Industrial Environmental History

Introduction to History of Environmental Wastes

The pollution of ground and surface waters in the United States began as soon as industry began producing manufactured goods and wasting liquids and solid matter simultaneously. One needs only to trace the Industrial Revolution period in the United States.

Industrial liquid effluents can be traced as far back as the nineteenth century. If we define pollution as that amount of industrial contamination that causes interference with the best usage of the receiving water, we can probably agree that this type of pollution did not begin until the turn of the twentieth century. Basic industries such as coal, power production, dairy, textile, cannery, tannery, and paper, which produce goods necessary for the sustenance of life, were the first to face the pollution problem.

Chemical industries, mainly inorganic, such as salt and salt degradation products including chlorine, lye, and soda ash, were next chronologically and in importance. These were followed by basic organic chemical plants, such as sugar, starch, and cellulosic wastes.

In the 1930s, all these industries began to be aware of the eventual danger of their wastes when sent untreated into waterways. It was natural for industry at that time to follow the lead of municipalities in using similar treatments to attempt to resolve their pollution problems. Then came World War II and its accelerated industrial production activity. New products and new wastes evolved and the quantity of older ones, such as metal plating, oil refining, and textiles increased tremendously.

Radioactivity, petrochemical, and synthetic organic chemicals were largely developed and surfaced in the environment in the 1940s and 1950s. During this period, major environmental problems surfaced with rapid and serious consequences.

Heretofore industrial waste treatment followed the examples of municipal waste treatment with certain variations in efficiency. The reason for success up to this point was the relative compatibility of these industrial and municipal wastes.

After the 1940s, however, new industrial products produced new wastes that exhibited toxicity as well as nonbiodegradability. These wastes did not respond to normal municipal (sewage) waste treatment. Industry found itself in a dilemma that persisted for several decades. Many decided to use antiquated municipal treatment methods despite knowing that the wastes would not respond appropriately and would find their way into the environment with disastrous results. At the same time industry and governmental agencies conducted serious studies to find appropriate treatment of these new wastes. Unfortunately, even today we find ourselves in much the same position as 50 years ago, although some progress has been made by recycling and changing production methods and materials.

The move to pollution prevention has been a slow one. It wasn't until the 1930s that the nation acknowledged that solving its pollution problems would require time, study, and most of all, money. Many of the early answers to these problems were stopgap measures intended to prevent overloading the environment. All too often, "solutions" were selected based on economics. Eventually company managers began to realize that recovering and reusing or selling their wastes was more practical and economical than treating and disposing of them.

Reuse began in the 1950s, when companies started to recover metals from plating wastes, fatty hides and hair from tannery wastes, and fine fibers from papermill wastes. By the 1980s companies also were reusing water and burning waste oil to produce energy. Recovery and reuse or sale of waste products grew but has been hampered by transportation hazards and costs, the difficulty of locating buyers, frequent disparities between supply and demand, and industry's discomfort with fully disclosing waste characteristics to potential buyers.

In the late 1990s pollution prevention became the buzzword described as a "win-win" effort. The environment wins because fewer pollutants are created, and industry wins because preventing waste minimizes or eliminates liability and disposal costs.

One of the more promising recent innovations is the creation of emissions and effluent trading programs in which a company spends money to treat or eliminate waste and receives "credits" from an environmental control agency. These credits can be sold to other companies that, for whatever reason, cannot reduce their wastes. The company that sold the credits could use the money to offset part of the cost of reducing or eliminating its waste streams.

This practice too has been slow to gain universal acceptance, because companies are still reluctant to accept the idea of paying for something they have been getting for years at little or no cost. They also recognize that whether they buy credits or pay to reduce or treat their wastes, production costs will still rise. The concept, however, is a good one and, in my opinion, eventually will prevail.

Even pollution trading, however, will not bring us to zero pollution. Achieving this goal will require a more radical approach: the creation of environmentally balanced industrial complexes (EBICs). Under this concept, "compatible" plants would locate in the same complex so that one plant's wastes would be another's raw material. Again, this would reduce production costs while eliminating environmental damages.

Despite the potential advantages of EBICs, which I have been advocating since 1977, several constraints have prevented their widespread acceptance: Relocating plants can be costly, initiating negotiations between compatible plants is difficult, and matching production objectives and quantities is not easy. Even if these obstacles can be overcome, company managers will still require proof that EBICs would reduce "real" production costs, which include direct costs of waste treatment and the indirect costs of environmental damage in addition to the cost of labor, materials, and utilities.

In 1995 and 1996, several colleagues and I studied and reported on the economics of co-locating fertilizer and cement plants in a single complex. The primary objective was to prove that these industries could manufacture their products less expensively if they were located in the same complex. These results and recommendations will be described in detail in Chapter 4. Once real costs are calculated, a comparison can be made between these costs at an EBIC and those at facilities in different locations.

The concept of EBICs was originally proposed for the pulp and paper industry in 1977 (Nemerow 1977). Over the next 22 years we have published many papers containing potential industrial complexes for many industries. Most of these are described in the author's book, *Zero Pollution for Industry* (Nemerow 1995).

The field of industrial waste treatment from the 1940s to the 1980s evolved into one of industrial waste utilization in the 1990s. Society is demanding lower manufacturing costs as well as less environmental degradation. Outside of ceasing production, the use of EBICs is not only the logical answer, but the only response to society's urgent need. The EBIC system must include compatible industrial plants. Such a system completely changes our concept of industrial manufacturing. No longer can we locate industrial plants based solely on the economic marketability of a product, but now we must consider the usefulness of its waste as a raw material for an ancillary plant. To discharge waste untreated into the environment is simply not an alternative. And to discharge the same waste when treated is too costly for both the industry and society. Simple logic dictates that this waste be utilized directly by another manufacturer to save money for the plants and the quality of the receiving environment for society.

Progress of Industrial Revolution

The Industrial Revolution as described by most historians did not happen overnight. It was a gradual, slow-moving process. Its progress was greatly affected by certain manufacturers and certain means of production. Most historians concur that it began in the late 1700s, largely in European countries. Novel machinery introduced in and around 1820 (such as the steam engine and machine-driven textile looms) produced remarkable increases and changes in productivity. From the 1860s, moreover, these same industrial developments intensified to such a degree that the United States already possessed about one-quarter of global world's industrial production. Productivity was enhanced greatly by the advent and increased use of steam power, railways, electricity, and other instruments of modernization.

The German socialist author Friedrich Engels is credited with coining the term, “industrial revolution” in 1844. He also attributed this period to the transformation of an agrarian to an industrial society occurring in England from the mid-eighteenth to the mid-nineteenth centuries.

Progress of the Industrial Revolution was enhanced largely by developments in three major industrial sectors: (1) textile, (2) iron and steel, and (3) power. Each industry, growth was energized by specific patented inventions.

Prior to the rapid development of industry, all factories located on rivers for enhanced transportation of raw materials and products and were powered by this same water. Its elevation was such that it supplied water pressure to the factories to turn water wheels that furnished power to the machinery for production processes.

Textiles, previously manufactured by hand in a multitude of separate homes, began to be mass-produced in factories prior to the mid-eighteenth century. The patented invention in the textile industry was the “flying shuttle” in 1733. Weaving of cloth sped up dramatically when compared to hand-loom weaving. Many other inventions followed in this industry, culminating in Eli Whitney’s cotton gin in the late 1800s. Other spin-offs occurred to society as a whole. When Elias Howe demonstrated in the mid-nineteenth century that a garment could be produced faster with his technology than by up to five women by hand, the textile industry became an American leader in productivity. Interestingly, this industry began in Lowell, Massachusetts, which also became the site of the first industrial pollution research laboratory in the United States.

Iron and steel, previously manufactured by subjecting iron ore to heat treatment with charcoal from trees, now could be reduced in England with coal. Coal proved much more efficient in converting iron ore to pig iron and then to steel. More power, however, was required to force air through the densely packed steel-making furnaces. Fortunately, James Watt’s invention of the steam engine in the 1760s aided in providing this power, which was also used to pump water out of the coal mines. In the United States, like England before it, iron and steel plants located near the coal mines to facilitate transporting coal to the plant. As a result both coal mining and steel manufacturing were located primarily in the eastern United States such as Pennsylvania and Ohio.

Power, originated by Watt’s steam engine, was further developed and enhanced by other inventors to make its equipment less bulky and more mobile. Henceforth, people as well as raw materials and products could be moved easily and more rapidly than ever before.

It was not until the late eighteenth or the early nineteenth century that steam power began to supplement hydropower. Although the latter was less expensive, steam power allowed industry to locate their factories at some distance from waterways and closer to their raw materials and product markets. By the mid-nineteenth century, railroads became available to industry to transport their goods more efficiently than ships.

Ironically, the U.S. government, spearheaded by Secretary of the Treasury Alexander Hamilton, encouraged the growth of the industrial revolution. Hamilton wanted to compete economically with the industrial nations of Europe despite Thomas Jefferson’s belief in keeping the United States a nation of small farms.

Free usage of new patents before 1790 and establishment of a separate bank solely for encouraging industrialization enhanced rapid industrial development. Innovative industrial machinery, when patented after 1790, became a source of revenue for inventors to further encourage industrialization. Mass production of machine parts, stimulated by Eli Whitney's cotton gin and later his firearms parts around the end of the eighteenth century, signaled the real beginning of the industrial era as we know it today.

Working conditions in and around the nineteenth-century factories deteriorated once the scarce labor demand had been satisfied. This brought on labor unions and strikes to attempt to ameliorate working conditions for laborers. However, pollution of the environment outside the plants received little or no attention during this period. In all fairness, the reason for this probably was the sparseness of industrial plants and the abundance of receiving waters.

During the nineteenth century, raw materials and finished products were transported to and from markets by steamboats. Even these caused water pollution and environmental damages due to the many boiler explosions in the early boats. As steam engines became more reliable, steam-powered trains replaced boats as a cheaper form of transportation over land areas. The growth of rail transportation was once again stimulated and supported by financing by the government.

Communication by telegraph developed simultaneously with the railroads and their lines often followed the same path as the tracks. Industrialization was accelerated both by rapid communication and transportation. By the beginning of the twentieth century, communication was further enhanced by Bell's new telephone system and later enhanced by all of Thomas Edison's inventions.

In the late nineteenth century (around 1880), electricity for homes, offices, and factories completely changed life in the United States. Electricity production utilized water and produced wastewater contamination even if it was only in the form of increased temperature. But this was a start in electrical energy water pollution that continued to grow as sophistication in electricity output increased.

Industries such as meat packing and steel learned during the late nineteenth century how to keep prices low by controlling all the raw material as well as the production markets. Usually these industries were led by great innovators such as Swift or Carnegie in the above-mentioned industries or John D. Rockefeller in the oil industry.

Between 1880 and 1910, the United States experienced the greatest rate of industrial growth and rise in air and water pollution. People learned also how to live with polluted air and water especially in or near the cities.

As Corrick (1998) concludes, "the industrial revolution is thus far from over." Most historians agree that the age of industrial growth is an always continuing phenomenon. Corrick suggests that "its next location may not even be on earth, but in space, where manufacturing may be possible using raw materials mined on the moon or from asteroids." He laments that despite the benefits of the industrial revolution, "it has also given us a world whose water and air are polluted with industrial waste, and an urban lifestyle that is rushed and stressful." The sad truth is that we chose to tolerate this pollution rather than make the necessary effort to avoid it.

Developing countries, where industrialization occurs later in time, often use economics as a legitimate excuse for avoiding pollution control expenditures. They often follow the bad example previously set by their developed country brethren of trying to use dilution as the solution to pollution. In this way they maintain that they keep their production costs down and are more competitive with the rest of the world.

As a consultant to many of these countries I often heard the comment that "you escaped pollution costs for years, why shouldn't we do the same"?

With clothing, steel, and steam power leading the way, American industry rapidly developed into a world-dominating power. In America, the necessary ingredients of natural resources, increasing wealth, and product demand existed. Other early ancillary industries also flourished such as food, dairies, paper, transportation, and metals.

The environmentalist may note that coincident with the development of these industries were the use of large volumes of water and the simultaneous wastage of this same water with added contaminants. Hence was born the advent of what was to become the water pollution problems of the twentieth century.

Academic and Scientific Development of Environmental Knowledge in the United States

Environmental knowledge became established in and through various U.S. universities. Each of these universities contributed special environmental knowledge in specific areas. These specialties were dependent upon and selected by the leading professor(s) at these institutions. In Table l, I have attempted to recall and list the primary universities involved, the major environmental subjects, and the leading professor(s). These should serve as a reminder of their contributions made to enhance the knowledge of water pollution abatement in the United States. Sadly, some of this knowledge was not put into practice until "after the fact" of pollution. Indeed, other knowledge was not made fully-available to the universities and general public by industries for a variety of self-serving reasons.

Universities were supplemented by research carried out by the U.S. Public Health Service, which also had its major areas of concentration and originators. It was and still is located in Cincinnati, Ohio, and focused on chemistry and microbiology with C. C. Rucchoft, Stream pollution with H. Streeter, toxicity and analysis with M. Ettinger and C. Tarzwell, and industrial wastes with H. Black.

Other research organizations such as river basin administrations and industrial research groups were involved in presenting and suggesting solutions to industrial waste problems. They include the following:

Ohio River Valley Sanitation Commission	River contaminants	E. Cleary
Delaware Water Resources Commission	River contaminants	J. Wright
National Council for Stream Papermill Waste Treatment		H. Gehm
Improvement of the Pulp and Paper Industry		

National Dairymen Association	Milk waste treatment	H. Trebbler
Oil and Petrochemical	Oil refinery wastes	R. Weston
Textile Institute of Research	Textile waste treatment	S. Coburn
Mellon Research Institute	Coal waste research	W. Hodge

Early consulting engineers and scientists active in the environmental area include:

Consulting engineer	All wastes	S. Powell
Consulting chemist	All chemical wastes	R. Hess

The New Dilemma of the 1990s

After paying for the costs and consequences of avoiding pollution prevention over the nineteenth and twentieth centuries, in the last decade of the twentieth century and in the new millennium, industry faces the dilemma of accounting for the real costs of

TABLE 1
Primary Personnel and Fields of Study in U.S. Universities

Origin Timeline	*University*	*Major Environmental Subject*	*Professor(s)*
1920–1930s	Harvard	Public Health Engineering	G. Fair
			E. Moore
	Johns Hopkins	Health and Water Resources	A. Wolman
			J. Geyer
	Rutgers	Industrial Wastes	W. Rudolfs
		Wastes	H. Heukelekian
1930–1940s	Florida	Water	A.P. Black
			E. Phelps
			J. Kiker.
Mass. Inst. Tech.	San. Eng.	H.P. Eddy	L. Metcalf
U. California			R. EliassenE.
			Pearson
	Waste Treat.	P. McGaughey	W. Oswald
	U. Illinois	Water	W.R. Steele
	Rennselear Poly	Environment	E. Kilcawley
	U. Michigan	Pub. Health	G. Rideneaur
	U. Wisconsin	Env. Eng.	G. Rohlick
	New York Univ.	Env. Eng.	W. Ingram
			W. Dobbins
1940s	U. Minnesota	Public Health	G. Schropfer
	Penn State	Sewage Treat.	R. Stiemke
	Georgia Tech.	Sewage Treat.	R. Stiemke
			R. Ingols
	Univ. Texas	Waste Treat.	E. Gloyna
	Cal Tech.	Env. Science	J. McKee
	Purdue U.	Ind. Wastes	D. Bloodgood
	Univ. Illinois	Digestion	A. Buswell

pollution. These include external damage costs to society as well as internal cost responsibilities.

Industry finally realizes that it must include these external costs in their production costs. With this startling, sudden realization comes the understanding that it may be less costly to internalize all waste costs into its manufacturing costs. Just exactly how to do this is the dilemma!

One obvious method of accomplishing such internalization of waste problems and associated costs is to reuse all wastes. To some extent this has worked. But it soon became apparent that it was nearly impossible to find reasonable and economical use for all wastes.

Next, industry tried to export unreusable wastes to external markets. This method also failed to operate completely satisfactorily—mainly because of matching markets of supply and demand. Quality and quantity control of wastes also were difficult to maintain.

Sometimes the use of these last two methods led to a rather haphazard location of industrial waste reusers in the vicinity of the primary industrial waste producers. Transportation of wastes and matching them with the quality and quantity desired by reusers still remain a deterrent with this procedure.

But from these tentative and vague attempts the era of waste utilization rather than waste treatment is slowly emerging. This book is an attempt to describe how the waste utilization era will work.

There were those who speculated that the era of industrial waste treatment would end with the closing of the twentieth century. But your author believes that it will not only continue to be an important aspect of industrial operations, but will change to more innovative solutions to more complicated waste problems, especially in the developed nations of the world.

Clare Ansberry reports (2005) that "many experts believe that the pattern of past years will continue—that low skilled jobs making lower value mass produced items will keep migrating to countries where labor is plentiful and cheap, while manufacturing in industrial nations, such as the U.S., Japan, and Western Europe, will contain complex, value-added products and systems." Some of these products suggested include medical instruments (complex), kitchen cabinets (costly to ship), and frozen foods (perishable), bearings for automobiles, X-ray machines, washing machines, cars, and telephones.

Ansberry believes, as I do, that "what will ensure U.S. manufacturing's future is innovation, just as it has in the past" (Ansberry 2005). Ansberry adds clothing, computers, automation equipment, robotics, toys, sporting goods, drugs, garden machinery, motor vehicles, metal coating and screw machine products, and bolts and rivets industries to the list requiring innovative solutions.

References

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