Electrolytic Respirometry

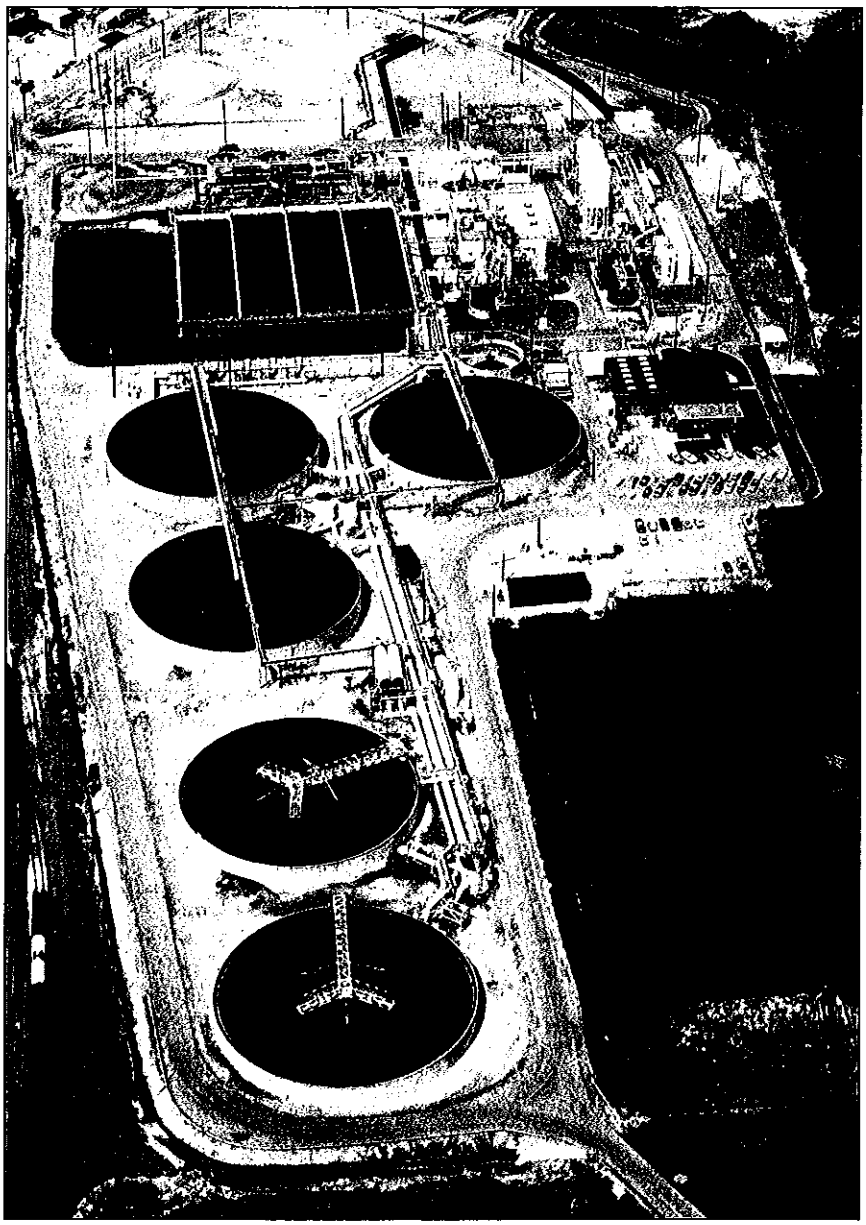

Figure 1. Aerial view of DuPont's chamber works treatment plant.

The 40-mgd wastewater treatment plant at the Chambers Works of E.I. Du Pont de Nemours & Co. in Deepwater, N.J., built in the late 1970s, is one of the largest industrial powdered activated carbon treatment (PACT) facilities in the United States. Designed to meet or exceed existing environmental standards for DuPont's own industrial aqueous waste streams, the plant has treated a growing variety and volume of commercial wastes since 1979.

The plant has successfully treated the entire spectrum of industrial wastes, from streams containing heavy metals to contaminated groundwater from Superfund sites. Figure 1 shows an aerial view of the plant. Figure 2 shows the plant processes. The key to successful contract wastewater treatment is determining the biodegradability before the waste stream enters the plant. DuPont began using electrolytic respirometry

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A Quick Way to Screen Wastewater Streams

for rapid analysis of biodegradability in 1980. This method produces quick and reliable treatability studies of multiple samples in 20 hours.

How the Process Works

Outside wastes constitute about 1% of the plant's influent, but more than ⅓ of its total organic loading. The balance comes from the Chambers Works internal processes for a wide variety of specialty chemicals. The evaluation process must be rigorous. A generator first submits a characterization form. If the prospective waste meets the company's criteria, a 500 mL sample is submitted and assigned a waste stream number.

Sample analyses include respirometry, pH, odor, specific gravity, dissolved organic carbon, miscibility in water, total acidity, suspended solids and special analyses of sulfides, cyanides, and metals. This preliminary analysis determines the cost of treatment.

Representatives of Environmental Services, Research and Development, and Operations must approve acceptance of a waste stream. The company has compiled a comprehensive, frequently updated list of known or suspected carcinogens or mutagenic agents.

If a waste stream falls outside the treatability range, Environmental Services may write a special procedure involving extra processing steps, such as precipitation of heavy metals or dilution, if practical.

After all departments have approved the specific waste stream, a legal contract is signed with the generator. The first shipment, by drum, tank truck, barge, or tank car, is checked on delivery to determine that it matches the sample and presents no additional hazards such as separate organic phases. Figure 3 shows tank trucks arriving at the plant. Spot checks thereafter ensure that the waste continues to meet the original specifications.

After primary treatment, the supernatant flows to aeration vessels where organic compounds are treated using a combination of naturally occurring bacteria and powdered activated carbon. In the process, developed by DuPont, the carbon adsorbs organic materials and also provides an active surface for concentration of oxygen and bacterially produced enzymes. The synergistic effect of the activated carbon-sludge matrix reduces organics in greater amounts than carbon or biological treatment alone, while the carbon also adsorbs many nonbiodegradable pollutants that would otherwise not be removed.

The company now accepts wastes from other DuPont facilities and outside generators. Contract waste treatment is in demand because of good eco-

Electrolytic respirometry has helped the plant treat the entire spectrum of industrial wastes

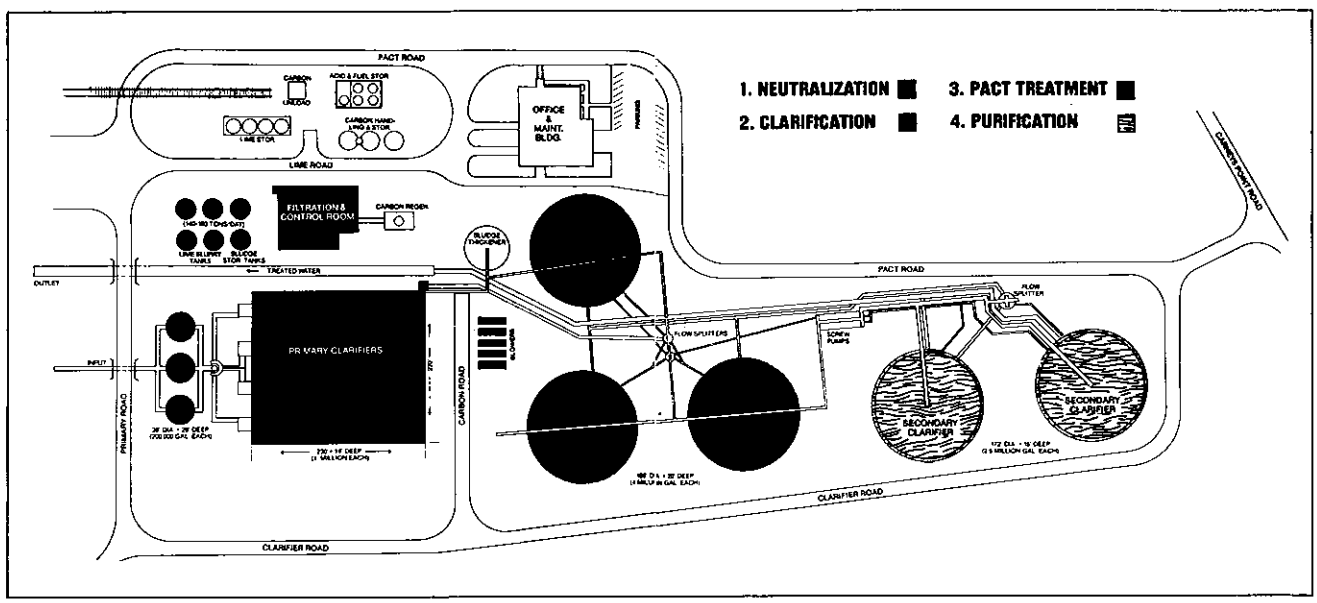

Figure 2. Schematic of plant processes.

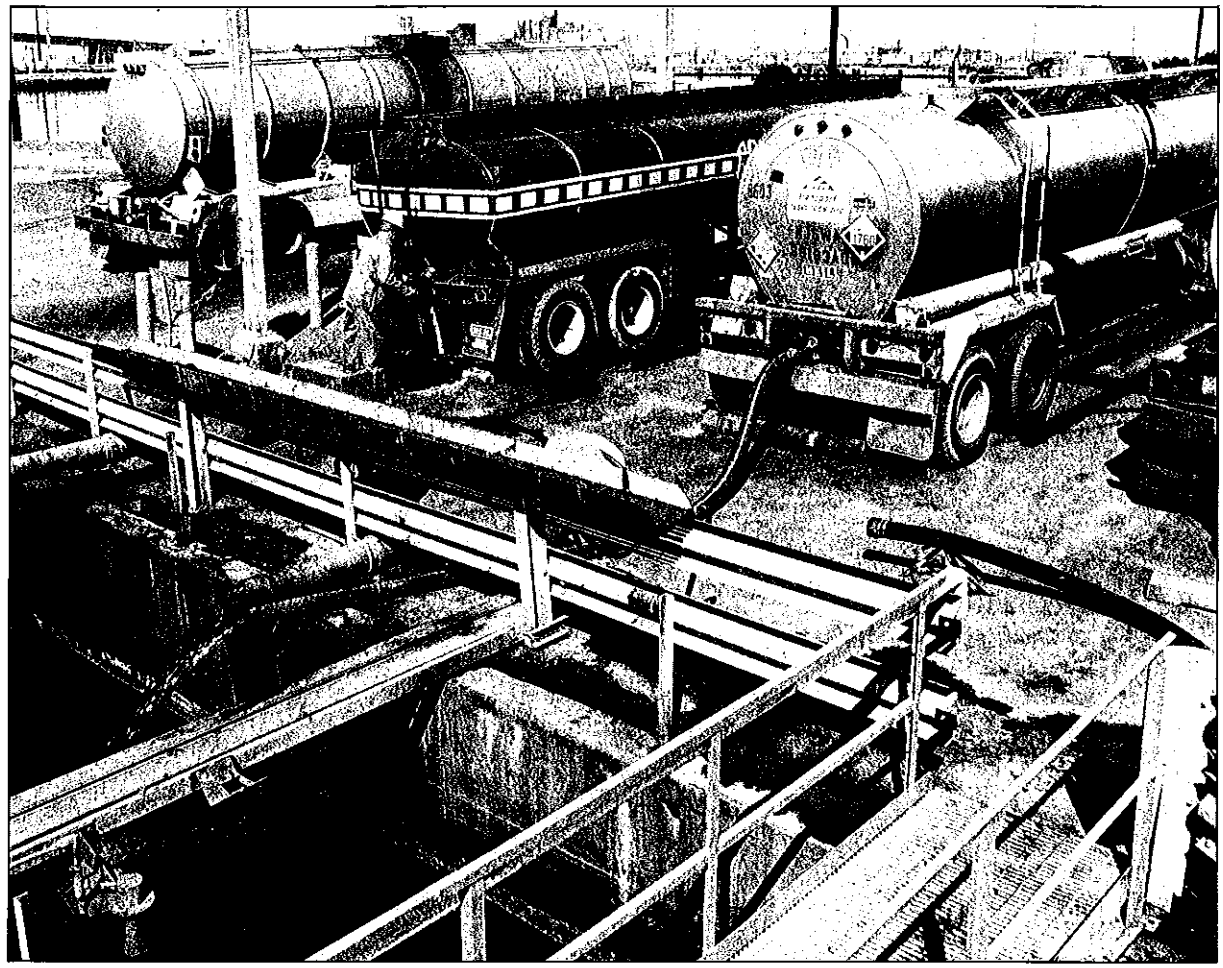

Figure 3. Tank trucks arriving at the plant.

nomic conditions and a crackdown on EPA priority pollutants.

Lab Processes

The lab is as busy as the treatment plant, with 12 to 18 electrolytic respirometry cells operating day and night. The lab can run 30 cells if necessary. Standard 20-hour tests on incoming wastes are done overnight, while samples requiring longer acclimation are run over the weekend. The cells are also used for long-term studies to determine the most effective treatment methods for internal waste streams.

Electrolytic respirometry relies upon the electrolysis of water to provide the oxygen necessary for biodegradation of a sample seeded with microorganisms taken from the biomass of the treatment plant. Each cell consists of a 1-liter reaction vessel and an electrolysis cell connected to a reactor control unit that monitors up to six cells.

As oxygen is consumed by biological activity in the reaction vessel, metabolically produced carbon dioxide is adsorbed by a KOH scrubber solution, creating a slight vacuum which lowers the electrolyte level in the electrolysis cell. When the level drops about 1 mm, the surface breaks contact with a switch electrode, allowing direct current to flow through the electrolyte. Oxygen produced at the positive electrode is added to the reaction vessel until the original internal pressure is restored. The control unit monitors the amount of oxygen required to equalize the pressure. The greater the oxygen demand, the greater the biological activity and (generally) treatability of the waste. Figure 4 shows the electrolytic respirometry set-up in the Environmental Services lab.

The control unit provides direct and continuous measurement of biochemical oxygen uptake in each cell for extended periods, without interruption or reduction of the oxygen content in the reaction vessel. Results are printed out by the control module at intervals as small as 6 minutes, or can be fed into a computer to display a biochemical oxygen demand (BOD) curve. Such curves indicate whether the waste is biodegradable, biodegradable but requiring acclimation, toxic, or non-biodegradable but non-toxic.

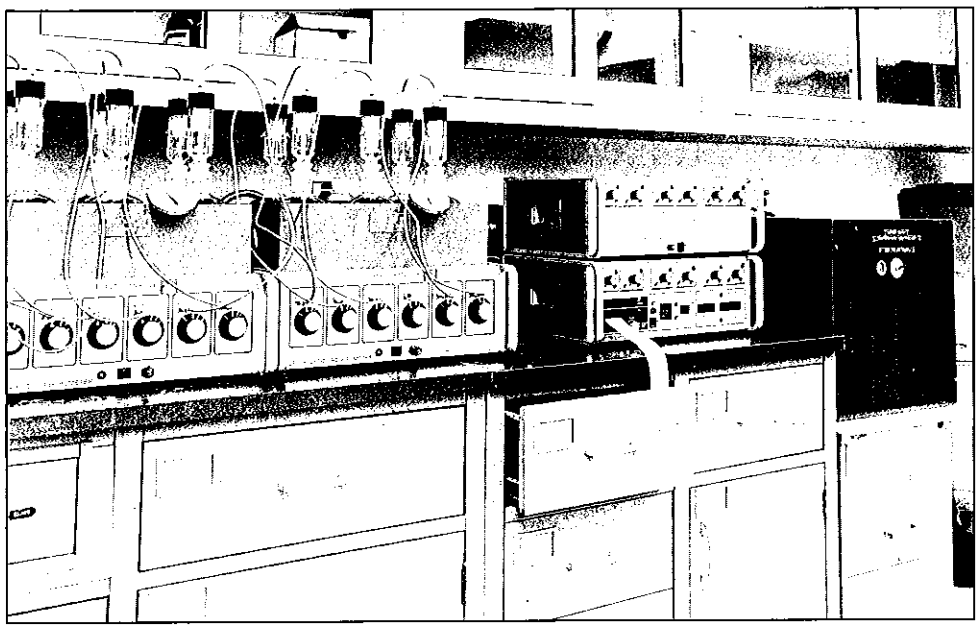

Figure 4. The electrolytic respirometry set-up in the lab.

With the continuous curve, you can see inter-reactions occurring that would be missed by a spot BOD test. This sometimes happens when metabolic products react with undigested components in wastewater.

The incoming wastewater samples are mixed with seed from the treatment plant, without dilution, and placed in the reaction vessels. The units take about 2 hours to reach equilibrium. For standard waste products, oxygen uptake is recorded at 4-hour intervals for 20 hours. The test looks for inhibitory effects, within pre-set limits, at this stage. If the sample fails to meet the set standards in two tests, it is rejected. If there is a large volume, further tests, such as a dose response curve, are needed to see how much can be handled. Because toxicity is a function of biomass loading, such a waste could be handled if it is fed to the plant more slowly. In these cases, primary treatment is simulated, and then respirometry tests are done at various waste concentrations. Conditions for the rapid tests, however, are more severe in the respirometer than in the plant—as if the waste were injected directly into secondary treatment.

The Environmental Services laboratory began using electrolytic respirometry soon after commercial units were introduced in 1979, and has added to the number of reaction vessels as demand for BOD analyses increased. The units are supplied and serviced by Bioscience Management, Inc., of Allentown, Pa. The laboratory is now installing a new BMI data acquisition system (ER-DA) to accumulate data generated by its respirometers and transfer it to a computer for further analysis. This will speed up data analysis, shorten sampling intervals, plot long runs, and analyse the relative degradability of various compounds.

Most of the long-term work in the laboratory deals with the various components of the Chambers Works waste stream, specifically, which areas are producing more or less biodegradable wastes and how they can be best dealt with. Each new product, such as the popular stain-blocking compounds for carpeting, requires extensive analysis to determine treatability. In these cases, the lab uses the respirometry vessels as long-term batch reactors to find out what happens to a waste product in the treatment plant. Is it removed, changed to something else, or are there inter-reactions? The record of oxygen uptake is then simply a bonus.

Monitoring is Vital to Program

Monitoring of both internal and external waste streams is rigorous. The plant annually submits about 350 individual reports to state and federal agencies on the status of its water protection programs. A single report may contain up to 129 analyses. Most include 24 permit guideline analyses. In the Discharge Monitoring Report to the EPA and the New Jersey DEP, 2,880 data points are reported each year. The plant has an excellent record in meeting permit limits, and because of the stringent influent monitoring, inhibitory effects on the biomass are rare.

In addition to treating many different industrial wastes, the process eliminates water-borne wastes from as far away as the West Coast. The wastes are treated safety, responsibly, and in an ecologically sound manner. Respirometry is a fast, reliable method of screening the wide variety on incoming compounds for treatability.