BUREAU APPLIED RESEARCH

*By Reza Ironpour, Omar Moghaddam, Gil Garnas Seung Oh, Dariush Vosooghi, Miguel Zermeno, Rick Mayer, Dipak Patel, and Zafar Karimi – **The Applied Research Group of the Wastewater Engineering Services Division***

During the five years since the former Head of the Wastewater Engineering Services Division, Ken Ludwig, established the Applied Research Group, we in the Group have greatly developed and expanded the inplant research program for the Bureau. We have carried out projects to optimize present operations, and examined new technology that the plants might use in the future. We have also built a large library with subscriptions to all the major journals that publish papers relevant to our work, and we consult them not only for the specific projects on which we are currently working, but for important ideas from other fields, such as artificial neural networks or pioneering studies of the molecular biology of anaerobic microbes, that might help us understand our current subjects, or might suggest further studies or innovations. We have now developed our expertise in many areas of the technology of aerobic secondary treatment, reclamation, and sludge digestion to the point that we believe that we are ready for anything needed by the Bureau.

Our primary purpose in all of this has been to convert Bureau needs into specific research programs, so that we would diminish the Bureau's previous dependence on consultants, and obtain results that would reduce Bureau costs, improve the quality of the plant effluents, and contribute toward a long-term effort to reclaim more and more of the effluent that is now being lost from our water-short region. Our chief concern is of course to meet the needs of the Bureau's management and the plant operators, but we also work on formal or informal bases with faculty at educational institutions, with researchers and engineers at similar plants, and with consultants, who have found that we can provide them with valuable information and provide us with information in return.

Part of this information exchange occurs at the technical meetings that the Group holds twice a month. Talks are given not only by outside experts, but by members of the Group and by operators. We strongly believe that it is good for everyone in technical activities to be able to present a well-organized discussion of matters that are related to his or her work. This program of meetings has been successful in establishing a common background among all the people with whom the Group works.

BIOSOLIDS: We have recently taken a role in the project to establish thermophilic sludge digestion at TITP. Understanding the biology and chemistry of new sludge digestion processes has been a significant addition to the Group's range of expertise, since we have only recently learned how much better it is to have two-phase (acid-gas) digestion than a one-phase process. One of the goals of this project is to enhance pathogen kill to produce Class A biosolids. This will benefit the Bureau by eliminating apprehensions in Kern County about health risks posed by applying biosolids to farmland there, and by preventing expenditures for transportation to more distant disposal sites, such as in Arizona.

Although pathogen reduction is the main focus of most efforts in the United States to improve biosolids processing, Bureau management now places a similar degree of emphasis on enhanced gas production and removal of toxins. This poses something of a conflict for the effort to establish thermophilic processing, since a thermophilic-mesophilic two-phase process produces more enduring disinfection, but a mesophilic-thermophilic process achieves better VS destruction and gas production.

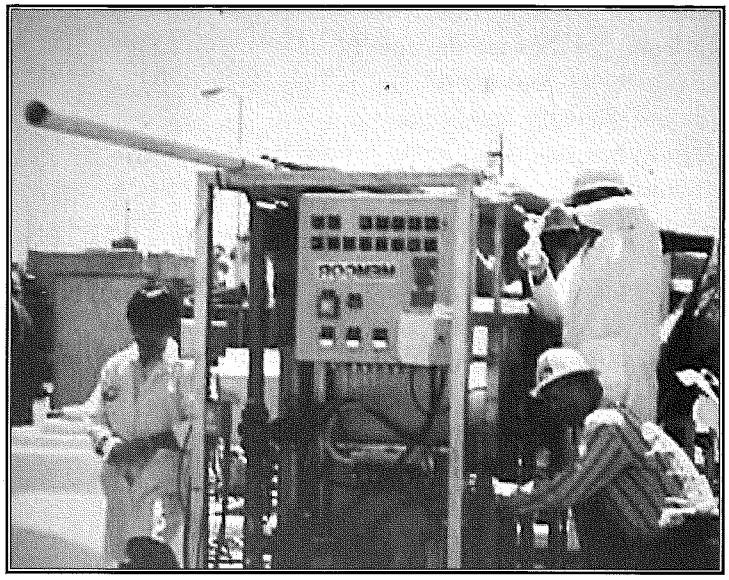
However, several other options for gas production enhancement have been identified. Adding lipids or lipid-rich wastes to the sludge now appears to be the most promising of these options, but we have also recently heard from UCLA that wastes rich in N,N-dimethylformamide from Osmotics, Inc., are another possible additive for gas enhancement. It may also be possible to enhance gas production by pretreating the raw sludge with Pulse Power™ equipment provided by Scientific Utilization Inc. (SUI), Decatur, AL, but the available evidence about this process is highly equivocal at present, and considerable additional work would be needed to evaluate and test it before a decision could be made about using it. The anaerobic sequencing batch reactor (ASBR) mode of operation is another modification that might enhance gas production,

Continued on Page 17

Continued from Page 16

because it would separate the solids retention time (SRT) from the hydraulic retention time (HRT), and would increase the SRT for more thorough digestion. In ASBR mode the digesters receive draw-and-fill feeding, after each feeding the contents of a digester are mixed for a few hours, and then the mixing is stopped for an hour or more to allow the solids to settle before the next drawing of the supernatant and feeding.

We are also currently investigating methods for toxin decomposition or removal, a topic that so far has received more research attention in Europe than in the US. This will change as the US adopts increasingly stringent pollutant limits. One of the goals of the toxin reduction effort will be to meet the exceptional quality standard for biosolids that are not only low in pathogens but in toxins. Formulating a process that also fulfills these other goals is much more challenging than simply reducing pathogens, but we believe that management's proactive approach is the right response to the evident trend in regulatory requirements and the benefits of gas as a low-pollution energy source.

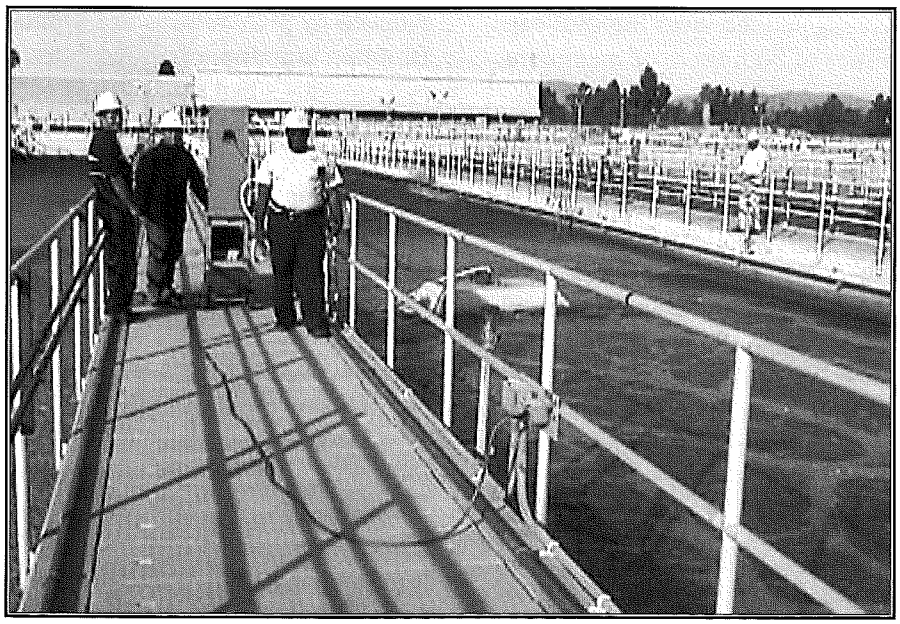


Taking samples to determine virus removal by microfiltration at the Terminal Island Treatment Plant, are, from the left, Soun Chanjamsri (Environmental Monitoring Division), Tito Jugo, and Reza Ironpour (foreground).

POLLUTANTS: We are further expanding our horizons by investigating new processes for meeting newly established extremely stringent limits for individual pollutants. These can be divided into compounds, such as cyanide, methyl tert-butyl ether (MTBE), hydrocarbons, and halogenated organic compounds, for which the toxicity results from molecular structure; and heavy metal elements, which may be removed in various ways, but cannot be detoxified by decomposition. However, in practice this distinction is usually unimportant except in digestion because most toxic organics are highly hydrophobic compounds that decompose very little during the brief retention times in primary and secondary treatment.

Preventing pollutants from entering the waste stream is often greatly preferable to allowing them to mingle with other wastes and be highly diluted by the time they reach a treatment plant. Unfortunately, for several of the pollutants in the Bureau's orders, source reduction appears to be extremely difficult or impossible. The available technologies for decomposing or removing pollutants are so diverse and the limits are so stringent that making good choices of technologies is a major challenge. Nevertheless, these limits ultimately govern all

Continued on Page 18



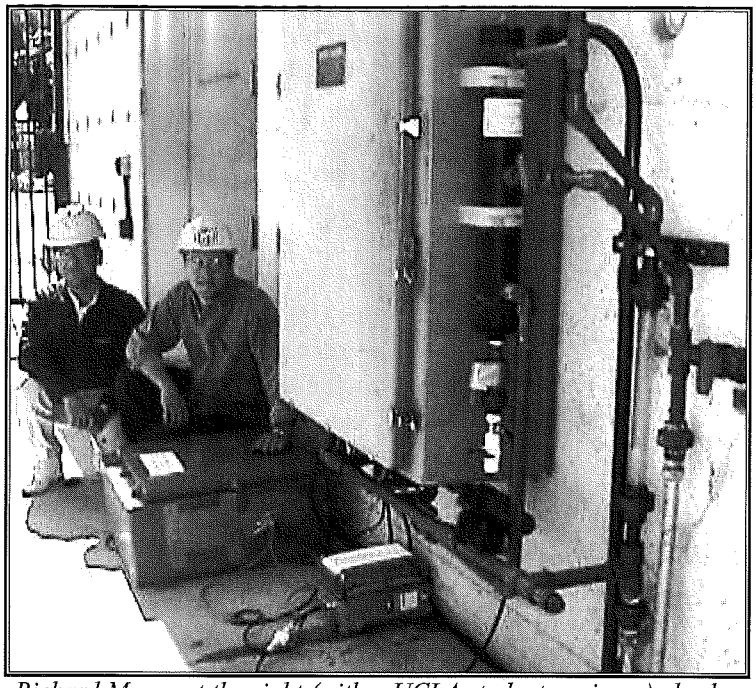
Oxygen transfer efficiency testing at the D. C. Tillman Water Reclamation Plant
Shown on a walkway dividing two aeration tanks are Miguel Zermeno, Alfredo Magallanes and Cornelius Reffegee testing oxygen transfer efficiency at an aeration basin. On the far walkway (right) Dipak Patel takes water temperatures.

Continued from Page 17

our work, for they are the core of the regulatory pressure on the Bureau. We expect additional standards to be established in the future by actions of regulatory bodies and consequent court orders.

AERATION: Perhaps our biggest experimental effort so far has been our program of measurements of oxygen transfer efficiency (OTE) in the aeration tanks, made by the off-gas method. We have observed both cleaned and dirty diffusers, and detected the rapid loss in OTE that occurred when a serious leak developed in the main air supply pipe of a tank at one of the plants, demonstrating the value of making such measurements in detecting damage or deterioration.

Since faster air flows tend to produce larger bubbles, OTE tends to decrease with increasing air flow. Plotting the oxygen mass transfer rate as a function of air flow gives the oxygen mass transfer curve (MTC). It is not common to make MTC measurements under operating conditions, because they are time-consuming and laborious, and likely to be inconvenient for operators. However, in April, 1999, we did so in a tank with fouled diffusers. The peak in the curve means that at high enough flows a further flow increase would decrease oxygen transfer because the reduction in OTE would more than counteract the effect of additional oxygen availability. This is highly undesirable from the viewpoints of both efficiency and control effectiveness. All of this OTE work is providing input to decisions to save money by cleaning, repairing, or replacing diffusers, and optimizing air flows.



Richard Mayer at the right (with a UCLA student engineer) checks computer data on particle characterization of secondary effluent at the Hyperion Treatment Plant.

SEPARATION/FILTRATION: Membrane filtration systems are increasingly important in water reclamation, especially when microfiltration is followed by reverse osmosis. The Research Group has investigated the virus removal capabilities of both types of membrane systems, and has compared them with other processes, such as ultraviolet (UV) irradiation and chlorination, that disinfect reclaimed water in other ways. This use of microporous membranes is just one aspect of the rising importance of plastic media and membranes in wastewater treatment. Another example is the current effort by chemical engineers to adapt microporous membranes for use in wastewater to produce microbubbles or bubbleless aeration methods, like those already used in other fields, that would greatly enhance OTE or might even make possible new treatment basins that would combine the functions of present aeration tanks and secondary clarifiers.

DISINFECTION: We have also studied UV disinfection. Our interest has been twofold: first, if used after the turbidity has been greatly reduced by pretreatment in a microfiltration unit or packed-bed filter, pathogen kills that meet California standards are achieved with much lower UV doses than what is needed when suspended particles can shield pathogens from the radiation; second, we have been looking into apparent departures from the expected relationship between dose and flow that appear to be due to hydrodynamic effects. We have made almost all the preparations for testing whether we can get better performance if we diminish the formation of boundary layers around the lamps and along the sides and bottom of the channel. As the risks posed by chlorine disinfection

Continued on Page 19

Continued from Page 18

byproducts are increasingly causing the abandonment of chlorination, we expect regulatory action requiring adoption of nonchlorine disinfection, and we will be ready to help the Bureau to respond.

PROCESS CONTROL: Online instruments are becoming available that use optical or relatively simple chemical or biological processes to measure many parameters that show the health of a treatment system. Among these are blanket depth in a clarifier or thickener, suspended solids, turbidity, total organic carbon, nitrate concentration, and biological oxygen demand (BOD).

BOD instrumentation has been another topic of research by this group. We found excellent correlation between the readings from the standard BOD5 test, which takes five days, and the BOD-2000 instrument, which uses a membrane biosensor for measurements that only take about thirty minutes. This instrument had not been tested on municipal wastewater before our work. Likewise, excellent agreement with BOD5 is produced by another instrument called the BIOX-1010, which measures the oxygen consumption in a bioreactor that is different from the BOD-2000 to give BOD estimates in about three minutes. We have also compared BOD5 and the outputs from the Pastel analyzer. This instrument obtains a UV spectrum of the water flowing through its cell and then fits a combination of stored standard spectra to the measurements. The success of this method depends on storing data appropriate to the wastes being monitored, so our calibration work improved the results.

Online instrumentation is expected to make its main contribution by preventing process upsets and thereby eliminating costs for recovering from upsets and fines for discharge violations. Although most of our work on BOD instrumentation was done four years ago, it has provided good preparation for evaluating currently available instrumentation now that the managements of LAG and TITP are interested in installing such equipment.

PARTICLE CHARACTERIZATION: We used a particle counter to gain greater insight into turbidity data for water that is being supplied from Hyperion to the West Basin Water Reclamation Plant. We found that two relatively broad populations of particles were present, showing generally contrary fluctuations in density, and the turbidimeter was only detecting the population of larger particles. This work showed that the filters at West Basin were passing many particles larger than five micrometers, contrary to specifications. We anticipate that the ability to perform particle analysis will be valuable in selling water to other customers.

We have presented our results at a number of conferences, and have published them in refereed journals and other magazines. For example, at the California Water Environment Association Conference, the president of the Water Environment Research Foundation (WERF) was present, along with the heads of several sanitation and water treatment agencies from California and elsewhere. Our presentation was very well received and prompted many questions and a lively discussion at the session. The presentation detailed our belief that a successful research program is essential for meeting requirements that are likely to be imposed in the future, as exemplified by the recently established standards for stormwater and sludge digestion that result from the stringent new pollutant limits for the environment in general.

At the 1998 and 1999 national WEFTEC conferences we informed the attendees of our important OTE findings and their applications. They were received extremely well at the national and international levels. Indeed, the Applied Research Group at Hyperion is now considered one of the world leaders in this field, and was mentioned by one of the other speakers, Dr. Musterman (in the Activated Workshop, WEFTEC'99) as having the world's largest database of diffuser OTE observations. Similarly, our presentations have been received well in the plant managers' meetings. We have also been invited to give presentations in major research universities.

Group members and the Bureau managers and executives who have contributed to our work and supported us have been listed as authors or in the acknowledgments in our publications. These papers are being quoted and cited by others, and we have received many requests for copies, reprints and our reports. In particular, our recent Science article has received very favorable attention from renowned researchers, consultants and faculty members in a number of states and foreign countries.

Continued on Page 20

Continued from Page 19

These publications are building a reputation that is bringing an increasing number of invitations to review research papers for important journals, and we now expect to establish more permanent relationships with these journals by being invited to membership on their editorial boards. This gradual development of a solid reputation is crucial for attracting external grant funding that will further enhance our research program to the level of leadership that the Bureau deserves. We have currently tentative approvals for three proposals submitted to the California Energy Commission, and expect to submit additional proposals to these and other agencies in coming months.

Many people from outside the Group have contributed to our success. First, of course, we thank Bureau Director Judy Wilson, who has found time, amid her much diverse and energetic efforts to improve the whole Bureau, to read all of our reports and to make thoughtful and knowledgeable recommendations. Likewise, Executive Assistant Director Jim Langley has expressed great interest, support and direction for our work. We thank them and the other executives, Vince Varsh, and our immediate superiors, Gil Garnas and Omar Moghaddam for the greatly increased support that the Group has received in the past two years, especially in the past year. Because of this, the group has not only improved its library and instrument inventory that have greatly increased our experimental capabilities but has undertaken more challenging projects.

We wish to express our great gratitude to the plant managers, Bob Birk, Y.J. Shao and Steve Fan, their operation staff and process engineers, who have worked very hard with us to make it possible to carry out our experiments. The analyses that the Environmental Monitoring Division laboratories have done for us has been a key part of many of our projects, and we thank them for being so helpful and cooperative. We also thank many experts from universities, industry and other agencies who have contributed to our work.

The Applied Research Group: *(From Left) Wastewater Engineering Services Division Head Gil Garnas, Dariush Vosooghi, Seung Oh, Zafar Karimi, Richard Mayer, Omar Moghaddam, Reza Ironpour, Miguel Zermeno, and Dipak Patel.*

We also thank several people who have contributed to the work of the Group in various capacities over the years, some of whom are no longer involved. Among them are Kris Flaig and Alfredo Magallanes, who have been transferred elsewhere, but who formerly were members of the Group. We thank Bill Straub, and the late Tito Jugo whose connection with the Group dates from the time that they assisted Ken Ludwig in establishing it. We also thank Sonia Alvarez and Tosin Aiyeola who have provided assistance when we have requested.

We believe that the research that we have been doing for the Bureau has already impacted our industry and will have applications in many places, both in the United States and in other countries. A strong research program will make it possible for us to take the initiative in dealing with regulatory agencies and perhaps allow us to set standards instead of always responding to outside demands. We have developed our research capabilities a long way from where they were a few years ago, but we see many more opportunities ahead. ■

Los Angeles City Department
of Public Works
Bureau of Sanitation
433 So. Spring St., Suite 400
Los Angeles, CA 90013
http://www.lacity.org/SAN/index.htm

The **Sani-Times Newsletter** is published quarterly by the Administration Division for the employees of the Bureau of Sanitation.

Editor:
Katherine Mussard
Assistant Editor
Ana Ricketts
Technical Production
Frankie Wong

In addition to the contributors of signed articles, the following personnel contributed to this issue:

Laural Airica
Bernard J. Barrett
Jorge De La Cerda
Joyce O'Neal
Jay Santos
Vince Varsh