduce intake water needs, recover materials, conserve energy, and save money, EPA has funded a major

the closed loop system



project to evaluate and demonstrate closed cycle dyeing. The technology which is applied is called reverse osmosis or hyperfiltration.

Reverse osmosis is a method of reversing nature's osmosis process in which a dilute or less concentrated solution passes spontaneously through a semi-porous membrane into a more concentrated solution. In reverse osmosis, sufficient pressure is applied to the concentrated solution to reverse the flow through the membrane. Membrane filters are designed to prevent molecules or dissolved solids larger than a designated size from passing through. In this way, the quality of the recycled water is strictly controlled.

The closed-cycle dyeing project initiated in 1977 includes: the preliminary evaluation of hyperfiltration membranes; the construction of a demonstration unit designed for installation at a fiberglass plant; and a twelve-month, full-scale operation of the closed-cycle system.

non-treatment alternatives

For those industries at which recycle/reuse is not possible, EPA is examining "nontreatment" alternatives. The theory behind nontreatment is to modify the industrial process so that there is no pollution produced in the first place. Modifications include process changes, such as water reduction techniques, and material substitutions, which involve using less polluting materials in manufacturing. These methods of industrial wastewater control may prove to be more efficient and economical than "end of pipe" wastewater treatment.

activated carbon regeneration

One million gallons or more of wastewaters saturated with pesticides are produced daily at many pesticide manufacturing plants. Biological treatment alone often does not successfully remove toxic organics from wastewater and, in many instances, the pesticides are poisonous to microorganisms used in the treatment process. For this reason, activated carbon treatment has been applied extensively in the pesticides industry. When the carbon becomes "loaded" through continuous adsorption of soluble components in wastewater, it is either discarded or regenerated. Due to the high cost of activated carbon, many industries have implemented regeneration technologies. Thermal regeneration is frequently employed. However, this process is often not considered to be a desirable alternative because it is expensive, highly energy consuming, and is not applicable for many types of wastewater.

EPA, in cooperation with private industry, is developing and laboratory testing the use of high pressure carbon dioxide, or supercritical fluid CO_2, for regenerating activated carbon in an inexpensive and energy conserving manner. As supercritical fluid CO_2 passes through the activated carbon, it removes the adsorbed pesticide components by putting them into solution. The pesticide components are later separated out of solution, and with further purification can be sold as dry pesticides or recycled back into the process. In this way, resource recovery is also made possible. The success of this technology has inspired future ORD research. Plans to initiate programs involving pilot and full-scale demonstrations of supercritical fluid CO_2 at pesticide manufacturing plants are under consideration.

water reduction in food processing

The development of techniques to reduce the amount of water used in food processing has been a major focus of ORD research for several years. Dry peeling, recently initiated in potato processing, represents an important breakthrough for the food processing industry. Prior to dry peeling, large volumes of water directed at high pressure forced the peels off of potatoes. In the dry peeling process, potatoes and other fruits and vegetables, are pretreated to soften the skin and then moved over rubber rollers which wear off the peels. In 1969, EPA funded the first commercial plant in the world, in North Dakota, to implement full-scale dry peeling. The success of that project has encouraged the widespread use of this technique. Currently, about 250 food processing plants around the world use dry peeling in the preparation of beets, tomatoes, pears, peaches, carrots, etc. Because food processing wastes contain such high concentrations of organic matter, water pollution problems can also be reduced through water reduction processes.

future research

Over the next 5 years, ORD's research will continue in three major areas: determining and analyzing industrial wastewater sources, evaluating and developing control methods, and developing recycle/reuse alternatives.

Any meaningful pollution control strategy requires the ability to determine which pollutants are, and will be, created; as well as the ability to accurately measure those pollutants. Analyses will be performed to determine probable future pollutant problems, and their environmental impacts. In order to assess those impacts, dependable methods of determining the presence and concentration of pollutants will be developed. One such method calls for the determination of indicator organisms or substances which have characteristics similar to problem pollutants, and are usually found in the same contaminated water, but are easier to detect.

A second major focus of future ORD research will be the evaluation and development of pollutant control techniques. Continued research will be performed on the treatability of specific pollutants by a wide range of conventional biological, physical, and chemical methods. Since individual pollutants increasingly disrupt, or are incompatible with, traditional treatment processes, more emphasis will be placed on developing new technologies or nontreatment alternatives, to meet changing pollution control problems. This may involve either process changes or raw material substitutions to eliminate or minimize the production of toxic wastes.

In light of national energy concerns, a final major area of focus will be the continued development of reuse/recycle alternatives. Research in this area has previously focused on industries producing highly toxic chemicals, or on industries for which alternative wastewater solutions are not being brought into full-scale operation. Future research efforts will emphasize the development of reuse/recycle techniques which are applicable to a variety of installations, and on reuse/recycle alternatives which will result in more efficient pollution control.

individual research projects

The projects described in this Research Summary represent only a small fraction of ORD's Industrial Wastewater Control Program research efforts. Selected projects being performed by or through the various ORD laboratories are listed below.

industrial environmental research laboratory (IERL) — cincinnati, ohio

- Multi-media Assessment of the Inorganic Chemicals Industry
- Removal of Cadmium by Activated Carbon from Industrial Wastewaters
- Evaluation of Soluble Sulfide Precipitation at a Primary Nonferrous Copper-Lead Smelting Complex — Boliden
- Treatability of Priority Pollutants by Amoco Powdered Activated Carbon-Enhanced, High Sludge-Age Treatment System
- Evaluation of Synthetic Adsorption Media for Priority Pollutant Control
- Investigation of Treatment Technology for Dyes Manufacturing Wastewaters
- Effluent Guidelines Development Sampling Analysis Program for Nonferrous Metals Smelting and Refining Subcategories
- Economics of Wastewater Treatment Technologies
- Field Demonstration New Reverse Osmosis Membranes for Closed-Loop Treatment of Electroplating Rinsewater
- Plating Catalysts: Change to a Less Polluting Process
- Demonstration of Electrodialysis for Recovery of Chromium from Decorative Chrome Plating
- Development of Electrodialysis for Recovery of Fluoborates from Fluoborate Plating Rinsewater
- Electrochemical Coagulation Study for Fish Processing Wastewaters
- Development of Chemical Toxicity Assay for Pulp Mill Effluents
- Protein Recovery from Meat Packing Effluent
- Demonstrating BAT for Slaughterhouses in Cold Climates
- Water Renovation and Reuse in Poultry Processing
- Treatment of Wood Preserving Wastewater Containing Phenolic Compounds Using Existing Technology
- Multi-media Pollution Assessment in the Wood Preserving Industry
- Advanced Filtration of Pulp Mill Wastes
- Elimination of Phenolic Materials in Bleach Wastes

industrial environmental research laboratory (IERL) — research triangle park, north carolina

- Removal of Toxic Pollutants in Textile Wastewaters by Powdered Activated Carbon
- *Chesapeake Bay Study*
- Coagulation Tests for Removal of Metals from Wastewater
- Field Testing and Laboratory Studies for the Development of Effluent Standards for the Steam Electric Utility Industry
- Comparison of Model Predictions and Consumptive Water Use of Closed Cycle Cooling Systems at Selected Power Plants
- Characterization of Effluents from Coal Fired-Power Plants
- Thermal Pollution Control State-of-the-Art Manual
- Assessment and Control of Wastewater Contaminants Originating from the Production of Synthetic Fuels from Coal
- Demonstration of Charged Fogger on Full Scale Iron and Steel Fugitive Dust Forces
- Sinter Plant Windbox Gas Recycle System Demonstration
- A Portable Pilot Study to Develop Optimum Steel Plant Wastewater Treatment Systems
- Evaluation of Steel Plant Wastewater Treatment Using a Mobile Wastewater Treatment System

robert s. kerr environmental research laboratory (RSKERL) — ada, oklahoma

- Indication of Refractory Organic Compounds from Treated Refinery Wastewaters
- *Mutagenistic Testing of Industrial Waste from Representatives of Organic Chemicals Industry*
- Treatment of Petrochemical Wastewater for Reuse
- Solvent Extraction for Treatment and Recovery of Chemicals from Acetic Acid Production Wastewaters
- *Solvent Extraction of Organic Priority Pollutants from Waters*
- Susceptibility of Metals to Treatment in Combined Industrial-Municipal System
- Study and Analysis of Muncie Indiana Pretreatment *Program*
- Treatment Compatibility of Muncipal Waste and Biologically Hazardous Industrial Compounds

for further information

publications

- EPA Research Outlook. February 1980. EPA-600/9-80-006. 224 Pages.

  A description of the EPA's plans for future environmental research.

- EPA Research Highlights. January 1980. EPA-600/9-80-005. 99 Pages.

  Highlights of the EPA research and development program of 1979.

- EPA/ORD Program Guide. October 1979. EPA-600/9-79-038. 85 Pages.

  A guide to the Office of Research and Development — its organizational structure, program managers, and funds available for contracts, grants, and cooperative agreements.

- EPA Research Summary: Chesapeake Bay. May 1980. EPA-600/8-80-019. 32 Pages.

- EPA Research Summary: Controlling Hazardous Wastes. May 1980. EPA-600/8-80-017. 32 Pages.

- EPA Research Summary: Controlling Nitrogen Oxides. February 1980. EPA-600/8-80-004. 24 Pages.

- EPA Research Summary: Acid Rain. October 1979. EPA-600/8-79-028. 24 Pages.

- EPA Research Summary: Oil Spills. February 1979. EPA-600/8-79-007. 16 Pages.

Information on the availability of these publications may be obtained by writing to:

Publications
Center for Environmental Research Information
US EPA
Cincinnati, OH 45268

technical reports

The Office of Research and Development has published hundreds of technical reports on industry-specific wastewater control technologies for specific industries. A listing of these publications and information on how to obtain them is available by requesting the EPA Publications Bibliography (NTISUB/E/042-04) from the above address.

conferences and workshops

The Office of Research and Development periodically sponsors various conferences, workshops, and seminars to inform environmental scientists, engineers, policy makers, and the interested public of the latest research and development accomplishments. Individuals interested in information about upcoming conferences should write to:

ORD Conference Coordinator
Center for Environmental Research Information
US Environmental Protection Agency
Cincinnati, OH 45268

questions or comments

The Office of Research and Development invites you to address any questions or comments regarding the EPA industrial wastewater control research program to the appropriate individuals listed below:

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