Other synthetic organic chemicals—Continued
- Calcium propionate
- Sodium propionate
- Propylene glycol (1,2-Propanediol)
- Propylene oxide
- (Ethylenedinitrilo)tetraacetic acid (Ethylenediaminetetraacetic acid)
- Sodium formaldehydesulfoxylate
- Sodium methoxide (Sodium methylate)
- Stearic acid salts:
  - Aluminum stearate
  - Calcium stearate
  - Lead stearate
  - Lithium stearate
  - Magnesium stearate
  - Zinc stearate
- Succinic acid
- Tetraethyl lead
- Tetramethyl lead
- Triethylene glycol
- Urea
- Vinyl acetate

Senator Moss. Dr. Bertram C. Raynes, chief engineer of the Rand Development Corp., will be our next witness.

We are pleased to have you, Mr. Raynes, and we look forward to hearing your testimony.

STATEMENT OF BERTRAM C. RAYNES, CHIEF ENGINEER, RAND DEVELOPMENT CORP., CLEVELAND, OHIO; ACCOMPANIED BY JAMES H. RAND, PRESIDENT, RAND DEVELOPMENT CORP.

Mr. Raynes. Thank you, Senator Moss.

Mr. Chairman and members of the subcommittee, I am Bertram C. Raynes, Rand Development Corp., Cleveland, Ohio. Rand Development Corp. is a private corporation engaged in contractual applied research and development. The corporation also does proprietary developmental work and has a limited line of products which it produces, or, alternatively, has produced for it by subsidiaries.

A substantial part of the Rand Development effort is presently directed toward matters concerned with water pollution control and water quality management. We are working, for example, under contract to the Department of the Interior and also to the Department of Health, Education, and Welfare on problems associated with water pollution control. Matters of public and private health have always been important in the affairs of my company.

My present remarks concern a novel sewage treatment process we have developed under the sponsorship of the Office of Coal Research, Department of the Interior. The project, in 18 months, has come from the laboratory through the test-rig or bench-scale and is now ready to go to pilot plant size and to larger efforts. Our goal in this work has been twofold. First, to develop a new market for coal in the treatment of sewage and industrial waste waters; secondly, to improve the quality of sewage effluents and reduce waste pollution. We have accomplished the initial goal of the project—to uncover a new market for coal—and we believe we have shown the basic steps of a wholly new sewage treatment process.

THE RAND DEVELOPMENT COAL-SEWAGE TREATMENT PROCESS

The process we have developed consists of two basic steps. In the first step, coal is used to filter raw sewage. No pretreatment is given the sewage with the exception of a typical comminution, or grinding, operation. The effluent from this filter is clear and almost free of suspended solids. The BOD and COD of the effluent from this coal filter is only about 40 percent of the BOD and COD in the raw sewage—a 60-percent reduction. The throughput in this step requires only about 20 minutes.

This is the first successful sewage filter the water pollution control industry has seen and its success is based upon the fact that a mixture of coal plus the filtered sewage solids is continuously removed during the operation, and the coal retains its value as a fuel and is disposed of without the need for backwashing. This simple 20-minute step provides an effluent superior to present conventional primary sewage treatment plants and requires, in addition to less throughput time, far less capital investment.

In the second of the two basic steps of this coal-sewage treatment process, the effluent from the coal filter is passed into a bed of sized coal in which organic contaminants are absorbed. In actual practice this is the identical coal which is on its way to the coal filter. This sewage treatment system is a countercurrent one in which the coal moves in one direction and the sewage in the opposite direction. The effluent from this adsorption step is essentially free of suspended solids and a removal in the range of 70–90 percent of the b.o.d. and COD producing materials originally present in the raw sewage has been effected. Total in-plant time is in the order of 2–4 hours.

Beyond that, certain pollutants and contaminants, which conventional secondary treatment processes cannot remove, are removed in the coal-sewage treatment system. These include phosphates which are removed in excess of 90 percent, and hard detergents which are removed in excess of 90 percent. The coal treatment process, in contradiction to conventional bio-oxidation systems, does not produce nitrates from nitrogen compounds so the concentration of nitrates in the effluent from the coal-sewage treatment process is very low.

We believe, and we have been advised by representatives of the water pollution control industry and of the sewage treatment industry, that this coal-sewage treatment system may represent the first new sewage treatment process in some 40 years. We believe and have been told that we have the first successful sewage filter, and we believe that we have shown an economical adsorption capability using coal. For the coal industry we believe we have developed an entirely new and substantial market.

We have made cost estimates based only on the prepilot plant data we have now available. We have tried to be conservative in making these estimates and we feel that even with simple disposal by incineration of the coal-sewage solids mixture this system will be more economical in operation than present conventional secondary treatment plants. This reduction in cost reflects a decreased requirement for land area and capital investment for the plant. In making these preliminary estimates and in attempting to be conservative, we have assumed there shall be no useful production of power from this coal-sludge mixture.

However, this mixture has a British thermal unit value of approximately 90 percent of that of the coal used in the process. The recovery of the energy contained in this mixture will make it possible first, to reduce the treatment costs or, second, to effect tertiary treatment of sewage effluent on at least a portion of the total sewage treatment plant flow. If the latter could be economically done, it would be the first time that tertiary treatment could be accomplished on a practical and economical basis. I should add that we are not substituting air pollution for surface water pollution. Present conventional treatment plants, whether primary or secondary, typically incinerate their wastes now. In the coal-sewage solids mixture incineration (the coal is in large excess in this mixture), it will be possible to incinerate at a higher temperature than is now possible in water treatment plants. With afterburners, air pollution could actually be reduced.

The test equipment on which this OCR development work has so far been carried out is now temporarily installed in Washington, at the District of Columbia Water Pollution Control Plant, testing its effectiveness on purely domestic and storm sewage. The previous work has been concerned with combined municipal and storm sewage in Cleveland, a heavily industrialized city. We hope some of you gentlemen may be able to take the opportunity to observe it here during the next several days.

This is, then, a new sewage treatment process, not merely an improvement or refinement on an old one. Since it is new there is much remaining to be done. We have disclosed the basic operation of the process: continuous filtration and adsorption, using coal. Scaling up of the work, to pilot plants and demonstration or prototype plants is needed before routine operations can be given over to plant operating personnel. The potential for improved treatment of a variety of industrial wastes—paper mill wastes, slaughterhouse wastes, and on and on—is great and these water pollution problems need to be examined using the coal-sewage treatment system. The economics need further refinement. We hope that the coal-sewage treatment process will be as important to water pollution control as the activated sludge process was when it was introduced. The basic process is now revealed; obviously, however, improvements and refinements we confidently expect to introduce will make it the more economical and useful.

Rand Development has proposed, for example, to accomplish at least the following specific tasks in bringing the coal-sewage process to acceptance and widespread use:

(1) The refinement of the operating limits to determine the most effective and economical form of the process;

(2) The refinement of preliminary cost analyses to provide more accurate capital and operating cost estimates;

(3) The exploration of all aspects of the process, or combinations with other processes, which enhance its attractiveness by effecting degrees of water purification unprecedented in the water pollution control field;

(4) The construction and operation of demonstration plants to illustrate pollution control using the basic process as it is now disclosed; and

(5) The evaluation of the coal-sewage process as the basic step in what may become a full waste-water/fresh-water renovation cycle.

All ranks of coal, with the possible exception of lignite, can be used in the treatment system. There is some variation among the ranks—not in filtration but in the absorptive efficiency. Significantly, some coals are as much as 30 to 40 percent as effective as activited carbons for some dissolved pollutants. Of course, the cost differential between coal and activated carbon is quite large. The coal process is potentially useful throughout most of our country, wherever coal is an item of commerce. In the most heavily populated regions of our country, then, the process can compete with conventional treatment processes.

Rand Development feels that intensive development of the coal-sewage system will make it possible to reduce the pollutant concentrations in sewage plant effluents, at economic advantage. We feel that sewage treatment plants using the coal system can meet new quality standards for sewage plant outflows, particularly those relating to plant nutrients (phosphates and nitrates) and those for detergents. We are working diligently toward that end.

Senator RANDOLPH (presiding). Thank you very much, Mr. Raynes. You are in a sense saying to the members of this subcommittee that there is a very significant breakthrough in this method of sewage treatment through utilization of coal. Is it that a correct statement?

Mr. RAYNES. I hope that is a correct statement.

Senator RANDOLPH. You believe in the findings of this pilot project and your studies have convinced you of the merits of this process.

Mr. RAYNES. Yes, sir; the evidence is all that way.

Senator RANDOLPH. At this point I am going to interrupt my questioning because our colleague who gives very careful attention to the subject matter of these hearings must of necessity leave for another committee meeting. Senator Moss.

Senator MOSS. Thank you, Mr. Chairman. It is musical chairs here in a way today. We are trying to cover all of the fronts we have to cover. Before I left I did want to compliment you, Mr. Raynes, and comment on the fact that it is most heartening to have some testimony this morning about a new process for treating sewage because this subcommittee sitting yesterday was discussing the fact that even though we have been treating sewage now for a hundred years and for 50 years very actively, we really haven't found any new avenues or any new ways. We are using basically the same sewage treatment system that we used 50 years ago, with slight modifications and updating but without any basic or different method and what you have said today indicates that we have now gone into another avenue of treatment that looks very promising at this point. If it proves out economically, as we would hope it would, perhaps we have taken that long step forward into a new type of treatment that can rehabilitate our waters so that they can be used over and over again, and I was most interested in this because I did not know much about it even though I take great interest in coal.

My State has a lot of coal, and you would think this would have come to my attention very pointedly but it has not. I am very glad to hear about it. I wish I had more time to remain to hear more in detail how much area is required for these sewage lagoons or racks of some kind, and what the comparison of capital investment would be in putting in this kind of sewage treatment as against the conventional activated sludge. Unfortunately I cannot remain but I accept your invitation to go see the demonstration project here at hand to learn more about it.

Mr. RAYNES. May I say we went to the Office of Coal Research with a proposal to examine the use of coal broadly just to see if we could improve sewage treatment and I would like to compliment them for letting us do this to look at the entire process rather than an individual step. We were able to look at the entire problem and not just one segment.

Senator MOSS. I am pleased to have that report and I am glad that the Office of Coal Research is willing to step into this field and employ your research corporation to help out on the job.

Senator RANDOLPH. Thank you, Senator Moss. It has been my privilege to share some of the thinking of the president of your company, Mr. Raynes and others, in reference to the pilot plant experience. I am sure Senator Moss and all members of this subcommittee including my colleague, Senator Boggs, and the members of the Committee on Public Works will be giving the most careful attention to these developments. There is a need for coordination and cooperation between the Government agencies and private agencies; is that true?

Mr. RAYNES. Yes.

Senator RANDOLPH. And with municipalities and possibly with industries located in certain areas of the country where the sewage treatment problem is more acute; is that correct?

Mr. RAYNES. Yes, sir.

Senator RANDOLPH. Let's return to where you refer to cost estimates. What would be the proportionate capital investments, Mr. Raynes, in land area and facilities for the process of which you speak in comparison to the conventional activated sludge treatment method?

Mr. RAYNES. On the basis of our estimates, assuming a new plant to be built for an activiated sludge process, we believe that land area and capital investment might be reduced by as much as 60 percent. That is, the coal filtration would require only about 40 percent of the land area required for an activated sludge treatment plant of equivalent capacity.

Senator RANDOLPH. I think this is a very important item. We know now that these ponds or lakes or impoundments required by conventional treatment methods cover huge acreages; is this not true?

Mr. RAYNES. Yes, sir.

Senator RANDOLPH. Thus, present methods remove this acreage from economic productivity or use of sites for industry—and when you say it will cut the land area down by what percentage——

Mr. RAYNES. Let's call it 50 percent—between 50 to 55 percent.

Senator RANDOLPH. I think this is a very important item for those of us on the subcommittee to remember.

Referring now to the potential market for coal which might be developed through application of this process, I would ask you what would be the daily requirements for coal in the treating of a population equivalent of 100,000 persons. I would give as an example the capital city of West Virginia, Charleston, and the immediate area. Could you comment on that?

Would the coal necessarily have to be dry before its incineration or could it be moved directly to incineration in the form, let's say, of slurry?

Mr. RAYNES. We have been advised by consultants in the Department of the Interior and experts in the field of incineration it would not have to be dried. It would be dried and sent to an incinerator with perhaps 40 percent of the water removed but there would be no difficulty.

Senator RANDOLPH. Would it be technically and economically feasible to convert the conventional plant throughout this country by the Rand method, or could it be applied only to new plants? I think Senator Boggs and I would both be interested in your response to that question.

Mr. RAYNES. It is a complicated question. If a plant is fully paid off it might not be economically feasible to convert. If it is a new plant construction I think there is no question if the economics hold up in the next stage of the development you would go to this process wherever you could. In between you have several choices. If you have a plant which is not a conventional plant which is not meeting quality standards, you could use the filtration on the effluent of that plant. I would say there are many existing opportunities in plants today to use this or at least the second or adsorption step in that.

Senator RANDOLPH. Would you say to the subcommittee members then that this process could be added to such plants?

Mr. RAYNES. I think there would be many opportunities to do that; yes, sir.

Senator RANDOLPH. I think that is important for us to have your response to in the way you have given it.

The Rand Development Corp. has an application with the Office of Coal Research—you have expressed complimentary remarks about the work being done there—for a larger pilot plant and an application with the Department of Health, Education, and Welfare for a grant for a commercial demonstration plant. I know of this and I know you are familiar with it. I have endorsed both applications, and I have on several occasions discussed this with responsible administration officials.

I ask unanimous consent at this point to include in the record relevent excerpts of several statements that have to do with the applicability of this process as I see it and some of the observations that I have made which have been published in West Virginia news media.

For the record, Mr. Raynes, would you distinguish between the purposes and the aims of, these two projects, the one pending with the Office of Coal Research, the other with the Department of Health, Education, and Welfare. Are they in conflict or do they compliment each other?

Mr. RAYNES. I think they are complementary. The basic process has been disclosed and it can be seen down here in the District of Columbia sewage treatment plant. There is much that can be done both for the coal industry to increase its market and the water pollution control market to refine the economics, develop a process to the point at which operating plant personnel can be given the key, and then told to go ahead. The demonstration plant would not be turned over to typical plant operation. It would have to be under the control of a company such as ours and I hope it will be ours. I believe these units are completely complementary. A demonstration plant would have to be based on what we know today and demonstrate what is known today.

Senator RANDOLPH. Thank you, Mr. Raynes.

To Mr. Rand who is in the room this morning for our hearing—Mr. Rand, if you desire you may come to the witness table and sit with Mr. Raynes. He has been testifying but we perhaps should have the record indicate that the two of you were present this morning because there may be questions which you might jointly clarify.

I find it necessary to go to another meeting and Senator Boggs, I know that you will chair the remaining time of this hearing and will, of course, question and observe in your own way.

Senator BOGGS. I would like to compliment you on your presentation. It is very interesting and appears to me to hold great possibilities. I am interested in the District of Columbia demonstration plant.

Mr. RAYNES. It is the District of Columbia Water Pollution Control Plant. We have the Office of Coal test rig installed.

Senator BOGGS. How long has it been in operation?

Mr. RAYNES. This is its seventh day. It is simply to demonstrate what can be done on a city which is not heavily industrialized and particularly to see what might be done on behalf of the Department of the Interior on the phosphate-nitrate problems in the Potomac.

Senator BOGGS. Can you give me some idea of the size of the operation?

Mr. RAYNES. It is a laboratory unit. The filter has a rated capacity of 1,000 gallons per hour. The adsorption step is only about one-sixteenth of that and it is simply used to characterize the effluent to find out what we are removing, or better still, what is going out as effluent from this process and what contaminants still remain in effluents.

Senator BOGGS. How long do you estimate it will be before you will move to the next phase?

Mr. RAYNES. On the pilot plant effort?

Senator BOGGS. Yes.

Mr. RAYNES. I hope to get started with that early in July.

Senator BOGGS. What amount of coal would be used by the unit in operation in the District of Columbia?

Mr. RAYNES. About 60 pounds a day is all we use.

Mr. RAND. It is parallel to the regular secondary treatment plant so that effluents are taken simultaneously from both effluents and run by the sewage plant in their own laboratories and the results are given to us.

Senator BOGGS. I believe the staff now has a few questions to ask.

Mr. ROYCE. Would it be possible, Mr. Raynes, to feed data from the proposed graduated pilot plant into a demonstration project if such a project receives a grant?

Mr. RAYNES. That is what I meant by complementary. All of the data that would be obtained in the flexible pilot plant, a rather aggressive effort we propose, would be fed directly into any drawing or construction for demonstration right up to the last minute and, therefore, would improve the demonstration plant capability. We would be able to incorporate any new developments or concepts or any new ideas.

Mr. ROYCE. Acknowledging the complexities of the problem and without attempting to pin you down to a fixed date, if such a grant were approved for a demonstration project, what would be the approximate time required to put such a demonstration plant into operation?

Mr. RAYNES. It could be begun immediately to pick a site, determine where it could be, but I would rather suppose it would be 6 to 9 months before any actual ground breaking might occur. There is sewer interceptor work that would be done and that sort of thing. We are proposing to look at the effluent of a town of perhaps 10,000–15,000 persons or that equivalent of sewage. It would require some sewer interceptor work and knowledge of the hydraulics, so I would guess it would be 6 to 9 months before any actual plant demonstration work could be done.

Mr. ROYCE. Thank you, Mr. Chairman.

Senator BOGGS. If there are no other questions, we will conclude with Mr. Rand and Mr. Raynes. We appreciate your cooperation.

(Subsequently the following memorandum was submitted:)

DEPARTMENT OF THE INTERIOR,
OFFICE OF COAL RESEARCH,
Washington, D.C., June 25, 1965.

THE USE OF COAL FOR SEWAGE AND INDUSTRIAL WASTE TREATMENT

SYNOPSIS

The Rand Development Corp., of Cleveland, Ohio, under sponsorship of the Office of Coal Research, has developed a process which uses coal for the purification of sewage and waste water.

The test rig in which the process was developed in Cleveland has been moved to the District of Columbia water pollution control plant in Washington to test the effectiveness of the process on sewage in the Potomac River Basin.

Limited analytical data obtained since the operation was begun on June 18, 1965, have confirmed the results obtained in Cleveland, and are summarized in the following:

Analytical test:	*Percent reduction through coal process*
Biochemical oxygen demand (BOD)[1]	91
Chemical oxygen demand (COD)[1]	80
Suspended solids	95
ABS (detergent)	85
Phosphate (total)	60–95

[1] The BOD, or biochemical oxygen demand, test is an accepted way of measuring the amount of sewage or other organic contamination present in water. The COD or chemical oxygen demand, test is another means of approximating the total organic pollution load in sewage or other waters.

The BOD analysis is a form of accelerated biological action in which the oxygen depletion of a sample due to biological action is measured over a 5-day period under controlled conditions. The COD is purely a chemical method.

This is believed to be the first successful sewage filter the water pollution control industry has seen, and its success is based upon the fact that a mixture of coal plus the filtered sewage solids is continuously removed during the operation, and the coal retains its value as a fuel and is disposed of without the need for backwashing. This simple 20-minute stage of the process provides an effluent superior to present conventional primary sewage treatment plants and requires, in addition to less throughput time, considerably less capital investment.

In the second of the two basic steps of this coal-sewage treatment process, the effluent from the coal filter is passed into a bed of sized coal in which organic contaminants are absorbed.[1] In projected commercial practice this will be the identical coal which is on its way to the coal filter. The proposed sewage treatment system will probably be a countercurrent flow in which the coal will move in one direction and the sewage in the opposite. The effluent from this adsorption [1] step is essentially free of suspended solids and a removal in the range of 70–90 percent of the BOD- and COD-producing materials originally present in the raw sewage has been effected in the present extremely small-scale quipment. Total inplant time will be on the order of 2–4 hours.

Certain pollutants and contaminants, which conventional secondary treatment processes cannot remove, are removed in the coal-sewage treatment system. These include phosphates which are removed in large measure, and hard detergents which are removed up to amounts of 90 percent. The coal treatment process, in contradiction to conventional bio-oxidation systems, does not produce nitrates from nitrogen compounds so the concentration of nitrates in the effluent from the coal-sewage treatment process is very low.

We have been advised by representatives of the water pollution control industry and of the sewage treatment industry, that this coal-sewage treatment system may represent the first new sewage treatment process in some 40 years. It is also believed that an economical adsorption capability using coal has been shown on a very small scale. For the coal industry, an entirely new and substantial market may be developed.

Cost estimates made are based only on the prepilot plant data now available. Even with simple disposal by incineration of the coal-sewage solids mixture this system is expected to be more economical in operation than present conventional secondary treatment plants. This reduction in cost reflects a decreased requirement for land area and capital investment for the plant. In making these preliminary estimates and in attempting to be conservative, no useful production of power from this coal-sludge mixture has been assumed. However, on a dry basis, this mixture has a British thermal unit value of approximately 90 percent of that of the coal used in the process. The recovery of the energy contained in this mixture will make it possible to reduce the treatment costs or, possibly, to effect tertiary treatment of sewage effluent on at least a portion of the total sewage treatment plant flow. If the latter could be economically done, it could be a breakthrough in tertiary treatment on a practical and economical basis. This concept does not substitute air pollution for surface water pollution. Present conventional treatment plants, whether primary or secondary, often incinerate their wastes now. In the coal-sewage solids mixture incineration, (the coal is in large excess in this mixture), it will be practicable to incinerate at a higher temperature than is now possible in water treatment plants. With afterburners, air pollution should actually be reduced.

This is essentially a new sewage treatment process, not merely an improvement or refinement on an old one. Much remains to be done. Scaling up of the work, to pilot plants and demonstration or prototype plants is needed before routine operations can be given over to plant operating personnel. The potential for improved treatment of a variety of industrial wastes—paper mill wastes, slaughterhouse wastes, and others—is great and these water pollution problems need to be examined using the coal-sewage treatment system. The economics need further refinement. The basic process is now revealed; however, improvements and refinements on a pilot-plant scale are desirable to make it more economical and useful.

Most ranks of coal can be used in the treatment system. There is some variation among the ranks—not in filtration but in the adsorptive efficiency. Significantly, some coals are as much as 30 to 40 percent as effective as activated carbons for some dissolved pollutants. The cost differential between coal and activated carbon is of a magnitude of 40 to 1.

THE DISTRICT OF COLUMBIA EXPERIMENTAL PROGRAM

At the request of the Office of Coal Research, the coal-sewage test rig built in the summer of 1964 and installed in the Cleveland Easterly Sewage Plant was dismantled and moved to Washington, D.C., in order to evaluate the effectiveness of the process on sewage typical of the Washington area, a combined storm and domestic sewage containing little industrial waste.

---

[1] Adsorption is the adhesion of an extremely thin layer of gas, solute, or liquid layer of molecules to the surface of solids with which they are in contact.

As developed through the past year in the small test rig and in the laboratory, a process appears to be emerging which appears to be effective in reducing the level of contaminants in municipal sewage to a degree equivalent of any other operating process, and at a potentially lower cost. Moreover, certain species of dissolved matter—phosphates and "hard" detergents—which are found in unusually high proportions in wastes discharged to the Potomac River, have appeared to be particularly amenable to treatment. A further attractive feature of the process is that nitrates, which are customarily discharged into receiving waters in large quantities as a consequence of their manufacture as a byproduct of the activated sludge sewage process, are not formed in the coal treatment, and are therefore not a source of pollution from the treatment process.

Although the process is still in the development stage, with the test rig remaining as a piece of experimental apparatus and not an exhibition plant, the techniques of treatment by using coal have been sufficiently advanced to warrant the use of the equipment in testing the process on other sources of waste. It must be emphasized that the installation in Washington is operating as an experimental tool; the form and arrangement of the operation is based on its usefulness for development purposes and can in no sense be considered as a prototype.

The coal-sewage test rig is tentatively scheduled to operate in Washington for a period of 2 weeks. The following is an interm report, describing the equipment and containing such analytical data as are available at this writing, following only 7 days of continuous operation.

INSTALLATION

As a consequence of the comparatively short notice for this operation, only slight modifications were made in the basic test rig. Certain large pieces of apparatus, having been found in previous work to be nonessential to operation, were omitted, and changes were made to improve the compactness and ease of transport. The equipment as seen in Washington comprises all essential parts of the basic installation. Operating procedures are identical to those employed in the earlier work; materials, including coal, have been taken from the same stock used during the experimental program.

Through the cooperation of the District of Columbia Department of Sanitary Engineering, under direction of Mr. R. L. Orndorff, arrangements were made on June 11, 1965, for installation of the rig at the District of Columbia Municipal Water Pollution Control Plant at 5000 Overlook Avenue SW., Washington, D.C.

This plant is the principal waste treatment plant for the area, collecting sewage from as far as 35 miles distance. It is a modern activated sludge secondary treatment plant, using the digestion/vacuum—filtration method for sludge disposal. The average daily flow approaches 200 million gallons, although broad daily fluctuations are encountered. The sewage influent is primarily domestic in nature and is noted for an unusually high concentration of detergents and phosphates.

The rig arrived on June 14, 1965, and was installed in the grit chamber building of the plant, from which a flow or raw sewage typical of the plant influent could be drawn prior to any treatment operation. With the generous cooperation of Mr. Hugh Schreiber, Superintendent of the plant, and of his entire staff, installation was completed by June 16 and arrangements made for sampling and analysis by the plant staff. The rig began 24-hour operation on June 18, 1965.

OPERATION

Although the projected coal-sewage process is seen as a single-step operation in which both filtration and adsorption take place in a single bed of coal, these two steps have been separated in the test rig for convenience of experimental study. The following operating conditions have been maintained during operation at the Washington plant.

Raw sewage is drawn from approximately 4 feet below the surface of the plant header channel by a submersible pump. The channel precedes the plant's grit separation step, and is turbulent, assuring that solid matter remains suspended. To maintain a uniform concentration of solids at the test rig a flow rate of approximately 5,000 gallons per hour is pumped to the rig; the excess is bled off immediately prior to the processing steps.

Owing to purely mechanical limitations of the present apparatus, it is not possible to sustain continuous operation of the filtration step beyond 30 hours; and as a consequence the procedures in Washington, as in Cleveland, have consisted of operating the filter for a period of 1½ hours in the morning of each day in order to collect a quantity of filtrate which is then metered through the absorption step on a continuous basis.

For filtration, pulverized coal (in this operation high-volatile bituminous-A) is metered into the flow of raw sewage at a rate of approximately 0.4 pound per 100 gallons of sewage and is caused to be wetted by a mixer. Particle size of this coal ranges from approximately 60 to 200 mesh.

The coal-sewage mixture flows into the filter, which consists of the original bed of crushed coal, 3 feet deep, from which the surface layer, along with deposited sewage solids and admix coal, is continuously scraped off as a thick sludge. Although this sludge is to be burned in eventual operation, it is here merely discharged to the drain. Total coal consumption, including both admix and that which is removed from the filter bed, is approximately 1 pound per 100 gallons of sewage (5 tons per million gallons).

The filter operates at a rate of approximately 30 gallons per square foot per hour producing filtrate which is essentially free of suspended solids and from which approximately 60 percent of organic contaminants, phosphates, and ABS (detergents) have been removed.

From the filtrate storage drum the filtered sewage is watered through the adsorption step at the same rate of 30 gallons per square foot per hour. In the test rig this step consists of the use of eight glass columns 2 inches in diameter and 2 feet long operating in series. Each column is filled with 16.5 inches of crushed coal (here bituminous high-volatile-C) in the size range of minus 40 plus 100 mesh. The total bed depth is 11 feet, a figure developed as a result of many factors to represent, as nearly as can presently be determined, the actual depth for an operating plant. Although the flow rate through the columns is the same as through the filter, the small size of the columns here requires a very low total flow. The visitor will see only a trickle of about 16.5 gallons per day.

ANALYSIS

All analysis of both the raw sewage and the final effluent are performed by the District of Columbia laboratory personnel by the same procedures used for evaluation of the plant's performance. Because this report covers only 7 days of continuous operation, and because certain of the analytical procedures require extended periods for completion, the data contained here are not complete. Likewise, evaluations of the data must therefore be broadly summarized.

RESULTS

Table I lists the analytical data available at this writing, for the operation of the OCR-Rand coal/sewage test rig at the District of Columbia Water Pollution Control Plant.

ACKNOWLEDGMENT

This preliminary report could not be complete without expression of our gratitude for the thoughtful, friendly, and unstinting cooperation of many organizations, and of many individuals who are not part of this program but who have contributed generously of their own time to assist in its success.

Mr. R. L. Orndorff, director of sanitary engineering, and his staff at the District Sanitary Commission, who completed all arrangements for this operation on 2 hours' notice.

Mr. Hugh Schreiber, superintendent of the District of Columbia Municipal Water Pollution Control Plant, who opened every door to us and who placed his entire staff at our disposal.

And at the plant, special thanks to the following:

Mr. George E. Tompkins, Jr., general maintenance foreman, who, with his staff, calmly handled the many crises of the technical installation.

Mr. Marion J. Fox, supervisory chemist, whose staff somehow wedged many additional analyses into their own schedules, and who personally contributed much of his own time to complete many of the analyses.

Mr. Samuel H. Hines, supervisory sewage disposal plant operator, whose friendly staff meticulously performed the sampling from the test rig, and who smoothed many of the problems attendant to such an abrupt move.

Mr. John W. Zelinsky, assistant superintendent, who was everywhere at all times in our behalf.

TABLE I.—*Analysis performed by laboratory of District of Columbia Water Pollution Control Center—RAND-OCR test rig*

Sample	Date	Total running time (hours)	Suspended solids	ABS	COD	BOD	Total phosphorous P in PO_4
Raw			380		278	295	6.7
Final	Friday, June 18	20	16		51	26	0.5
Removal...percent			96		82	91	93
Raw			104		236	135	5.7
Final	Saturday, June 19	44	8	0.58	51	22	1.9
Removal...percent			92		78	84	67
Raw			62	2.97	224	135	5.5
Final	Sunday, June 20	68	28	0.43	46		2.2
Removal...percent			55	86	80		60
Raw			380	2.17	251		5.3
Final	Monday, June 21	92	10	0.30	52		
Removal...percent			97	86	79		
Raw			100	2.97	229		
Final	Tuesday, June 22	116	5	0.30	48		
Removal...percent			95	90	79		
Raw			244	4.56	536		
Final	Wednesday June 23, p.m.	140	12	0.40	91		
Removal...percent			95	91	83		
Raw			124	2.54	236		
Final	Thursday, June 24	164		0.48			
Removal...percent				81			
Raw				2.12			
Final	Friday, June 25	188					
Removal...percent							
Raw							
Final	Saturday, June 26	212					
Removal...percent							

Table II is a comparison of the coal-sewage process with conventional activated sludge/digestion-filtration plants. Data for the coal-sewage process are taken from the present test rig operation in Washington; data for the activated sludge process are taken from the literature as typical.

TABLE II

Material	Coal-sewage process		Activated sludge/digestion-filtration process percent removal (typical)
	Percent removal (average)	Percent removal range this run	
Biochemical oxygen demand (BOD)	88	84 to 91	60 to 85.
Chemical oxygen demand (COD)	80	79 to 83	Do.
Phosphates (total as phosphorous)	73	60 to 93	Slight.
ABS (detergents)	85	81 to 91	Less than 40.
Suspended solids	95	92 to 97	60 to 80.

TABLE III.—*Analyses from OCR test rig*

COAL USED IN FILTER

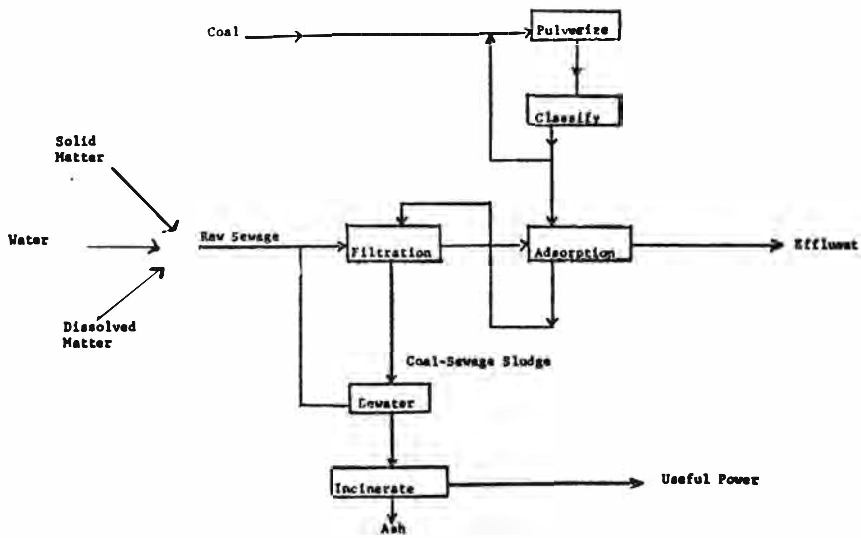
	Percent	Dry (percent)
As received:		
Moisture	3.2	
Vol. matter	36.7	37.9
Fixed carbon	53.1	54.8
Ash	7.0	7.3
Sulfur	1.4	1.5
Hydrogen	5.2	5.0
Carbon	73.6	67.1
Nitrogen	1.4	1.5
Oxygen	11.4	8.6
B.t.u	13,150	13,590

TABLE III.—*Analyses from OCR test rig*—Continued

SLUDGE

	Percent	Dry (percent)
As received:		
Moisture	46.3	----
Vol. matter	20.4	38.1
Fixed carbon	26.9	[illegible]
Ash	6.4	11.9
Sulfur	.9	1.6
Hydrogen	7.8	4.9
Carbon	38.9	72.5
Nitrogen	.8	1.4
Oxygen	45.2	7.7
B.t.u.	6,940	12,910

PROPOSED FLOW DIAGRAM FOR COAL SEWAGE PILOT PLANT



Senator BOGGS. We have next scheduled this morning the panel, Dr. Smith, Mr. Clapper, Mr. Poole, Mr. Douglas, Mr. Callison, and Mr. Dennis. We thank you for your cooperation and your kindness in being here and your helpfulness.

PANEL OF DR. SPENCER M. SMITH, COORDINATOR, SECRETARY, CITIZENS COMMITTEE ON NATURAL RESOURCES; LOUIS S. CLAPPER, CHIEF, CONSERVATION EDUCATION DIVISION, NATIONAL WILDLIFE FEDERATION; DANIEL A. POOLE, SECRETARY, WILDLIFE MANAGEMENT INSTITUTE; PHILIP A. DOUGLAS, EXECUTIVE SECRETARY, SPORT FISHING INSTITUTE; CHARLES H. CALLISON, ASSISTANT TO THE PRESIDENT, NATIONAL AUDUBON SOCIETY; AND ROBERT T. DENNIS, ASSISTANT CONSERVATION DIRECTOR, THE IZAAK WALTON LEAGUE OF AMERICA

Mr. SMITH. I am Dr. Spencer Smith.

Mr. Clapper, who is the chief of the conservation education division of the National Wildlife Federation, will testify first.