RESEARCH AT SANEPAR AND STATE OF PARANA, BRAZIL, WITH ANAEROBIC TREATMENT OF DOMESTIC SEWAGE IN FULL SCALE AND PILOT PLANTS.

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SUMMARY

Research of anaerobic treatment of domestic sewage in the State of Parana started in year 1980 with the joint effort of SANEPAR, Catholic University and State Energy Company, in the search of biogas production through anaerobic treatment. Since then over 20 plants have been constructed with the use of septic tank followed by anaerobic filter (with problems of filter clogging) and use of Imhoff's type tanks followed by UASB reactors and use of RALF-UASB type tanks (cone or trunk-cone shaped) with just 2 to 3 hours detention time for primary treatment purpose, with no smell problem. Three units, with conventional UASB reactors for treating primary effluent, were constructed to generate biogas for homes. The largest unit, PIRAI DO SUL started up in March 1983 and is supplying biogas to 286 homes, as part of a "biogasification plant" for domestic sewage+municipal solid wastes+crop wastes+industrial wastes. With UASB reactors it is possible to have good quality removal of BOD/COD, and 20 to 50 mg/L BOD_5 in effluent, but poor/regular SS removal and even at 15ºC. Sludge becomes very active (1.1gCOD/gVSS.day, 37ºC), can become granulated and settle fast. Biogas has 80%CH_4.

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INTRODUCTION

Little attention was given, before 1980, in the State of Parana, to the anaerobic treatment process for domestic sewage. The exception was the utilization of anaerobic and facultative ponds, as the one in use since some 10 years ago at the town of Maringa, treating the domestic sewage of some 100,000 inhabitants. Generally the anaerobic pond is deeper and more compact than the facultative pond, but remove only 30 to 50% of the BOD load (primary to primary plus treatment efficiency) and sometimes becomes "smelly", as is being the case of one anaerobic pond at the town of Paranavai treating domestic sewage and overloaded with the discharge of dairy wastewaters. One advantage is that almost none cost is envolved with the operation and maintenance of such anaerobic ponds. Removal of excess sludge is very rare, if it happens in the useful life of the pond. Sometimes it is necessary/advisable to remove grit from the raw sewage. The only benefit of one anaerobic pond - is the treatment itself, as it produces no fertilizer (sludge) and the biogas produced (fuel) is lost to the atmosphere and dissolved in the effluent. Some anaerobic ponds, for industrial wastes, are being covered to capture biogas (and smells). It is believed that an anaerobic pond is unable to produce a secondary level treated effluent (30 mg/L BOD_5 and 30 mg/L SS). This is the result of the usual design criteria for anaerobic ponds being not favorable for the intimate contact of the dissolved and undissolved organic matter of sewage with as much active anaerobic bacteria as possible.

The conventional two story septic tank (Imhoff tank) only remove and digest the settled organic matter (sludge) of sewage, and so is not a treatment for the "whole" sewage, which do not become "anaerobic" or "septic".

In order to get a secondary level treated effluent, it is necessary a post-treatment (aerobic) for the anaerobic pond effluent. Because of the general fear of anaerobic ponds becoming smelly, it is used facultative ponds which are anaerobic at the bottom layer and aerobic at the upper layer. In this way, smelly products of anaerobic digestion (H_2S, mercaptans, volatile acids, etc) are oxidized to inodorous compounds before they can reach the atmosphere. When there is no land available at reasonable cost and with good conditions for earthmovement (soil quality, topography, etc), such type of anaerobic treatment associated to aerobic treatment is abandoned in favor to more "compact" treatment process, as the activated sludge and trickling filter, with several variations and associations. Now there is need of more qualified operators, laboratory control, maintenance of equipments, consumption of energy for pumping and/or aeration, etc. And also we have the problem with the disposal of the excess sludge, which is very costly. In general, the excess aerobic sludge mixed with primary sludge is sent to an anaerobic sludge digestor, which produces biogas (fuel) and a stable digested sludge. Generally one part of the biogas is burned to heat the digestor and the remainder is generally flared. After the year 1973, with the increasing cost of petroleum and electricity, biogas became valuable as fuel, to generate electricity and/or heat, and to be used in industries, homes and as automotive fuel. Simultaneously the increased cost of energy for aeration/pumping, in the aerobic proces, introduced the desire to make less use of energy in the treatment of sewage. The other obvious desire was to maximize the biogas production, because of the monetary value of the biogas as fuel to power vehicles (saving petrol/gasoline) and as fuel to generate electricity and/or heat. Things would be even better if we could generate less sludge in the treatment process. All these features and reasoning should point to the direct anaerobic treatment of the <u>whole</u> sewage. But it was difficult to change the mind of sanitary engineers acquainted with aerobic treatment process, and having one conventional activated sludge plant for 30,000 inhabitants working since 1965 (with all biogas being flared, some $800 m^3/day$) and having in construction, started in year 1977, one extended aeration treatment plant for a design load of 25,000 kg BOD_5/day and 0.85 m^3/s average flow. Such plant has bar screens and grit chamber, and has no primary treatment. Raw sewage is introduced into aeration tank 5m deep with 83,300 m^3 capacity, or with some 27.2 hours average detention time of aeration. Aeration tank is divided in two units, endless oxidation ditch channels in which we have 16 surface aerators, of 150 HP and 4 m diameter each, at the 180º curves of the channels. Each aeration unit is coupled to a secondary clarifier of 65 m diameter and 3.5m deep at the border. Such plant started up in year 1979 and other similar plants were under design and to be constructed. Notice the very large detention time in the whole unit (aeration tank + secondary clarifier), and have this number in mind when thinking on detention time in anaerobic treatment units for domestic sewage. Such Carrousel plant is the largest one in the world treating domestic sewage, and is constructed in Curitiba, and is operated by SANEPAR. We are having 98 to 99% BOD_5 removal efficiency in it, which is much more than what is required. It is being considered the conversion of such Carrousel plant into an anaerobic treatment plant for sewage, with the transformation of the aeration tanks (5 m deep) into upflow anaerobic sludge bed reactors with little changes of civil construction. Both aeration tanks could be converted to upflow anaerobic sludge bed reactors or in a first phase just one aeration tank would be converted to upflow anaerobic sludge bed reactor and the anaerobic effluent would enter into the other aeration tank, as the polishing activated sludge process. In such solution, the upflow velocity would be of $(0.85 \times 3,600)/(83,330/2 \times 5) = 3,060 / 8,330 = 0.367$ $m^3/m^2.h$ or 0.367 m/h, which is very small in relation to the settling velocity of the anaerobic sludge "flocs" of the sludge bed. So, little sludge would tend to escape.

It is interesting to notice that this Carrousel plant of Curitiba replaced a conventional activated sludge plant that had been designed in years 1972 to 1974, of similar capacity, and had a conventional primary treatment process (rectangular settling tanks; pumps for primary sludge mixed with excess secondary aerobic sludge; heated and mixed anaerobic digestors for primary+excess sludge; secondary thickner digester; pumping of digested sludge to sludge drying beds) and a conventional secondary treatment process (rectangular aeration tank with air diffusers,followed by rectangular secondary settling tanks). All equipments would use external electricity. A small part of the biogas would be burned in a furnace to heat water to heat the digesters. The remainder of biogas would be flared. In the comparisons made in year 1973 to 1975 we found - that the Carrousel plant had a smaller initial investment(and equivalent operational cost)than the conventional activated - sludge plant, so it was selected the Carrousel plant for construction in Curitiba. Probably several other Carrousel plants and other aerobic process plants,would have been built in the State of Parana if we did not have the "energy crisis", and - contact with other researchers interested in anaerobic treatment and in biogas (alternative energy).

In 1978,one author,Mr.Gomes,was studying in the University of California,at Berkeley,having his M.S. course in sanitary engineering. He had oportunity to take part of the 51 st Annual Conference of the W.P.C.F.,at Anaheim,California,in 1 to 6 October 1978,and to see one conference of M.Switzenbaum and W.J.Jewell (1),in which was demonstrated that an anaerobic treatment process could be efficient at low temperatures and for diluted wastewaters,requiring small hydraulic retention time. Other paper in the Conference was about the utilization of an anaerobic filter,in full scale plant, for the treatment of domestic wastewater,which showed good results - and some problems with clogging of filter media (stones). In that year,visiting sewage treatment plants in USA and Europe, He saw the utilization of biogas for heat and electricity production. In Netherlands the trend was to use Carrousel plants as a polishing step or to return to conventional activated sludge process with anaerobic digestion of primary+excess aerobic sludges,in order to save energy.

In early 1980 the State Energy Company (Public Utility for Electricity),named COPEL,had a Department of Alternative Energy. They were taking care of a State Program of construction of farm anaerobic digesters to generate biogas,to be burned in stoves and lamps. A former President Director of SANEPAR (Sanitation Company) was taking care of such programme of rural anaerobic digesters,and He wondered if it wouldn't be - possible to generate biogas from domestic sewage treatment to use such biogas in stoves. They were to start the construction of an hydroelectric plant,and they were to build a town - for the employees of the construction companies (some 10,000 inhabitants). The treatment of the sewage of such persons was expected to generate enough biogas to power the stoves of a collective restaurant. With this in mind, the Energy Company, COPEL, asked to the Sanitation Company, SANEPAR, a study of treatment of domestic sewage that could generate as much biogas as possible. If possible the plant should be made of units that could be moved to another future site of hydroelectric plants. The first reaction of the sanitary engineers was that such idea was not feasible or interesting, probably because they were much envolved with conventional ponds (aerated, facultative, anaerobic) and with Carrousel plants.

In the first study prepared by SANEPAR to COPEL, by the author (Mr.Gomes), it was suggested that the best way to maximize biogas would be the utilization of a two stage process, each one with digestion of settled sludge. In the first stage we could use an Imhoff tank (two story septic tank) or a conventional primary settling tank and with an anaerobic digester for digesting the primary sludge. In the second stage we should use an aerobic biological process that would maximize the conversion of not settleable organic matter (dissolved organics) into a "slime" or "biologic sludge", and with such slimes or biologic sludges being settled and removed /sent to an anaerobic digester. One possible solution would be the utilization of high rate trickling filter followed by an Imhoff tank. Also it was included a high rate pond to remove nutrients and decrease the concentration of coliforms and other pathogens. The settled algae would be also anaerobically digested to increase the biogas production.

At that time, middle of year 1980, it was made some studies in SANEPAR about the economic feasibility of utilization of biogas (some 800 m³/day being flared in one plant in Londrina, since 1965). Very soon it was concluded that the best utilization would be substitution of gasoline (petrol), very expensive in Brazil (some US$ 0.50/litre), by compressed and purified biogas. Biogas utilization in stoves, in substitution of LPG, didn't appear to be good business, because LPG is subsidized in Brazil. These conclusions attracted attention of the sanitary engineers to the value of biogas as source of earnings to the sanitation company. As result, treatment process that could generate more biogas would be in more favor.

At the end of year 1980 the Energy Company COPEL was convinced that it was necessary to invest some money in a pilot plant to demonstrate the process of generation of biogas. This is a very usual procedure for design of hydroelectric plants, the construction of hydraulic reduced models. It was decided to construct a pilot plant for some 800 inhabitants load,and it was decided to construct such pilot plant at the Campus of the Catholic University in Curitiba,because of the interest of such University and land availability and because a main - sewer of SANEPAR pass through the Campus transporting exclusivelly domestic sewage of a large neighborhood.

THE PILOT PLANT AT THE CATHOLIC UNIVERSITY OF PARANA (ISAM)

Figure 1 and 2 are lay-out of pilot plant already constructed at the Campus of the Catholic University of Parana.As can be seen,it was installed a submersible pump in a pit of - the main sewer. In this way it is possible to control the influent flow to the pilot plant,as to reproduce several load - conditions. Raw sewage enters at the middle of a primary settling channel with walls being flexible PVC structure of lateral inflatable gas holders. Flow is split in two equal streams which run in opposite directions to V-notch weirs. There are walls into the digestion compartment to avoid circulation of raw sewage from the settling compartment into and out of - the digestion compartment. So it is a kind of Imhoff tank with trunk of pyramid bottom shaped. It is a kind of lagoon with floor and side walls being made of soil-cement. At the very center of unit "01" there is a cylinder pit to store primary digested sludge. This is more clear in Figure 3,which is a vertical cross-section of the unit. Later on,in late December 1980,it was decided to construct this unit also to work - as an UASB (upflow anaerobic sludge bed/blanket) reactor,and, for this,raw sewage can enter at the very bottom of the cylinder pit,flowing upflow against a sludge bed of anaerobic sludge.Also industrial wastewaters (like from meat/dairy/beer/sugar/ethanol industries) could be introduced at the bottom of the primary unit. For storing such type of concentrated wastewaters it was constructed a unit "09",to be filled with trucks transporting such wastes. With this,it would be possible to study increased organic loadings and also the treatbility of selected wastewaters (as ethanol stillage). All biogas produced is collected under inflatable PVC gas holders,one in each side of the primary settling compartment (which also could be used as UASB settling compartment). Primary effluent can - be pumped to over the unit "02",to feed rotary distributors over the trickling filter,of high rate,inteded to convert dissolved and colloidal organic matter into "slimes". There is a pump to feed a two story septic tank,in which there is no provision to avoid the influent to flow from settling compartment to into the digestion compartment. Walls of the settling compartment are flexible PVC structure of gas collectors. Also it is possible to feed the unit "03",the two story septic tank,at the bottom of a central cylindric pit,and so making unit "03" work as an UASB type unit. The effluent of unit "03" can be recycled to the high rate trickling filter "02". It is also possible to feed the unit "03" with concentrated industrial wastewaters,at the very bottom,to increase the organic loading and to study the anaerobic treatbility. For such,the industrial wastewater is fed from storage tank "09". Excess sludge from units "01" (primary) and "03" (secondary) can be sent to a storage pit "08". The primary effluent or the secondary effluent (from unit "03") can be sent to a high rate algae pond,shallow and with endless channels and forced flow by a paddle-wheel pump. Here we have a polishing treatment to remove pathogens and to remove nutrients. Algae settle well and flocculate. Excess algae is removed from the high rate algae pond "04" to a settling tank (Dortmund) placed in the dark,unit "05". Settled algae can be sent to the bottom of units "01" or "03" or to an algae digester unit "06". Generally the pond effluent is to pass trough the two story septic tank unit "06",with surface radial flow from center to periphery weirs,in a circular unit. Digested algae is sent to the sludge storage pit "08". Biogas is also collected under the flexible PVC structure (floor of settling compartment) of unit "06". Biogas produced in units "01","03" and "06" are flow measured and are purified (H_2S removal),and are sent to a biogas compression unit "07",with storage of gas at some 5 to 10 bar (kg/cm^2). From such storage,gas is sent to use in the stove and lamps of one house unit "10". All the mentioned units are already constructed and operative. Later on we will discuss the results. Construction took place in year 1981,and some units became operative in the beginning of year 1982 (units 01 to 04),when construction ceased because there was no more financial support for the project. At the end of year 1983 construction was concluded,now with some contribution from the State Sanitation Company-SANEPAR,and with a great support from FIPEC of Bank of Brazil. With this,in early of 1984 all units again became operative,including the paddle-weel pump of unit "04" in July 1984. Figure 4 shows the unit "03".

It is strange,but the sanitation company had little participation in this research at the Catholic University, since early of year 1981 to almost the end of year 1983,because of some rivalry between the sanitation company and the energy company, with the last giving financial support for construction of the pilot plant. Probably this reflects our problems of facing biogas (energy) distribution and utilization as a source of income for the sanitation company and as an "utility" for the energy company. As result of little cooperation (and much competition) between such companies, several projects started in parallel at the sanitation company, without waiting the results of the pilot plant, for biogas production (anaerobic treatment) and utilization. We can mention the utilization of pure and high pressure methane (from scrubbed biogas) as vehycle fuel, which started up in october 1981 with the fuelling of the first vehycle, at the town of Londrina. It became obvious that this is the best economic option of utilization of biogas for a sanitation (or energy) company, for brazilian conditions. Other projects are the utilization of septic tanks followed by anaerobic filter, constructed in several neighborhoods across the State of Parana, in years 1981 to 1983 (it stopped because of clogging the filter media). In late 1982 we started the utilization of the RALF process, trunk cone shapped reactors UASB type but without settling compartment, with feed at deepest point and weirs at the periphery. But the more interesting projects, similar to the one of the pilot plant of Catholic University, were constructed in the town of Pirai do Sul (10,000 inhabitants) and Curitiba (Bracatingas neighborhood), to be discussed in this paper.

THE PILOT PLANT AT THE BRACATINGAS NEIGHBORHOOD OF CURITIBA

This plant was conceived in year 1980 to treat the domestic sewage of some 680 inhabitants of a neighborhood of poor families. As construction started only in 1982, we had time to change the design in relation to the original design similar to the pilot plant at the Catholic University. Raw sewage is pumped to the plant. To avoid problems with contamination of biogas with nitrogen (and oxygen) dissolved in raw sewage, it was constructed a barometric vacuum siphon in which dissolved gas are removed with the help of a vacuum pump. Degasified sewage enters at the very bottom of the primary unit which is a perfect and deep cone reactor, with walls at 45º slope made of bricks covered with mortar. At surface there is a settling channel made with asbest cement plates. The whole unit is covered with a flexible PVC gas holder to collect and store biogas. So this unit works as an UASB type unit. But it can also work as a two story septic tank,with raw sewage being introduced at the middle of the settling channel and the flow being split in two equal parts,each flowing in opposite direction along the channel. Some of the raw sewage may enter into the digestion compartment as there is no compartmentalization in it. The excess primary sludge is sent to an endless channel of a "ditch digestion unit",similar to a high rate algae pond totally covered by an inflatable PVC gas holder. In such ditch digestor is to be added ground municipal solid wastes (hand sorted garbage) and agricultural wastes. Digested sludge is sent to a sludge drying bed. The primary effluent is sent to the bottom of a secondary unit, UASB type,being introduced through 3 diffusers (one each 3m²),in a trunk of cone reactor with flat bottom,with walls at 45º slope,made with bricks and covered with mortar. At the surface of the secondary unit there are two settling channels,also made with asbest cement plates. The whole surface is covered by a flexible PVC gas holder to collect and store biogas. The secondary UASB effluent can be sent directly to the river or can pass first through the barometric vacuum siphon to recover the dissolved methane gas in the effluent. Also CO_2 is degasified. This unit is complete but not yet fully operative. Biogas is compressed in a liquid ring compressor and sent to 52 homes of the neighborhood,through steel pipes, to be used in stoves as fuel.

THE FULL SCALE PLANT AT PIRAI DO SUL (BIOGASIFICATION PLANT)

This plant was conceived in early of year 1981 when ceased the cooperation of the sanitation company with the energy company. This is somewhat the same design of the pilot plant Bracatingas in a larger scale. But the full scale plant was constructed before the pilot plant, because it received more support from the politicians. Here the idea was to construct a sanitary biogasification plant, able to digest domestic and industrial wastewaters, and to batch digest municipal solid wastes (to be sorted out,by hand,and ground) and to digest also agricultural wastes and crops grown for biogas production. The idea was to make one town of 10,000 inhabitants self-sufficient in home fuel,with the utilization of biogas in place of LPG in stoves.Biogas was to be distributed at 4 bar through high density polyethilene pipes,and pressure reduced to 1 to 2 psig,to be used in LPG stoves not converted to natural gas standard. Figure 5 is a general lay-out of the biogasification plant,which is partly constructed,and operative since early of March 1983. Basically the raw sewage was discharged in the Pirai River since some 30 years ago. Making use of - the slope of the main sewer,it was included the anaerobic se wage treatment,also by gravity. Raw sewage is diverted in a pit by a sluice-gate,going to a cyclone grit removal unit in which grit is removed by air lift. The degritted sewage is - sent to a pit with a bar screen (2 cm free opening),and is - divided in two equal flows in a weir,each one feeding a pipe that go to the middle of one settling channel made of asbest cement plates on a wood/concrete structure. Such settling cha nnel is very long,and perpendicular to the feeding pipe at - the middle and has two opposite exit,one in each extremity of the channel. Each exit is a submersed pipe going to a pit wi- th a weir. So the influent is divided in 4 equal flow primary effluent. As the settling channels are very long and there is no compartmentalization of the digestion chamber, a great pro portion of the flow travels through the digestion compartment and the primary unit works more like an anaerobic pond or con ventional septic tank. The whole unit is covered by an infla- table gas holder which collect and store biogas. Primary di- gested sludge pile up at the bottom,sloped to the central pit and from it,there is one pipe going to the pump station pit nr.1,having two sluice gates in it. Opening both sluice gates the primary sludge can flow directly to the river by gravity. Or primary sludge can be pumped to batch digestors or other convenient use. A typical cross-section of the primary unit is shown in Figure 6. Such unit has 28 m diameter at water surface level and 45º slopped walls,made of not reinforced - concrete,finishing at 4 m water depth,making a trunk of cone, over a flat cone shapped bottom (also of not reinforced con- crete) of 20 m diameter at base. Theoretically only a cylin- der of 16m diameter and 5 m deep would suffice as a primary unit,but it would be necessary to use reinforced concrete. So the volume and dimensions of the reactor were increased for - constructive reasons,but probably with none influence in the treatment itself. There is one way to introduce the whole raw sewage flow at the very bottom of the primary unit,making it to work as an UASB unit. This has not been done yet. Other op tion,already in use, is the feeding of concentrated wastewa- ters (like molasses, ground agricultural wastes as onions,and like "leachate" of batch static digestors),and diluted waste- waters,as recycle of some of the secondary effluent,at the ve ry bottom of the primary unit,making it to work as an UASB u- nit for such feed,as is being the case. The primary effluent is fed to a secondary UASB type unit,trunk of cone of 12m at the flat horizontal bottom and 20m at the water surface,being 4m deep with 45º slopped walls made in not reinforced concrete. Also,theoretically,a cylinder reactor of 11.85m diameter and 4 m deep would be enough for the treatment. So,the remainder volume,related to constructive reasons (not use of concrete reinforced in vertical walls),has no effective use in the treatment process (dead volume),mainly if we consider the aspects of flow of sewage against the sludge blanket to 4 settling compartments at surface,over the 12m diameter bottom, and made of asbest cement plates and wood/concrete structures. The influent is divided in a central pit to 6 pipes,each one feeding 2 diffusers. So we have 1 diffuser each 9.4 m^2 of bottom of reactor. But to avoid much short-circuiting of the influent (less dense) against the sludge bed (more dense), over each of the 12 feeding pipe (10 cm diameter) it was placed a concrete plate of 1.2m diameter with the center over the feeding pipe,and so the influent is forced to leave horizontally at the border of the plate. Primary unit was included in the treatment plant more to protect the system of feeding the secondary unit,than for treatment purposes. The worry was about clogging of the feeding pipes and plate diffusers. The secondary effluent is collected at channels placed along the 4 settling compartments,and is transported by 4 pipes to an external pit. The whole secondary unit is also covered by an inflatable (PVC+hypalon) gas holder. There is no provision to remove excess sludge. But there was no provision to introduce seed sludge to generate the sludge bed in the secondary unit, and attempts to introduce it mixed with primary effluent caused the diffusion system to become clogged. Later on it was installed a pipe over the bottom of the secondary unit and through it was (is) possible to add primary digested sludge, to create the sludge bed,and also to recycle secondary effluent to force the scape of poor settling sludge. During the design it was assumed that the secondary effluent would leave the unit saturated with dissolved methane,and to recover this dissolved gas,the project considered the construction of a barometric degasifier siphon kept run with the help of a vacuum pump. But there was no money to construct such degasifier.The effluent falls in a weir,being somewhat aerated,and pass through a parshall flume to measure the flow. Water level is being measured to compute the flow,because there was no money to install a flow-indicator/recorder. We are observing the deposition of a pale product in the walls,underwater of the flume, and such whitish deposition appears to be sulphur smelling. In the parshall flume we measure also the effluent temperature. The measured effluent can flow to the nearby river by gravity (if there is no flooding) and/or can flow to the pump station nr. 1 to be sent to the by-pass of the plant or to feed the primary unit (mixed with raw sewage or introduced at the bottom of the unit) or to feed the secondary unit (mixed with primary effluent or introduced at the bottom of the unit) or to the batch digestors. Primary digested sludge, instead of going to sludge drying beds, is sent to "dry digestors", to be used as inoculum to speed up the digestion of solid wastes. As result, during the first days, the digestors become "sour", and secondary UASB effluent is used to "leach" the soluble organics of the solid wastes being digested/leached. As result it is drained a "leachate" at the bottom of the batch digestors, and this wastewater is sent to the sewage treatment process, generally being introduced at the bottom of the units working as UASB units. It was considered the processing of the municipal solid wastes (hand sorting and recycling of useful products), and the hammer milling of the garbage (organic fraction) before introducing it in the batch digesters. Also to increase biogas production, rural wastes would be also used. And we would have the production of agricultural crops, like whole - sugar cane plants, potatoes, etc, to feed the biogasification - plant. Readilly digestible parts, like the sugar cane juice, could be added to the digestion units for sewage, and the less digestible parts, like bagasses, would be digested in the batch digestors, which also could store "sour" products (like silage) to be leached when necessary to increase biogas production. In Figure 6 we also show the details of the secondary unit in a cross-section vertical view. Figure 7 shows the details of batch type inoculated "dry digestors" for solid wastes, in plan view and cross-section (vertical). Figure 8 shows a flow diagram of the biogasification plant. It is to notice that the - plant is very much oversized in some aspects for the nowadays load of domestic sewage of only 6,000 inhabitants. As practical consequence, the plant is supplying biogas to only 286 homes of such town of Pirai do Sul, at 13 to 20 psig in the distribution system. When there is no biogas available for cooking, it is used LPG, because none change was made in stoves.

EVALUATION OF THE RESULTS OF THE PIRAI DO SUL's PLANT

Next we will discuss some more recent results (period of

August 1984 to February 1985). In a previous paper by one writer (2), is given (in 47 pages and 32 figures, in English) the whole details of design and operation of the biogasification plant up to August 1984. As a summary, it can be said that the start up took place in March 1, 1983, when entered raw sewage into the primary and secondary tanks already filled with river water. During the next 2 weeks the plant became smelly, but 1 month later the smell went away. It was not added digested sludge as seed, and also pH was never chemically controled. During the first year the plant received very little attention, and there was no operator. PVC inflatable gas holder had leakage of biogas through seams. Plant became entirelly flooded by the nearby river and this did not affect the plant and did not cause the sludge to escape. Quite a lot of grit piled up at the bottom of primary unit, mixed with digested sludge, because rarelly bar screen and grit chamber were cleaned. Very little sludge had accumulated at the bottom of secondary unit, probably because most of the suspended solids were removed in the primary unit. Two attempts to introduce primary digested sludge (having grit in it) mixed with the primary effluent, into the secondary unit, through the diffuser system, caused the clogging of the diffusers, and flooding of the primary unit. So, when treating primary effluent in UASB type reactors it is necessary to create the sludge blanket/bed to make the UASB unit work. Later on it was constructed a pipeline ending over the bottom of the secondary unit which made it feasible the addition of large amounts of primary digested sludge in the secondary unit to create a "sludge blanket". It was filled up the secondary unit with primary digested sludge, but some sludge was removed with the effluent and the remain became a thick and dense sludge bed of only some 1 to 1.5m thick. In early of 1984 it was decided to recover and conclude the biogasification plant. Gas holders were rubber lined (hypalon) to make them gas tight. Some gritty digested primary sludge was discharged by gravity in the river. It was installed the more efficient cyclone grit chamber (easy to clean). Since May of 1984 it was started the recording of sewage flow (secondary effluent), temperature, regular sampling to get results of BOD/COD/SS removals with "grab samples", regular operation and maintenance of the biogasification plant and the distribution system, reading of home gas meters, etc. Plant was again inaugurated in late April 1984, starting the gas distribution to 286 homes, free of charge, during 1 year. Before the inauguration it was added sugar cane stalks milled and comminuted, to the -

primary unit to increase biogas production and to have gasholders totally inflated during the inauguration. Sugar cane juice was added at the bottom of primary unit. Bagasse and also grass cuts were added to the raw sewage. Later on it was comminuted rotting onions and added at the bottom of primary unit. In June 1984 started the filling of the batch digestors with municipal solid wastes. This was concluded in late July of 1984. It was added some primary digested sludge as seed to the batch digestors, but they became "sour", and biogas could - not burn (very high CO_2 concentration) in home stoves. We learned how difficult is to deliver biogas, free of cost and limits, to customers in the wintertime when biogas production decline at the biogasification plant. One help came from an industry of sugar and ethanol production (from sugar cane), interested in having very active seed sludge for their UASB reactors to treat a COD load of 25,000 kg/day, and to start up in May of 1985. They decided to bring several truck loads of concentrated molasses, which have been introduced at the bottom - of primary and secondary unit (and some mixed with raw sewage) to increase the sludge activity (as it in fact has done), and also the granulation of the anaerobic sludge. One advantage is that probably in the future we will have a source of very good seed sludge for future reactors treating domestic sewage. From time to time we took samples of biogas, to know its composition, and we got surprised with results to be discussed. Up to - the end of August 1984 we have daily results of grab samples, for raw sewage, primary effluent and secondary effluent. Later on it was implemented the composite proportional sampling, so we get composite samples. The first thermometer used was not accurate, and so it was changed by a precise one. In November 1984 it was installed a large gas meter (American Meter) lent by the Gas Company of Rio de Janeiro (CEG), but it was installed in the discharge of compressor, where pressure changes in the range of 12 to 20 psig, so it was measuring nothing. Late January 1985 it was installed a BP1 integrator, also of CEG, - but the equipment soon became not operative. Because of this the only results we have is the monthly consumption of the town, measuring 286 home gas meters. Biogas is odorized with THT, because the smell of biogas is not enough for safety reasons. Generally the smell of biogas is minimum. Also the plant do not present smell, as a general rule. Exception is when massive amounts of onions or molasses are added in the process. Also biogas from solid wastes, in the beginning, is very smelly.

Next we will examine the Table I, from August to February.

Table I. Operational Data

Date	Flow m³/day infl.	eff.+ (rec)	Eff. Temp °C	T.BOD$_5$ mg/L inf	pri eff	sec eff	T.COD in mg/L infl.	pri eff	sec eff	SS in mg/L inf	pri eff	sec eff
8/01	-	1,187	16.0	882	254	206	1,694	649	410	260	116	128
8/02	-	Flood	16.0	-	-	-	-	-	-	-	-	-
8/03	-	Flood	15.0	269	113	34	524	372	88	384	104	56
8/04	-	Flood	15.0	-	-	-	-	-	-	-	-	-
8/05	-	1,231	15.0	-	-	-	-	-	-	-	-	-
8/06	-	1,404	15.5	463	123	66	907	265	198	485	124	108
8/07	-	1,312	16.0	-	-	-	-	-	-	-	-	-
8/08	-	1,331	16.0	109	101	48	331	192	127	150	80	96
8/09	-	1,323	16.0	736	-	45	1,340	-	182	448	-	162
8/10	-	697	16.5	122	152	72	504	250	144	152	152	108
8/11	-	397	16.5	-	-	-	-	-	-	-	-	-
8/12	-	203	16.0	-	-	-	-	-	-	-	-	-
8/13	-	1,129	16.0	-	164	56	-	328	157	-	244	172
8/14	-	661	16.0	405	-	53	820	-	104	284	-	168
8/15	-	1,220	16.0	624	-	193	1,380	-	318	475	-	360
8/16	-	1,247	16.0	244	109	82	480	321	324	105	110	200
			16.0	164	119	182	569	250	312	220	235	208
8/17	-	1,233	16.0	-	-	-	-	-	-	-	-	-
8/18	-	1,147	16.0	-	-	-	-	-	-	-	-	-
8/19	-	1,108	16.0	-	-	-	-	-	-	-	-	-
8/20	-	1,345	16.0	549	196	192	1,223	474	438	420	310	180
8/21	-	1,395	16.0	305	183	193	628	413	296	196	152	200
8/22	-	705	16.0	475	141	96	861	253	192	216	128	180
8/23*C	744	945	16.0	275	137	101	545	295	210	164	138	110
8/24	2,001	2,762	15.5	-	-	-	-	-	-	-	-	-
8/25	2,294	3,041	15.5	-	-	-	-	-	-	-	-	-
8/26	3,156	3,156	15.0	123	100	39	265	204	152	225	104	100
8/27	1,852	2,506	15.5	227	115	106	447	222	184	188	140	128
8/28	1,618	1,922	15.0	168	61	77	328	193	104	168	144	96
8/29	1,669	1,939	15.0	240	120	97	480	247	154	224	124	112
8/30	1,595	1,846	15.0	281	181	177	593	369	304	210	160	100
8/31	1,718	1,907	15.5	-	-	-	-	-	-	-	-	-
Data average	1,850	1,439 (1,319)	15.7	351	139	106	733	312	220	262	151	149

Note: up to August 22,1984,all samples were grab samples collected randomlly,at operator's will. After that time the samples are composite proportional flow samples.

Table I. Operational Data

Date	Flow m³/day infl.	eff.+ (rec)	Eff. Temp °C	$T.BOD_5$ mg/L inf	pri eff	sec eff	T.COD in mg/L infl.	pri eff	sec eff	SS in mg/L inf	pri eff	sec eff
9/01	1,636	1,853	16.0	-	-	-	-	-	-	-	-	-
9/02	1,330	1,740	15.5	219	160	120	439	272	219	122	130	108
9/03	1,726	1,946	16.0	211	214	124	531	358	217	164	108	88
9/04	1,800	1,899	16.0	162	150	63	611	330	271	256	140	110
9/05	1,698	2,557	16.0	219	166	55	520	206	124	180	132	110
9/06	1,621	2,430	16.0	573	163	37	1,437	297	89	160	112	92
9/07	1,426	2,278	16.0	177	102	48	396	183	83	124	136	120
9/08	1,381	2,582	16.0	-	-	-	-	-	-	-	-	-
9/09	1,285	2,541	16.0	219	106	312	444	142	848	168	132	100
9/10	1,717	2,647	16.0	-	-	-	-	-	-	-	-	-
9/11	1,366	2,635	16.0	240	110	134	438	299	328	160	104	124
9/12	1,584	2,505	16.0	211	97	43	605	230	149	308	132	104
9/13	1,689	2,691	16.0	385	212	78	796	530	173	368	132	120
9/14	1,419	2,335	16.0	187	107	65	436	210	143	240	132	112
9/15	1,395	2,206	16.0	-	-	-	-	-	-	-	-	-
9/16	1,225	1,974	16.0	208	115	48	446	276	127	220	140	144
9/17	1,337	2,322	16.5	-	-	-	-	-	-	-	-	-
9/18	1,320	1,950	17.0	361	105	99	607	226	187	268	256	144
9/19	1,266	1,887	17.0	325	108	65	658	314	185	304	168	104
9/20	2,607	2,977	16.5	142	-	75	292	-	185	148	-	108
9/21	1,815	2,783	16.0	190	123	55	380	289	138	192	124	72
9/22	1,427	2,437	16.0	229	133	99	546	332	182	232	144	80
9/23	1,341	2,286	16.0	222	245	-	486	523	-	192	240	-
9/24	1,419	2,159	16.5	220	157	188	875	416	411	-	-	-
9/25	1,595	1,816	17.0	-	-	-	-	-	-	-	-	-
9/26	1,264?	1,264?	16.0	-	-	-	-	-	-	-	-	-
9/27	flood	flood	-	-	-	-	-	-	-	-	-	-
9/28	2,807	2,807?	16.0	276	90	48	575	252	107	-	-	-
9/29	1,858	2,252	16.0	235	113	21	610	260	131	-	-	-
9/30	1,498	1,661	16.0	280	44	18	790	81	79	-	-	-
Data average	1,581	2,256	16.1	250	135	85	587	287	208	211	145	108

Note: All results of BOD_5 (unfiltered),COD(unfiltered) and SS are related to composite proportional flow samples,of 6:00PM and 8:00PM and 10:00PM of previous day and 6:00 AM,8:00AM, 10:00AM,12:00AM,2:00PM and 4:00 PM of the given day date of the results of composite sample.

Table I. Operational Data

Date	Flow m³/day infl.	eff.+ (rec)	Eff. Temp ºC	T.BOD$_5$ mg/L inf	pri eff	sec eff	T.COD in mg/L infl.	pri eff	sec eff	SS in mg/L inf	pri eff	sec eff
10/01	1,675	1,772	16,5	226	152	100	549	268	235	–	–	–
10/02	1,703	1,914	17,0	172	117	41	325	247	116	–	–	–
10/03	1,736	2,272	17.0	272	96	60	507	245	167	–	–	–
10/04	1,736?	2,272?	17.0	200	68	70	540	218	93	–	–	–
10/05	1,690	2,594	17.0	232	218	72	420	355	163	–	–	–
10/06	1,745	2,468	17.0	80	61	49	145	119	141	–	–	–
10/07	1,483	2,340	17.0	160	76	29	255	204	149	–	–	–
10/08	–	–	–	151	69	30	331	151	105	–	–	–
10/09	–	–	–	130	52	30	378	196	115	–	–	–
10/10	–	–	–	241	174	113	546	426	349	–	–	–
10/11	–	–	–	250	119	141	660	387	294	–	–	–
10/12	–	–	–	296	181	100	787	332	238	–	–	–
10/13	–	–	–	296	121	82	686	334	204	–	–	–
10/14	1,352	2,222	17.0	139	171	98	679	239	192	–	–	–
10/15	1,451	2,286	17.0	195	135	69	567	302	119	–	–	–
10/16	1,443	2,021	17.0	261	110	69	681	262	157	–	–	–
10/17	1,316	1,735	17.0	–	–	–	–	–	–	–	–	–
10/18	1,843	1,944	17.0	218	96	42	329	162	84	–	–	–
10/19	1,825	1,946	17.0	256	49	52	406	136	103	–	–	–
10/20	1,428	2,164	17.0	113	26	11	280	67	44	–	–	–
10/21	1,271	1,410	17.0	130	54	5	424	116	37	–	–	–
10/22	1,292	1,586	17.0	240	69	24	593	179	113	–	–	–
10/23	1,336	2,184	17.0	282	71	23	491	252	130	–	–	–
10/24	1,368	2,006	17.0	–	–	–	–	–	–	–	–	–
10/25	1,330	1,755	17.0	276	95	89	711	209	138	–	–	–
10/26	1,242	2,123	17.5	216	109	72	574	279	208	128	176	92
10/27	1,484	2,280	18.0	193	114	92	500	329	208	172	160	112
10/28	1,053	2,236	18.0	148	53	88	399	267	215	188	44	88
10/29	1,088	2,229	18.0	244	72	19	401	196	61	180	76	58
10/30	1,251	2,278	18.0	271	53	43	811	257	204	364	136	140
10/31	1,128	2,176	18.0	–	–	–	–	–	–	–	–	–
Data average	1,451	2,089	17.2	210	100	61	499	241	149	206	118	98

Note: All results of BOD$_5$ (unfiltered), COD (unfiltered) and SS are related to composite proportional flow samples. Some flow data are missing. Nitrification is not inhibited in BOD test.

Table I. Operational Data

Date	Flow m³/day infl.	eff.+ (rec)	Eff. Temp °C	$T.BOD_5$ mg/L inf	pri eff	sec eff	T.COD in mg/L infl.	pri eff	sec eff	SS in mg/L inf	pri eff	sec eff
11/01	1,389	2,316	18.0	48	67	18	123	187	71	184	124	44
11/02	1,619	2,399	18.0	53	46	16	170	159	155	184	100	124
11/03	1,805	2,580	18.0	87	43	35	171	88	144	124	64	104
11/04	790?	790?	18.0	-	-	-	-	-	-	-	-	-
11/05	2,392?	2,392?	18.0	169	87	75	281	138	132	92	100	88
11/06	1,727	1,905	18.0	153	46	18	595	257	57	156	112	100
11/07	1,906	2,255	18.0	89	54	43	155	131	105	168	124	99
11/08	1,934	2,093	18.0	196	60	15	510	192	86	88	100	76
11/09	1,766	2,120	18.0	236	53	18	483	82	24	88	104	48
11/10	1,884	2,604	18.0	99	24	30	110	42	61	140	52	84
11/11	1,938	2,525	18.0	99	-	44	178	25	82	140	80	116
11/12	1,786	1,900	18.0	165	53	28	296	107	77	96	52	108
11/13	1,000?	flood	18.0	62	47	19	180	121	25	84	100	76
11/14	1,327	flood	18.0	138	114	19	373	212	73	72	68	44
11/15	2,527	2,530	18.0	210	94	61	664	127	119	180	140	96
11/16	2,782	2,691	18.0	126	45	47	438	120	196	60	84	68
11/17	1,357	flood	18.0	133	174	432	393	527	1,103	116	80	144
11/18	2,400	2,592	18.0	-	-	-	-	-	-	-	-	-
11/19	2,142	2,787	18.0	-	-	-	-	-	-	-	-	-
11/20	3,187	flood	18.0	47	22	29	118	38	50	88	46	54
11/21	flood	flood	17.0	35	17	21	90	64	65	62	50	52
11/22	2,452	flood	17.0	118	34	44	174	188	96	104	100	34
11/23	2,728	flood	18.0	957	196	126	2,126	334	273	1,576	144	144
11/24	3,407?	3,407?	18.0	107	82	82	256	121	151	100	92	88
11/25	2,304	2,956	18.0	183	45	34	270	160	110	124	140	84
11/26	3,020	3,408	18.0	139	34	21	306	94	142	148	96	92
11/27	2,498	3,033	18.0	-	-	34	142	-	63	116	-	18
11/28	2,239	3,082	18.0	128	75	29	329	207	99	116	160	120
11/29	2,623	3,130	18.0	132	84	19	400	299	119	136	96	88
11/30	2,578	3,168	18.0	-	-	-	-	-	-	-	-	-
Data average	2,121	2,551	17.9	156	67	52	359	161	141	175	96	84

Note: There is a great infiltration of ground water into the sewers and there is also a direct leakage of large flow of rainwater into the sewers, diluting the domestic sewage. Large amounts of grit reaches the sewage treatment plant.

Table I. Operational Data

Date	Flow m³/day infl.	eff.+ (rec)	Eff. temp ºC	T.BOD$_5$ mg/L inf	pri eff	sec eff	T.COD in mg/L infl.	pri eff	sec eff	SS in mg/L inf	pri eff	sec eff
12/01	2,525	2,886	18.0	190	58	26	209	96	69	236	56	76
12/02	2,365	3,129	18.0	119	49	27	283	59	53	168	116	56
12/03	2,860	3,360	18.0	174	95	50	277	132	86	124	104	68
12/04	2,014	2,885	18.5	200	83	41	411	168	86	244	120	84
12/05	2,101	2,881	19.0	84	35	36	138	60	48	176	84	112
12/06	2,193	2,893	20.0	206	67	51	621	191	117	312	72	68
12/07	1,835	2,394	20.5	–	–	–	256	71	50	116	124	144
12/08	1,697	1,888	21.0	–	69	20	174	123	32	108	128	72
12/09	1,469	1,607	21.0	102	28	20	271	70	91	52	–	72
12/10	1,764	1,768	21.0	141	102	38	748	286	153	278	114	160
12/11	1,512	1,698	21.0	–	69	20	174	123	32	108	128	72
12/12	1,833	1,974	21.0	84	122	45	228	220	121	96	108	130
12/13	2,289	2,580	21.0	96	138	42	258	248	184	64	96	66
12/14	2,379	2,801	21.0	–	–	–	–	–	–	–	–	–
12/15	2,064	2,279	21.0	102	77	18	256	232	118	120	162	100
12/16	1,726	2,001	21.0	108	77	30	298	222	104	120	140	120
12/17	2,650	3,006	21.0	108	56	69	301	192	154	120	86	114
12/18	2,165	3,131	21.0	192	73	12	437	223	82	220	170	106
12/19	2,084	2,700	21.0	118	134	82	392	324	202	148	196	118
12/20	1,940	2,822	21.0	329	86	58	697	244	184	236	154	128
12/21	1,889	2,632	21.0	166	112	70	522	319	198	196	122	136
12/22	1,802	2,503	21.0	214	90	78	516	245	194	220	142	146
12/23	1,676	2,481	21.0	160	104	104	453	248	267	–	–	–
12/24	1,862	2,598	21.0	206	80	7	465	200	58	–	–	–
12/25	1,645	2,430	21.0	190	97	40	484	279	94	–	–	–
12/26	1,947	2,448	21.0	–	–	–	–	–	–	–	–	–
12/27	1,648	2,273	21.0	–	–	–	–	–	–	–	–	–
12/28	1,788	2,654	21.0	–	–	–	–	–	–	–	–	–
12/29	1,946	2,585	21.0	–	–	–	–	–	–	–	–	–
12/30	1,777	2,333	21.0	–	–	–	–	–	–	–	–	–
12/31	1,951	flood	21.0	–	–	–	–	–	–	–	–	–
Data average	1,981	2,521	20.5	157	82	43	370	191	115	165	121	102

Note: Samples after December 25,1984,were not transported to the central laboratory of Sanepar,some 200km far away from – the pilot plant of Pirai do Sul.

Table I. Operational Data

Date	Flow m³/day infl.	eff.+ (rec)	Eff. temp °C	T.BOD$_5$ mg/L inf	pri eff	sec eff	T.COD in mg/L infl.	pri eff	sec eff	SS in mg/L inf	pri eff	sec eff
1/01	1,443	2,138	21.0	-	-	-	-	-	-	-	-	-
1/02	1,610	2,538	21.0	-	-	-	-	-	-	-	-	-
1/03	1,466	2,352	21.0	-	-	-	-	-	-	-	-	-
1/04	1,409	2,362	21.0	-	-	-	-	-	-	-	-	-
1/05	1,342	2,201	21.0	-	-	-	-	-	-	-	-	-
1/06	1,237	2,186	21.5	-	-	-	-	-	-	-	-	-
1/07	1,292	2,243	21.5	-	-	-	-	-	-	-	-	-
1/08	1,296	2,304	21.0	-	248	54	-	708	173	-	-	-
1/09	1,213	2,237	21.5	-	-	-	-	-	-	-	-	-
1/10	1,250	2,240	21.5	249	96	14	653	247	52	-	-	-
1/11	1,149	2,066	21.5	136	76	40	592	276	129	-	-	-
1/12	1,212	2,175	21.5	185	150	28	503	332	77	-	-	-
1/13	984	1,916	21.5	157	-	14	347	-	81	-	-	-
1/14	1,140	2,121	22.0	151	75	26	371	182	57	-	-	-
1/15	1,134	1,947	22.0	94	107	14	199	229	28	-	-	-
1/16	1,029	2,005	22.0	-	-	-	-	-	-	-	-	-
1/17	1,047	1,886	22.0	436	137	22	938	386	126	-	-	-
1/18	957	1,863	22.0	242	161	46	652	352	179	-	-	-
1/19	971	1,702	22.0	190	97	19	595	320	104	-	-	-
1/20	912	925	22.0	170	136	48	455	302	172	-	-	-
1/21	1,084	1,167	22.0	260	106	66	731	254	154	-	-	-
1/22	1,009	1,011	22.0	192	83	21	922	223	155	-	-	-
1/23	1,020	972	22.0	-	84	17	-	231	86	-	-	-
1/24	1,016	924	22.0	205	110	27	752	243	65	-	-	-
1/25	943	931	22.0	279	109	16	652	253	79	-	-	-
1/26	897	964	22.0	229	107	18	489	267	90	-	-	-
1/27	843	836	22.0	180	63	13	371	200	69	-	-	-
1/28	904	978	22.0	285	79	15	556	187	73	-	-	-
1/29	963	934	22.0	453	121	20	971	256	95	-	-	-
1/30	1,068	934	22.5	158	81	3	427	112	11	218	72	52
1/31	957	874	22.5	175	30	44	295	158	119	244	62	100
Data average	1,122 (1,034)	1,675	21.7	221	107	27	573	273	99	231	67	76

Table I. Operational Data

Date	Flow m³/day infl.	Flow m³/day eff.+ (rec)	Eff. temp °C	T.BOD$_5$ mg/L inf	T.BOD$_5$ mg/L pri eff	T.BOD$_5$ mg/L sec eff	T.COD in mg/L infl.	T.COD in mg/L pri eff	T.COD in mg/L sec eff	SS in mg/L inf	SS in mg/L pri eff	SS in mg/L sec eff
2/01	919	919	22.5	298	138	39	633	255	97	312	450	22
2/02	972	972	22.5	214	121	79	607	312	222	148	30	44
2/03	889	889	22.5	253	70	131	679	310	327	176	52	38
2/04	892	892	22.5	402	114	42	829	272	119	216	34	90
2/05	843	879	22.5	283	95	15	575	203	51	300	118	50
2/06	909	944	22.5	-	-	-	-	-	-	-	-	-
2/07	937	972	22.5	200	77	18	467	248	68	164	98	114
2/08	956	991	22.5	202	85	61	591	226	174	224	116	94
2/09	1,123	1,158	22.5	280	52	53	472	132	111	292	52	122
2/10	1,049	1,084	23.0	349	80	32	653	215	100	228	176	66
2/11	1,145	1,180	23.0	177	63	20	295	163	69	384	94	72
2/12	1,200	1,247	23.0	182	75	34	388	172	50	256	148	112
2/13	955	1,025	23.0	314	77	13	659	214	87	360	82	58

As can be seen in the Table I,we have a full period from the peak of winter time (15ºC in August) to the summer time (23ºC in February),with temperatures measured in the Parshal flume, where we notice a whitish deposit on thermometer and submersed concrete walls/floor,probably a sulphur deposit from oxidation of H_2S with air in the aeration of effluent weir.
Before the end of August we were measuring only the effluent flow in the Parshall flume,which sometimes becomes submerged, with river flooding. To avoid this,we started to measure the water level before a rectangular weir some 3 m upstrema the Parshall flume. This way we can say if the Parshall is submerged,and,for such condition,what is the range of effluent.Also at that time we installed a triangular V-notch (90º) weir upstream the primary unit,so we could know the raw influent flow and also the recirculated flow (in the general case). This is why we have two flow values in Table I. During some storms it is usual to by-pass,during some 30 to 90 minutes,the influent flow when it arrives "sandy",as there is very large infiltration of rainwater and groundwater in the sewerage system.This generally happens after a drought period. Looking at the hour flow data,we can see very large peak flows reaching the plant. We also discovered that some sewers had open joints (without mortar),so working as a "drain",with infiltration/exfiltration and this may help to explain so much variation in the concentrations of BOD_5,COD and SS reaching the plant. Also we have some discharge of industrial wastewaters (all clandestine,but known),as from milk transfer station, chicken abattoir, clandestine (home) killing of pigs, potatoes processing,etc. In any way such industrial load is welcomed in this case.

In the initian period of August,we had only grab samples and we can see the huge variations of concentrations (BOD_5,SS and COD) of raw sewage,because of hourly variations.

At the end of the month,it is given the data average of the available data in the column.

Probably now the plant is treating the sewage of 6.000 inhabitant,with little fluctuation population. In this way,the sewage per capita has changed from 172 L/inhab.day (January)to 354 L/inhab.day (November). Water per capita is about 150 L/inhabitant.day. We can notice the large infiltration flow.But we didn't find a direct relationship of influent concentration,as BOD,COD,SS,with the influent flow,as could be expected to be.

It appears that the final effluent concentration of BOD, COD and SS is more related to the temperature of the sewage - than the influent flow. Lets examine now the Tables II,which

Table II. Physical Data

Date	time sample	pH			alkalinity mg/L $CaCO_3$			volat.dissol. matter mg/L			settleable matter mL/L		
		inf	pri eff	sec eff	inf	pri	sec	inf	pri	sec.	inf	pri	sec
8/01	07:00	5.2	6.4	6.6	45	166	212	578	108	89	8.0	0.5	0.2
8/02	-	-	-	-	-	-	-	-	-	-	-	-	-
8/03	07:00	5.1	6.4	6.5	27	181	149	277	143	118	0.3	0.0	0.0
8/04	-	-	-	-	-	-	-	-	-	-	-	-	-
8/05	-	-	-	-	-	-	-	-	-	-	-	-	-
8/06	13:00	6.6	6.4	6.5	87	125	147	308	93	93	4.5	0.3	0.0
8/07	-	-	-	-	-	-	-	-	-	-	-	-	-
8/08	06:30	6.8	6.7	6.5	137	123	97	178	157	133	5.0	0.4	0.1
8/09	15:00	6.4	-	6.2	84	-	169	432	-	86	2.5	-	0.2
8/10	06:20	6.3	6.5	6.6	45	126	145	176	130	68	3.0	0.3	0.1
8/11	-	-	-	-	-	-	-	-	-	-	-	-	-
8/12	-	-	-	-	-	-	-	-	-	-	-	-	-
8/13	07:20	-	5.9	6.2	-	113	155	-	44	49	-	0.3	0.3
8/14	13:00	6.3	-	6.7	107	-	241	208	-	114	4.0	-	1.5
8/15	08:00	5.9	-	6.3	100	-	280	679	-	291	4.0	-	0.8
8/16	15:30	6.9	6.5	6.6	94	137	218	177	111	119	2.0	0.5	0.5
	21:45	6.9	3.2	6.6	79	0	224	118	183	234	2.5	0.2	1.5
8/17	-	-	-	-	-	-	-	-	-	-	-	-	-
8/18	-	-	-	-	-	-	-	-	-	-	-	-	-
8/19	-	-	-	-	-	-	-	-	-	-	-	-	-
8/20	14:30	6.8	6.0	6.3	136	114	98	548	201	200	8.5	0.6	1.5
8/21	18:00	6.4	6.0	6.2	200	124	77	96	155	167	1.0	0.2	2.0
8/22	07:30	5.6	5.6	6.2	46	110	164	491	93	108	1.3	0.3	0.1
8/23	compo	6.9	6.5	6.5	77	101	130	143	134	127	2.0	0.5	0.7
8/24	-	-	-	-	-	-	-	-	-	-	-	-	-
8/25	-	-	-	-	-	-	-	-	-	-	-	-	-
8/26	compo	7.1	6.9	7.1	69	69	108	262	95	77	1.0	0.2	0.2
8/27	compo	6.8	6.8	6.7	95	87	104	160	125	48	1.2	0.2	1.0
8/28	compo	6.9	6.8	6.7	83	124	107	80	59	104	1.4	0.6	0.1
8/29	compo	6.7	6.5	6.6	80	93	121	134	120	73	2.0	1.5	1.0
8/30	compo	7.1	6.9	7.0	-	-	-	184	128	170	1.0	0.1	0.5
8/31	-	-	-	-	-	-	-	-	-	-	-	-	-
Data average		6.5	6.2	6.5	88	120	155	275	122	123	2.9	0.4	0.6

Note: "compo" means composite proportional flow sampling starting at 6:00PM of previous day up to 4:00PM of the day.

Table II. Physical Data

Date	time sam-ple	pH inf	pH pri eff	pH sec eff	alkalinity mg/L $CaCO_3$ inf	alkalinity pri	alkalinity sec	volat.dissol. matter mg/L inf	pri	sec.	settleable matter mL/L inf	pri	sec
9/01	-	-	-	-	-	-	-	-	-	-	-	-	-
9/02	compo	7.0	6.7	7.2	70	93	124	172	110	69	1.5	0.2	0.3
9/03	compo	6.8	6.2	6.6	96	101	140	133	179	98	3.0	0.5	0.7
9/04	compo	6.8	6.6	6.8	85	90	114	229	121	123	2.5	0.4	1.0
9/05	compo	6.2	6.6	6.4	75	116	89	171	136	89	1.5	0.1	0.3
9/06	compo	6.2	6.0	6.4	80	84	135	111	129	94	1.2	0.1	0.4
9/07	compo	7.0	6.8	6.8	92	114	123	84	51	69	2.0	0.4	0.3
9/08	-	-	-	-	-	-	-	-	-	-	-	-	-
9/09	compo	6.9	7.0	7.3	90	108	132	76	100	46	2.0	0.4	0.2
9/10	-	-	-	-	-	-	-	-	-	-	-	-	-
9/11	compo	6.4	6.2	6.0	79	85	102	128	75	60	1.9	0.4	0.3
9/12	compo	7.1	6.7	6.8	130	100	147	226	100	86	2.5	0.5	0.3
9/13	compo	5.8	6.9	6.6	74	127	147	252	112	80	3.5	0.5	0.5
9/14	compo	6.4	6.5	6.4	151	120	96	95	58	69	2.5	0.5	0.8
9/15	-	-	-	-	-	-	-	-	-	-	-	-	-
9/16	compo	6.2	6.3	6.4	67	100	137	83	80	38	2.0	0.5	0.2
9/17	-	-	-	-	-	-	-	-	-	-	-	-	-
9/18	compo	7.3	7.1	7.3	140	96	163	165	230	75	3.0	0.1	0.1
9/19	compo	6.7	6.9	7.2	94	135	138	225	108	105	4.5	0.5	0.5
9/20	compo	6.7	-	6.7	74	-	55	120	-	73	0.2	-	0.0
9/21	compo	6.0	6.5	6.6	53	113	140	110	110	92	0.2	0.2	0.0
9/22	compo	6.4	6.4	6.6	77	113	128	187	168	84	0.0	0.0	0.0
9/23	compo	6.4	6.5	-	85	133	-	155	169	-	2.0	1.0	-
9/24	compo	6.6	6.7	6.9	-	-	125	-	-	-	0.0	0.0	0.0
9/25	-	-	-	-	-	-	-	-	-	-	-	-	-
9/26	-	-	-	-	-	-	-	-	-	-	-	-	-
9/27	-	-	-	-	-	-	-	-	-	-	-	-	-
9/28	compo	6.5	6.6	6.4	115	121	84	-	-	-	2.2	1.0	0.5
9/29	compo	6.6	6.7	6.7	107	99	120	-	-	-	0.9	0.5	0.5
9/30	compo	6.7	6.7	6.8	97	99	115	-	-	-	0.1	0.0	0.0
Data average		6.6	6.6	6.7	92	107	122	151	120	79	1.8	0.4	0.3

Table II. Physical Data

Date	time sample	pH inf	pH pri eff	pH sec eff	alkalinity mg/L $CaCO_3$ inf	alkalinity pri	alkalinity sec	volat.dissol. matter mg/L inf	volat.dissol. pri	volat.dissol. sec.	settleable matter mg/L inf	settleable pri	settleable sec
10/01	compo	6.6	4.6	6.5	109	0	102	-	-	-	3.0	1.2	0.8
10/02	compo	7.0	6.7	6.6	102	102	114	-	-	-	1.3	0.5	0.7
10/03	compo	6.4	6.6	6.4	74	82	132	-	-	-	3.0	0.5	0.5
10/04	compo	6.0	6.2	6.0	99	103	108	-	-	-	0.6	0.3	0.1
10/05	compo	6.6	6.6	6.7	93	114	129	-	-	-	2.0	1.5	2.0
10/06	compo	6.6	6.6	6.4	87	110	125	-	-	-	0.5	0.0	0.0
10/07	compo	6.6	6.4	6.6	92	121	126	-	-	-	2.5	0.2	0.3
10/08	compo	7.0	6.7	6.9	126	135	145	-	-	-	0.3	0.5	0.4
10/09	compo	6.6	6.6	6.7	95	124	126	-	-	-	0.3	0.5	0.3
10/10	compo	6.4	6.4	6.6	100	120	146	-	-	-	2.5	1.0	1.1
10/11	compo	2.2	6.8	6.9	0	132	141	-	-	-	1.8	0.7	0.8
10/12	compo	6.4	6.7	6.8	91	123	140	-	-	-	2.5	1.7	1.2
10/13	compo	6.4	6.6	6.7	92	127	141	-	-	-	3.5	0.6	1.5
10/14	compo	6.5	6.5	6.7	105	131	143	-	-	-	2.5	0.5	0.5
10/15	compo	6.5	6.5	6.6	95	130	137	-	-	-	3.0	0.8	0.5
10/16	compo	6.5	6.6	6.4	79	111	137	-	-	-	3.5	0.5	0.1
10/17	-	-	-	-	-	-	-	-	-	-	-	-	-
10/18	compo	6.8	6.8	6.8	79	124	153	-	-	-	1.0	0.5	0.2
10/19	compo	6.7	7.0	6.9	70	93	126	-	-	-	1.4	0.8	0.2
10/20	compo	6.9	6.9	7.0	77	92	98	-	-	-	0.5	0.1	0.3
10/21	compo	7.1	6.9	7.0	86	93	143	-	-	-	0.5	0.0	0.0
10/22	compo	6.5	6.7	6.9	248	110	126	-	-	-	3.5	0.8	0.4
10/23	compo	5.9	6.9	7.0	48	118	144	-	-	-	1.3	0.8	0.2
10/24	-	-	-	-	-	-	-	-	-	-	-	-	-
10/25	compo	5.9	6.3	6.6	87	108	152	-	-	-	2.0	0.5	0.3
10/26	compo	6.4	6.5	6.9	101	121	142	162	62	80	1.0	0.8	0.5
10/27	compo	6.9	6.5	6.9	105	123	111	150	123	111	1.5	0.8	0.2
10/28	compo	6.4	6.5	7.2	97	127	123	150	164	92	1.3	0.7	0.2
10/29	compo	6.4	6.2	-	127	120	-	150	55	59	3.0	0.6	0.1
10/30	compo	6.3	6.5	6.6	83	96	88	188	109	26	4.5	1.5	0.2
10/31	-	-	-	-	-	-	-	-	-	-	-	-	-
Data average		6.4	6.5	6.7	94	111	130	160	103	74	1.9	0.7	0.5

Table II. Physical Data

Date	time sample	pH			alkalinity mg/L $CaCO_3$			volat.dissol. matter mg/L			settleable matter mg/L		
		inf	pri eff	sec eff	inf	pri	sec	inf	pri	sec.	inf	pri	sec
11/01	compo	7.0	6.8	6.8	300	197	114	147	82	43	0.2	0.1	0.2
11/02	compo	6.8	6.8	7.2	310	197	135	215	146	37	1.5	0.2	0.2
11/03	compo	6.8	6.4	7.0	256	171	144	144	159	46	1.5	0.4	0.0
11/04	-	-	-	-	-	-	-	-	-	-	-	-	-
11/05	compo	6.4	6.7	6.8	187	114	133	134	82	59	1.0	1.0	1.5
11/06	compo	6.7	6.9	7.0	71	76	115	117	101	36	0.5	0.4	0.1
11/07	compo	7.3	7.2	7.2	83	106	114	210	175	143	2.0	1.0	0.2
11/08	compo	6.6	6.7	6.8	67	77	96	143	84	50	1.5	0.6	0.1
11/09	compo	6.7	6.8	7.0	72	99	105	110	43	58	1.0	0.5	0.2
11/10	compo	6.4	6.6	6.8	76	101	111	115	125	48	1.5	1.5	0.2
11/11	compo	6.4	6.4	7.0	79	98	109	47	73	17	1.0	1.0	0.3
11/12	compo	6.6	6.7	6.8	93	99	104	27	81	47	1.5	0.4	0.1
11/13	compo	7.0	6.9	6.9	148	104	124	41	61	50	1.8	0.6	0.1
11/14	compo	7.0	6.9	-	74	96	-	21	83	34	1.5	0.5	0.2
11/15	compo	6.6	6.5	6.7	66	65	102	115	40	23	2.0	0.8	0.1
11/16	compo	6.9	6.4	6.4	95	76	84	95	92	46	1.0	0.3	0.1
11/17	16:00	6.8	6.7	6.8	84	74	96	122	61	186	0.8	0.6	0.3
11/18	-	-	-	-	-	-	-	-	-	-	-	-	-
11/19	-	-	-	-	-	-	-	-	-	-	-	-	-
11/20	16:00	-	-	-	-	-	-	75	15	53	1.4	0.3	0.1
11/21	16:00	7.1	7.0	6.9	73	80	93	79	36	34	0.2	0.1	0.0
11/22	16:00	7.0	6.9	7.2	93	76	81	89	32	26	0.2	0.2	0.1
11/23	16:00	6.1	6.8	6.4	127	73	77	334	54	86	7.0	0.4	0.1
11/24	19:00	6.0	6.1	6.4	61	87	88	123	72	60	0.8	0.5	0.1
11/25	compo	6.0	6.1	6.2	65	78	78	106	49	82	1.2	0.4	0.1
11/26	compo	6.1	6.8	7.0	54	78	85	134	69	56	0.3	0.1	0.0
11/27	compo	6.0	-	6.2	57	-	94	89	-	98	0.5	-	0.1
11/28	compo	7.4	7.4	7.6	89	88	94	100	52	30	1.5	0.5	0.3
11/29	compo	7.0	7.0	7.2	85	96	124	167	114	69	0.2	0.6	0.2
11/30	-	-	-	-	-	-	-	-	-	-	-	-	-
Data average		6.7	6.7	6.8	111	100	104	119	79	58	1.3	0.5	0.2

Table II. Physical Data

Date	time sample	pH inf	pH pri eff	pH sec eff	alkalinity mg/L $CaCO_3$ inf	alkalinity pri	alkalinity sec	volat.dissol. matter mg/L inf	pri	sec.	settleable matter mg/L inf	pri	sec
12/01	compo	6.8	6.7	6.9	101	71	87	163	83	80	2.5	1.8	0.2
12/02	compo	6.6	7.1	7.0	26	79	89	60	48	58	1.0	0.5	0.3
12/03	compo	6.1	6.2	6.4	66	83	89	128	94	44	2.5	0.5	0.1
12/04	compo	7.1	6.9	7.0	91	74	82	166	83	70	1.0	0.5	0.1
12/05	compo	7.0	7.0	7.1	75	83	89	129	31	57	0.5	0.0	0.0
12/06	compo	6.9	6.8	6.7	96	87	100	186	54	62	0.8	0.5	0.1
12/07	compo	7.0	6.8	7.2	93	79	95	123	34	72	2.0	0.1	1.0
12/08	compo	7.1	6.7	6.4	60	83	90	125	82	61	2.0	0.2	0.2
12/09	compo	6.9	6.7	6.9	86	80	79	86	-	53	2.0	0.1	0.1
12/10	compo	6.0	6.6	6.7	71	102	91	135	58	23	3.5	0.2	1.0
12/11	compo	7.1	6.7	6.4	60	83	90	125	82	61	2.0	0.2	0.2
12/12	compo	-	-	-	-	-	-	63	83	41	2.0	0.1	0.1
12/13	compo	6.7	6.0	6.2	72	69	103	132	91	92	1.8	0.1	0.1
12/14	-	-	-	-	-	-	-	-	-	-	-	-	-
12/15	compo	7.1	6.4	6.2	68	76	75	98	46	71	2.5	0.3	0.5
12/16	compo	6.8	6.2	6.4	76	74	94	146	60	46	1.6	0.2	0.2
12/17	compo	6.9	6.1	6.2	88	85	110	90	76	69	2.5	0.3	1.2
12/18	compo	6.9	7.0	-	83	90	-	112	44	66	1.8	0.4	0.5
12/19	compo	6.9	7.1	-	98	89	-	115	103	141	2.0	0.4	0.3
12/20	compo	6.4	6.2	6.9	87	84	103	157	54	57	1.5	0.2	0.4
12/21	compo	6.9	6.8	7.0	70	99	95	74	100	67	1.6	0.2	0.2
12/22	compo	6.8	6.9	6.9	113	107	132	107	105	58	1.5	0.2	0.4
12/23	compo	5.6	6.9	2.2	29	109	0	-	-	-	1.0	0.3	0.8
12/24	compo	6.4	6.4	7.0	128	105	123	-	-	-	2.0	0.1	0.6
12/25	compo	6.5	6.4	6.8	100	100	146	-	-	-	1.8	0.1	0.5
12/26	-	-	-	-	-	-	-	-	-	-	-	-	-
12/27	-	-	-	-	-	-	-	-	-	-	-	-	-
12/28	-	-	-	-	-	-	-	-	-	-	-	-	-
12/29	-	-	-	-	-	-	-	-	-	-	-	-	-
12/30	-	-	-	-	-	-	-	-	-	-	-	-	-
12/31	-	-	-	-	-	-	-	-	-	-	-	-	-
Data average		6.7	6.6	6.5	80	87	94	120	71	64	1.8	0.3	0.4

Table II. Physical Data

Date	time sample	pH			alkalinity mg/L $CaCO_3$			volat.dissol. matter mg/L			settleable matter mg/L		
		inf	pri eff	sec eff	inf	pri	sec	inf	pri	sec.	inf	pri	sec
1/01	-	-	-	-	-	-	-	-	-	-	-	-	-
1/02	-	-	-	-	-	-	-	-	-	-	-	-	-
1/03	-	-	-	-	-	-	-	-	-	-	-	-	-
1/04	-	-	-	-	-	-	-	-	-	-	-	-	-
1/05	-	-	-	-	-	-	-	-	-	-	-	-	-
1/06	-	-	-	-	-	-	-	-	-	-	-	-	-
1/07	-	-	-	-	-	-	-	-	-	-	-	-	-
1/08	17:00	-	6.7	6.4	-	-	140	-	-	-	-	0.0	0.3
1/09	-	-	-	-	-	-	-	-	-	-	-	-	-
1/10	compo	6.0	6.4	7.0	-	-	-	-	-	-	4.5	0.5	0.3
1/11	compo	6.8	6.9	7.0	111	137	159	-	-	-	1.0	0.1	0.1
1/12	compo	6.5	6.6	7.3	107	135	156	-	-	-	1.2	0.1	0.2
1/13	compo	6.9	-	7.0	137	-	158	-	-	-	2.0	-	0.2
1/14	compo	6.9	-	7.0	114	154	125	-	-	-	1.0	0.2	0.1
1/15	compo	6.8	7.0	7.3	131	139	159	-	-	-	2.5	0.2	0.2
1/16	-	-	-	-	-	-	-	-	-	-	-	-	-
1/17	compo	6.7	7.0	6.9	132	165	194	-	-	-	0.2	0.1	0.5
1/18	compo	6.8	6.8	7.1	174	175	197	-	-	-	5.0	1.5	2.0
1/19	compo	6.6	6.8	7.0	146	156	265	-	-	-	2.0	0.2	0.2
1/20	compo	6.7	6.8	7.0	98	131	197	-	-	-	2.0	0.6	0.5
1/21	compo	6.5	6.8	7.0	169	149	178	-	-	-	2.5	0.0	0.1
1/22	compo	6.0	6.5	6.6	130	154	175	-	-	-	2.0	0.2	0.1
1/23	compo	-	7.0	7.3	-	168	183	-	-	-	-	0.1	0.2
1/24	compo	6.8	7.0	7.0	126	132	133	-	-	-	2.5	0.2	0.1
1/25	compo	6.8	7.3	6.9	130	173	157	-	-	-	2.5	0.5	0.1
1/26	compo	6.6	7.0	7.4	109	178	185	-	-	-	2.0	0.2	0.1
1/27	compo	6.7	6.9	7.9	114	160	183	-	-	-	4.0	0.4	0.2
1/28	compo	7.0	6.9	6.7	161	170	136	-	-	-	4.5	0.2	0.1
1/29	compo	6.5	7.0	-	146	169	-	-	-	-	2.0	0.2	0.1
1/30	compo	6.7	7.0	-	156	175	-	-	-	-	2.5	0.3	0.0
1/31	compo	6.7	7.0	7.1	127	86	182	-	-	-	1.0	0.2	0.2
Data average		6.6	6.9	7.1	133	153	172	-	-	-	2.3	0.3	0.3

Table II. Physical Data

Date	time sample	pH inf	pH pri eff	pH sec eff	alkalinity mg/L $CaCO_3$ inf	alkalinity pri	alkalinity sec	volat.dissol. matter mg/L inf	volat.dissol. pri	volat.dissol. sec.	settleable matter mg/L inf	settleable pri	settleable sec
2/01	compo	6.2	6.8	7.3	104	161	185	-	-	-	1.5	1.0	0.2
2/02	compo	6.4	7.1	6.9	102	196	167	-	-	-	2.0	0.2	0.0
2/03	compo	6.7	6.8	6.9	112	183	176	-	-	-	2.1	0.2	0.1
2/04	compo	6.4	6.7	6.8	126	173	176	-	-	-	2.5	0.5	0.5
2/05	compo	6.7	6.9	7.1	124	175	200	-	-	-	4.0	0.6	0.1
2/06	-	-	-	-	-	-	-	-	-	-	-	-	-
2/07	compo	6.3	6.7	7.1	102	171	176	-	-	-	1.3	0.7	0.2
2/08	compo	6.1	6.8	6.9	102	168	187	-	-	-	3.0	1.6	0.3
2/09	compo	6.4	6.8	7.0	113	164	173	-	-	-	2.5	0.5	1.0
2/10	compo	6.5	6.9	7.2	110	109	175	-	-	-	3.5	0.6	0.1
2/11	compo	6.4	6.6	6.7	83	136	158	-	-	-	-	-	-
2/12	compo	6.6	7.0	-	142	163	-	-	-	-	1.0	1.1	0.1
2/13	compo	6.7	6.9	-	116	229	-	-	-	-	4.5	0.6	0.1

are related to some physical data, for the period August 1984 to February 1985. The idea was to present all tables in figures, but there was no time for such. Here is presented the time of sampling, if it was grab, or indication of composite proportional flow sampling ending at 4:00 PM of the given day.

As a general trend, we can see that the pH decreases during the primary treatment, and pH increases during the secondary treatment. But this trend is not constant all time. Also the alkalinity increases during the anaerobic treatment, as a general rule. But, sometimes, alkalinity decreases during the primary treatment, probably when it is overloaded. Probably alkalinity is related to the transformation of organic nitrogen into ammonia nitrogen, which increases from primary to secondary treatment. Also volatile acids, which are leached from the primary unit with the primary effluent, are converted to methane gas and carbonic acid, part of which is released as biogas.

There is a large decrease in the concentration of volatile dissolved matter in the primary unit, showing a large circulation of the raw sewage through the anaerobic reactor of the primary unit, because the settling channels are very long and small (in relation to the anaerobic compartment), and because there is no compartimentalization in the digestion compartment, as is the case of Imhoff tanks of large/long settling - compartments, and as it was made in the primary unit constructed at the pilot plant in the Catholic University in Curitiba.

The decrease of concentration of volatile dissolved matter is not large in the secondary unit in some months, but it is reasonable in other months. Probably the concentration of volatile dissolved matter should be related to the concentration of COD in the primary and secondary effluent, or at least to the concentration of dissolved COD in such primary and secondary effluents, but there is no evident relationship among such variables. It is to be noticed that during several periods there is no data for concentration of volatile dissolved matter, and also, for suspended solids, and this is related to problems with materials or equipments or personal available - for such determinations in the main laboratory of Sanepar. It is very frequent fo have problems with the drying oven and with the muffle furnace, or with the supply of fiber filter, etc. And the priority is given to samples from the large Carrousel plant (25,000 kg BOD_5/day) of Curitiba, in which is the laboratory. For the analysis is used Standard Methods, 14th Edition.

The settleable matter concentration is also given in Tables II. Little reduction happens in secondary unit. Tables III present data of reduced forms of nitrogen,and chloride and volatile suspended matter for the period August to Febraury.

As a general rule we have some 10 to 20% removal of "total nitrogen load" (organic+ammonia N) in the primary unit, and almost none removal of "total nitrogen load" in the secondary unit. This is because some of the organic nitrogen, present in raw sewage,settle to the digestion compartment,and is stored as ammonia+organic N in the primary digested sludge.If we remove the excess primary sludge,such "total nitrogen load" is effectivelly removed in the treatment (except when such - excess sludge is discharged in the river,as it happened). In the case of secondary unit,very little (if any) excess sludge is accumulating in the sludge bed (blanket),and also very little,if any,"total nitrogen load" is being removed,because the organic N is converted into ammonia N and some (little) organic N sludge,both of which are "leached" from the secondary unit. It is evident that,from raw sewage to primary treatment and to secondary treatment,organic nitrogen decreases and ammonia nitrogen increases in load and concentration.

The worry about the reduced forms of nitrogen is related to their biochemical oxidation in the receiving stream and in the BOD_5 test,by causing an oxygen depletion. But,the receiving stream has very little nitrifying organisms (it is quite clean,yet) and chances are that some of the ammonia nitrogen is stripped to the atmosphere in the waterfall (in the weir), and in the river.Also some of the organic nitrogen can be eaten by fishes or other organisms. Also ammonia can be removed by aquatic plants and weeds.

In relation to the BOD_5 test, we do not filter the samples (except where stated the opposite),and so,we do not remove organic nitrogen compounds. We take the samples before the overflow weirs (where they can be aerated),and so the BOD_5 - test include the oxidation of sulfite,sulfide,ferrous iron, etc,and also,include the oxidation of ammonia and reduced nitrogen compounds.But we are using pure water as dilution water. So,we are not inhibiting the nitrification,but we aren't helping the nitrification to take place. It is possible that in the future we will make use of secondary effluent of the - Carrousel plant of Curitiba as dilution water for BOD test,because of low BOD_5 (5mg/L) and because all nitrogen is converted to nitrate and is denitrified in such plant,so its effluent is rich in nitrifying organisms.

Chloride should be a conservative element. The reason - for the decline is that we do not take samples in the period

Table III. Nitrogen, Chloride and Solids Data

Date	Organic N mg/L infl			Ammonia N mg/L infl			Chloride Cl^- mg/L in			Volat.susp. solids mg/L inf			VSS+SS s.ef
	infl	prim effl	sec. effl	infl	prim effl	sec. effl	in	pr	se	inf	pri	sec	
8/01	19.5	7.9	2.6	6.8	28.3	31.1	80	43	103	155	70	68	53 %
8/02	–	–	–	–	–	–	–	–	–	–	–	–	–
8/03	5.3	7.9	5.0	4.1	23.8	27.5	24	43	42	260	80	40	71 %
8/04	–	–	–	–	–	–	–	–	–	–	–	–	–
8/05	–	–	–	–	–	–	–	–	–	–	–	–	–
8/06	22.7	7.1	4.6	24.5	16.3	20.2	36	35	37	370	88	64	59 %
8/07	–	–	–	–	–	–	–	–	–	–	–	–	–
8/08	10.8	7.0	6.1	4.9	18.5	25.5	19	35	35	100	44	28	29 %
8/09	16.9	–	6.2	18.7	–	25.6	34	–	45	280	–	86	53 %
8/10	4.5	5.0	4.3	3.8	23.4	23.0	15	40	40	128	104	84	78 %
8/11	–	–	–	–	–	–	–	–	–	–	–	–	–
8/12	–	–	–	–	–	–	–	–	–	–	–	–	–
8/13	–	6.9	6.8	–	23.7	23.0	–	38	38	–	172	132	77 %
8/14	17.6	–	11.3	19.6	–	28.4	44	–	53	200	–	108	64 %
8/15	12.6	–	8.6	25.8	–	11.9	53	–	48	315	–	260	72 %
8/16	24.4	22.8	11.0	17.3	13.0	17.3	47	88	59	65	90	116	58 %
	9.5	–	11.6	17.7	–	25.9	47	50	50	180	155	116	56 %
8/17	–	–	–	–	–	–	–	–	–	–	–	–	–
8/18	–	–	–	–	–	–	–	–	–	–	–	–	–
8/19	–	–	–	–	–	–	–	–	–	–	–	–	–
8/20	32.1	13.8	15.1	30.4	26.5	26.5	66	46	46	305	235	112	62 %
8/21	–	–	–	–	–	–	–	–	–	–	–	–	–
8/22	16.9	9.8	8.7	19.3	10.0	25.2	28	34	41	124	84	128	71 %
8/23	13.6	9.1	9.1	11.1	15.5	17.1	33	35	36	96	74	72	65 %
8/24	–	–	–	–	–	–	–	–	–	–	–	–	–
8/25	–	–	–	–	–	–	–	–	–	–	–	–	–
8/26	7.7	6.2	4.1	11.4	11.9	15.6	28	25	28	150	62	56	56 %
8/27	10.1	5.0	6.0	13.8	13.4	13.3	30	27	27	124	92	88	69 %
8/28	12.0	4.8	5.8	16.6	14.2	14.0	33	28	26	128	96	64	67 %
8/29	10.1	0.0	4.0	13.0	10.4	16.0	32	29	28	148	80	72	64 %
8/30	9.5	7.8	3.2	14.1	16.1	18.1	41	31	29	110	95	57	57 %
8/31	–	–	–	–	–	–	–	–	–	–	–	–	–
Data average	14.2	8.1	7.1	15.1	17.7	21.3	38	39	42	180	101	92	62 %

Table III. Nitrogen, Chloride and Solids Data

Date	Organic N mg/L infl	prim effl	sec. effl	Ammonia N mg/L infl	prim effl	sec. effl	Chloride Cl^- mg/L in	pr	se	Volat. susp. solids mg/L inf	pri	sec	VSS+ SS s.ef
9/01	-	-	-	-	-	-	-	-	-	-	-	-	-
9/02	8.6	9.0	5.4	13.7	16.8	18.8	31	31	30	62	76	84	78 %
9/03	14.5	9.8	7.5	16.7	16.5	17.2	-	31	31	112	72	56	64 %
9/04	14.5	8.2	8.5	15.0	17.0	15.8	32	31	31	180	85	70	64 %
9/05	14.7	9.9	4.2	15.7	12.9	11.1	-	31	32	112	64	76	69 %
9/06	9.9	6.1	5.1	19.3	19.5	17.6	34	31	31	84	76	56	61 %
9/07	13.8	20.1	22.0	18.8	20.4	20.3	44	32	42	86	84	72	60 %
9/08	-	-	-	-	-	-	-	-	-	-	-	-	-
9/09	6.1	8.9	2.1	18.9	15.3	21.7	41	37	34	140	84	64	64 %
9/10	-	-	-	-	-	-	-	-	-	-	-	-	-
9/11	8.0	7.0	8.0	17.0	24.1	25.8	37	35	35	116	80	76	61 %
9/12	14.6	7.3	4.9	15.1	22.4	23.9	36	32	33	204	88	68	65 %
9/13	24.4	7.7	6.3	21.8	13.6	10.4	37	35	37	244	88	80	67 %
9/14	15.2	8.2	4.7	14.4	19.2	21.2	40	34	-	152	92	72	64 %
9/15	-	-	-	-	-	-	-	-	-	-	-	-	-
9/16	15.3	20.6	6.7	20.5	18.4	22.3	50	38	33	144	64	92	64 %
9/17	-	-	-	-	-	-	-	-	-	-	-	-	-
9/18	13.4	21.6	12.6	17.8	24.7	22.1	39	35	34	180	168	96	67 %
9/19	19.6	8.4	5.1	17.8	26.2	25.0	41	34	34	204	112	68	65 %
9/20	-	-	-	-	-	-	30	-	36	100	-	72	67 %
9/21	29.0	6.5	4.8	15.0	20.9	24.6	30	64	33	116	68	52	72 %
9/22	8.3	7.1	3.8	14.5	20.0	21.4	32	31	31	152	96	48	60 %
9/23	11.2	13.2	-	13.8	15.8	-	39	34	-	128	160	-	-
9/24	13.6	17.0	17.6	16.0	24.0	21.0	36	36	35	-	-	-	-
9/25	-	-	-	-	-	-	-	-	-	-	-	-	-
9/26	-	-	-	-	-	-	-	-	-	-	-	-	-
9/27	-	-	-	-	-	-	-	-	-	-	-	-	-
9/28	10.5	3.8	2.5	16.2	15.5	20.2	34	26	25	-	-	-	-
9/29	10.2	5.7	3.3	17.2	16.9	19.2	7	17	19	-	-	-	-
9/30	5.9	5.0	2.3	12.2	13.1	16.0	33	26	26	-	-	-	-
Data average	13.4	10.1	6.9	16.5	18.7	19.8	35	33	32	140	92	71	65 %

Table III. Nitrogen, Chloride and Solids Data

Date	Organic N mg/L infl	prim effl	sec. effl	Ammonia N mg/L infl	prim effl	sec. effl	Chloride Cl⁻ mg/L in	pr	se	Volat.susp. solids mg/L inf	pri	sec	VSS+ SS s.ef
10/01	13.3	9.8	5.2	0.9	13.0	16.0	31	29	27	-	-	-	-
10/02	11.8	8.9	6.0	14.8	12.7	15.4	17	29	30	-	-	-	-
10/03	10.7	8.7	5.3	14.5	13.3	17.5	34	28	29	-	-	-	-
10/04	8.7	3.1	4.0	15.2	12.6	16.0	36	31	30	-	-	-	-
10/05	8.1	9.2	7.0	20.0	18.3	19.0	30	30	32	-	-	-	-
10/06	2.6	3.2	4.1	14.8	16.0	18.6	30	30	27	-	-	-	-
10/07	8.0	4.4	2.2	17.4	18.8	21.4	41	29	-	-	-	-	-
10/08	6.1	6.4	5.0	20.2	20.7	19.4	37	34	36	-	-	-	-
10/09	3.2	10.2	12.2	17.1	21.6	23.2	41	35	34	-	-	-	-
10/10	18.0	9.0	8.0	15.3	17.9	21.0	37	36	34	-	-	-	-
10/11	8.5	5.7	5.0	21.3	20.9	20.7	15	32	33	-	-	-	-
10/12	9.4	6.4	-	19.7	20.8	-	35	33	33	-	-	-	-
10/13	16.4	7.6	5.4	15.8	17.2	19.7	34	31	32	-	-	-	-
10/14	13.8	6.5	4.0	23.2	20.8	26.1	39	32	33	-	-	-	-
10/15	16.9	8.5	3.5	21.0	24.1	24.4	37	36	34	-	-	-	-
10/16	21.4	7.1	3.1	20.6	17.9	24.3	39	33	-	-	-	-	-
10/17	-	-	-	-	-	-	-	-	-	-	-	-	-
10/18	9.9	5.0	1.6	12.0	18.7	25.0	26	29	31	-	-	-	-
10/19	7.2	0.4	2.9	12.9	18.2	19.7	24	24	26	-	-	-	-
10/20	9.5	5.5	3.3	17.8	17.3	19.2	30	25	26	-	-	-	-
10/21	0.8	0.7	0.5	3.0	2.7	3.0	37	29	29	-	-	-	-
10/22	2.2	2.0	1.0	4.8	3.7	3.5	37	31	29	-	-	-	-
10/23	13.6	6.9	4.2	16.7	16.5	16.9	20	21	23	-	-	-	-
10/24	-	-	-	-	-	-	-	-	-	-	-	-	-
10/25	-	10.4	7.4	-	14.3	22.5	41	34	34	-	-	-	-
10/26	4.7	6.6	8.3	22.3	25.5	26.9	32	33	33	68	124	60	65 %
10/27	8.2	7.2	4.4	21.8	23.4	27.2	36	34	35	120	92	72	64 %
10/28	9.2	7.1	4.6	24.8	23.6	26.0	35	34	36	116	28	56	64 %
10/29	11.2	6.0	3.4	28.9	24.2	26.6	37	33	33	132	44	36	62 %
10/30	18.1	7.1	12.4	17.0	22.2	25.0	34	32	32	252	68	96	69 %
10/31	-	-	-	-	-	-	-	-	-	-	-	-	-
Data average	10.1	6.4	5.0	16.8	17.7	20.2	33	31	31	138	71	63	65 %

Table III. Nitrogen, Chloride and Solids Data

Date	Organic N mg/L infl	prim effl	sec. effl	Ammonia N mg/L infl	prim effl	sec. effl	Chloride Cl^- mg/L in	pr	se	Volat.susp. solids mg/L inf	pri	sec	VSS÷SS s.ef
11/01	5.2	0.1	4.6	39.2	33.6	27.6	40	35	37	108	84	28	64 %
11/02	5.7	5.4	3.2	39.1	33.1	25.0	34	34	37	108	56	84	68 %
11/03	5.0	4.0	3.4	32.7	26.0	26.7	33	27	37	92	32	72	69 %
11/04	–	–	–	–	–	–	–	–	–	–	–	–	–
11/05	7.7	4.1	3.0	10.5	19.0	24.5	26	26	27	52	60	48	55 %
11/06	12.2	6.0	3.8	11.8	16.6	21.0	27	26	27	104	64	80	80 %
11/07	9.8	7.1	3.1	13.5	16.4	17.4	31	28	28	124	92	56	57 %
11/08	8.1	27.0	3.0	11.1	9.3	17.3	30	29	26	48	48	44	58 %
11/09	5.0	4.2	2.9	13.4	13.0	17.1	31	29	24	52	80	32	67 %
11/10	7.3	5.6	3.0	16.4	16.0	18.0	31	29	29	88	36	64	76 %
11/11	9.5	6.0	3.1	13.4	16.0	18.3	33	28	28	112	44	72	62 %
11/12	10.6	5.1	3.1	14.2	15.0	18.0	25	26	25	60	28	64	59 %
11/13	5.0	4.2	3.0	5.0	13.3	18.0	25	25	31	52	60	52	68 %
11/14	6.2	5.6	3.2	9.1	15.5	18.4	24	25	27	48	40	24	55 %
11/15	5.3	5.4	5.0	6.6	12.5	16.0	24	27	23	112	116	64	67 %
11/16	5.4	5.0	3.0	13.5	11.3	12.5	28	23	24	36	52	40	59 %
11/17	5.4	4.9	3.4	4.4	11.8	12.7	22	23	22	76	44	96	67 %
11/18	–	–	–	–	–	–	–	–	–	–	–	–	–
11/19	–	–	–	–	–	–	–	–	–	–	–	–	–
11/20	6.8	4.6	3.1	7.6	10.5	12.9	17	19	20	56	33	36	67 %
11/21	4.6	0.9	1.8	8.7	8.3	10.1	21	16	18	40	32	34	65 %
11/22	7.4	4.0	2.0	12.8	8.0	10.7	27	21	20	68	68	40	–
11/23	82.7	3.9	1.7	24.2	11.7	12.0	94	20	21	1048	26	92	64 %
11/24	4.8	4.0	2.9	11.0	7.8	8.3	21	22	23	60	56	56	64 %
11/25	6.3	5.1	3.9	9.4	10.1	11.8	27	21	22	80	92	52	62 %
11/26	9.4	4.4	2.8	28.3	17.8	8.4	21	22	23	96	56	56	61 %
11/27	8.6	–	3.1	10.2	–	15.5	24	–	22	76	–	11	61 %
11/28	7.1	5.1	3.2	9.5	9.0	14.4	26	23	22	68	108	80	67 %
11/29	8.1	5.2	3.1	11.2	10.7	14.3	23	23	22	88	60	56	64 %
11/30	–	–	–	–	–	–	–	–	–	–	–	–	–
Data average	10.0	5.5	3.1	14.9	14.9	16.4	29	25	26	114	59	55	64 %

Table III. Nitrogen, Chloride and Solids Data

Date	Organic N mg/L infl	prim effl	sec. effl	Ammonia N mg/L infl	prim effl	sec. effl	Chloride Cl^- mg/L in	pr	se	Volat.susp. solids mg/L inf	pri	sec	VSS÷ SS s.ef
12/01	8.8	3.7	4.1	11.0	11.0	14.6	21	23	23	-	-	-	-
12/02	8.7	7.6	4.2	8.8	11.6	14.3	25	22	23	-	-	-	-
12/03	21.0	11.0	2.4	10.3	11.3	14.1	23	20	21	76	64	44	65 %
12/04	10.2	7.0	3.2	10.4	10.0	14.0	31	24	25	156	76	52	62 %
12/05	7.5	5.6	2.8	10.8	12.9	14.3	29	23	27	116	92	72	64 %
12/06	13.6	5.1	5.5	19.0	14.1	18.1	29	25	24	212	48	40	59 %
12/07	8.0	3.0	3.3	20.0	14.4	15.0	30	25	25	64	92	96	67 %
12/08	5.6	5.2	4.4	11.5	14.0	13.0	30	37	32	68	88	40	56 %
12/09	6.6	4.4	2.2	13.1	13.0	12.0	28	34	8	44	-	48	67 %
12/10	12.2	5.0	2.6	12.2	16.7	16.2	30	30	28	224	72	114	71 %
12/11	11.2	9.4	7.7	15.6	14.0	14.8	35	29	29	68	88	40	56 %
12/12	10.7	9.4	7.2	13.6	12.6	12.8	30	29	30	72	72	88	68 %
12/13	9.8	8.5	7.3	11.5	14.3	15.1	24	27	27	40	60	42	64 %
12/14	-	-	-	-	-	-	-	-	-	-	-	-	-
12/15	6.5	5.7	5.6	11.2	11.7	12.5	30	23	26	80	126	66	66 %
12/16	9.0	6.2	4.4	15.5	13.8	15.5	26	23	27	72	114	82	68 %
12/17	9.8	7.2	5.2	13.5	15.3	15.3	37	25	26	84	52	68	60 %
12/18	15.7	7.2	5.2	15.1	14.0	13.5	30	25	26	128	110	74	70 %
12/19	5.8	5.3	3.0	12.4	14.1	14.0	29	27	26	96	120	78	66 %
12/20	13.3	4.3	5.2	19.0	14.8	14.5	33	26	27	124	112	90	70 %
12/21	22.0	5.1	4.9	20.3	17.7	16.0	34	29	28	136	66	92	68 %
12/22	11.5	5.4	6.5	21.7	16.4	14.3	34	28	29	176	116	110	75 %
12/23	12.1	7.2	16.0	17.4	18.5	21.4	32	27	46	-	-	-	-
12/24	31.4	8.9	8.9	25.2	21.9	21.2	37	29	30	-	-	-	-
12/25	15.3	7.4	4.9	27.0	21.3	22.4	45	30	33	-	-	-	-
12/26	-	-	-	-	-	-	-	-	-	-	-	-	-
12/27	-	-	-	-	-	-	-	-	-	-	-	-	-
12/28	-	-	-	-	-	-	-	-	-	-	-	-	-
12/29	-	-	-	-	-	-	-	-	-	-	-	-	-
12/30	-	-	-	-	-	-	-	-	-	-	-	-	-
12/31	-	-	-	-	-	-	-	-	-	-	-	-	-
Data average	11.9	6.5	5.3	15.3	14.6	15.4	30	27	27	107	87	70	65 %

Table III. Nitrogen, Chloride and Solids Data

Date	Organic N mg/L infl	prim effl	sec. effl	Ammonia N mg/L infl	prim effl	sec. effl	Chloride Cl^- mg/L in	pr	se	Volat.susp. solids mg/L inf	pri	sec	VSS+ SS s.ef
1/01	-	-	-	-	-	-	-	-	-	-	-	-	-
1/02	-	-	-	-	-	-	-	-	-	-	-	-	-
1/03	-	-	-	-	-	-	-	-	-	-	-	-	-
1/04	-	-	-	-	-	-	-	-	-	-	-	-	-
1/05	-	-	-	-	-	-	-	-	-	-	-	-	-
1/06	-	-	-	-	-	-	-	-	-	-	-	-	-
1/07	-	-	-	-	-	-	-	-	-	-	-	-	-
1/08	-	5.9	8.1	-	21.8	25.4	-	-	28	-	-	-	-
1/09	-	-	-	-	-	-	-	-	-	-	-	-	-
1/10	16.9	8.0	0.4	17.4	19.3	23.8	43	30	30	-	-	-	-
1/11	11.5	7.7	5.2	19.7	21.5	25.2	35	33	34	-	-	-	-
1/12	13.3	5.5	4.3	19.9	21.5	22.3	43	33	33	-	-	-	-
1/13	13.5	-	5.3	17.3	-	22.6	35	-	36	-	-	-	-
1/14	16.5	9.3	5.5	15.7	16.8	23.1	20	32	31	-	-	-	-
1/15	19.4	9.2	5.4	21.8	19.1	26.1	48	32	33	-	-	-	-
1/16	-	-	-	-	-	-	-	-	-	-	-	-	-
1/17	7.9	32.5	5.0	16.0	20.6	26.7	111	36	35	-	-	-	-
1/18	9.0	8.0	6.4	28.9	29.3	28.2	37	37	30	-	-	-	-
1/19	11.9	7.2	5.6	26.0	28.8	30.7	42	38	33	-	-	-	-
1/20	9.1	5.8	3.8	23.4	26.1	26.2	36	35	34	-	-	-	-
1/21	18.6	10.0	4.8	27.8	24.4	28.1	38	34	34	-	-	-	-
1/22	25.2	9.8	6.2	22.5	26.4	28.3	40	35	36	-	-	-	-
1/23	-	8.7	5.7	-	27.6	30.3	-	37	33	-	-	-	-
1/24	21.9	9.8	4.8	23.2	29.6	31.7	43	36	37	-	-	-	-
1/25	7.1	6.9	4.5	26.1	22.7	28.0	46	37	37	-	-	-	-
1/26	13.3	8.5	5.0	22.4	28.9	32.2	47	37	36	-	-	-	-
1/27	16.6	9.1	3.5	27.7	22.0	31.8	40	39	39	-	-	-	-
1/28	24.6	8.8	4.4	27.9	29.4	33.6	45	39	40	-	-	-	-
1/29	44.6	6.3	3.5	24.8	28.7	16.5	42	41	40	-	-	-	-
1/30	21.2	7.1	5.5	33.8	32.4	35.4	47	38	38	-	-	-	-
1/31	16.1	9.7	6.3	24.8	27.5	33.3	44	39	39	-	-	-	-
Data average	16.9	9.2	5.0	23.4	25.0	27.7	44	36	35	-	-	-	-

Table III. Nitrogen, Chloride and Solids Data

Date	Organic N mg/L infl	Organic N mg/L prim effl	Organic N mg/L sec. effl	Ammonia N mg/L infl	Ammonia N mg/L prim effl	Ammonia N mg/L sec. effl	Chloride Cl^- mg/L in	Chloride Cl^- mg/L pr	Chloride Cl^- mg/L se	Volat. susp. solids mg/L inf	Volat. susp. solids mg/L pri	Volat. susp. solids mg/L sec	VSS+ SS s.ef
2/01	15.4	12.6	5.2	27.3	32.4	32.8	49	40	40	–	–	–	–
2/02	10.4	10.3	6.1	17.6	32.6	34.5	41	38	40	–	–	–	–
2/03	13.6	9.1	5.0	23.3	30.3	34.0	33	39	41	–	–	–	–
2/04	–	–	–	–	–	–	43	39	40	–	–	–	–
2/05	–	–	–	–	–	–	50	39	41	–	–	–	–
2/06	–	–	–	–	–	–	–	–	–	–	–	–	–
2/07	–	–	–	–	–	–	38	36	41	–	–	–	–
2/08	–	–	–	–	–	–	42	37	38	–	–	–	–
2/09	–	–	–	–	–	–	40	35	34	–	–	–	–
2/10	14.3	8.4	4.0	17.5	19.5	31.7	38	33	35	–	–	–	–
2/11	–	–	–	–	–	–	30	31	34	–	–	–	–
2/12	–	–	–	–	–	–	36	34	31	–	–	–	–
2/13	–	–	–	–	–	–	–	–	–	–	–	–	–

after 10:00 PM to before 6:00 AM,because no operator remain - at the plant because there is no biogas consumption during - the night (biogas stored in gas pipelines,at 20 psig is enough for night consumption.Also this is to avoid people to make use of home heating with gas). During the very early morning probably the flow reaching the plant is basically infiltration water which has little (if any) chloride,and this appears in the composite proportional samples of primary and secondary effluent (due to the retention time in the reactors).

Also in table III is presented the data about the concentration of volatile suspended matter and its relationship,for the secondary effluent,with the total suspended matter. The conclusion is that there is a large removal of volatile suspended matter in the primary unit,and a small removal of volatile suspended matter in the secondary unit (only around 10%) and that the suspended solids in the secondary effluent is about 60 to 65% volatile suspended solids (matter). The general conclusion,from tables I and III,is that the UASB secondary reactor is not efficient for SS and VSS (volatile suspended solids) removal. The larger efficiency of SS and VSS removal in the primary unit appears more related to plain sedimentation of such solids,and easy of digestion of less refractory solids in suspension travelling through the primary digestion - compartment. Or we could say,that the bacteria of sludge bed of secondary UASB unit are digesting more refractory matter than what would be the case if they were digesting the effluent of a conventional primary settling tank.

Next is presented the data of nitrite,nitrate,phosphate, air temperature (mean) and rain precipitation/weather condition,for the days of August and January (as a sample of available data). There is no relationship between air temperature - and sewage temperature. There is a trend to have lower sewage temperatures during the winter and higher during the summer, but not direct relationship with air temperature,except if it is rainy (and rain water enters into the sewers). As a general rule,sewage has a larger temperature than mean air temperature,for the town of Pirai do Sul,in winter and summer.

It is presented the data of nitrite and nitrate concentration in raw sewage,primary effluent and secondary effluent. The concentration is very small,and generally there is some removal of nitrite in the primary and secondary anaerobic treatment,but nitrate reduction do not take place (as a rule) in - the primary and secondary treatment,and even,appears to be increasing.It could be laboratory mistake,but they checked it.

Table IV. Nitrate, Nitrite, Phosphate and Local Data

Date	Air temperature in °C			Rain mm/day	NO_2^- in mg/L			NO_3^- in mg/L			PO_4 in mg/L		
	max	min	mean	w.cond	inf	pri eff	sec eff	inf	pri eff	sec eff	inf	pri eff	sec eff
8/01	21	3	12	dry	0.4	0.2	0.5	0.3	0.6	0.2	0.9	0.7	0.8
8/02	14	10	12	rains	-	-	-	-	-	-	-	-	-
8/03	14	8	10	dry	0.3	0.3	0.3	0.2	0.1	0.1	1.0	1.0	0.5
8/04	20	-1	13	n.data	-	-	-	-	-	-	-	-	-
8/05	21	10	17	n.data	-	-	-	-	-	-	-	-	-
8/06	25	15	22	n.data	0.3	0.2	0.2	0.2	0.3	0.2	0.7	0.8	0.9
8/07	20	10	15	n.data	-	-	-	-	-	-	-	-	-
8/08	22	8	16	n.data	.08	0.4	0.2	0.3	0.5	0.5	0.8	0.9	0.9
8/09	24	10	16	n.data	0.3	-	0.1	0.4	-	0.3	0.2	-	0.5
8/10	25	9	19	n.data	.05	0.2	0.1	0.1	0.1	0.1	0.6	0.9	0.9
8/11	25	7	16	n.data	-	-	-	-	-	-	-	-	-
8/12	25	7	16	n.data	-	-	-	-	-	-	-	-	-
8/13	22	8	15	n.data	-	0.2	0.1	-	0.3	0.3	-	0.8	0.9
8/14	20	10	15	dry	0.4	0.4	0.2	0.4	0.3	0.2	0.4	3.0	0.4
8/15	11	7	9	rains	0.2	-	0.1	1.1	-	0.4	0.9	-	0.4
8/16	10	6	9	dry	0.3	0.2	0.3	0.8	0.6	1.0	0.3	0.4	0.4
					0.2	0.2	0.2	0.4	0.1	0.2	0.7	0.9	0.9
8/17	11	6	8	n.data	-	-	-	-	-	-	-	-	-
8/18	11	6	9	n.data	-	-	-	-	-	-	-	-	-
8/19	11	8	9	n.data	-	-	-	-	-	-	-	-	-
8/20	14	7	11	rains	0.2	0.2	0.1	0.1	0.2	0.1	0.5	0.7	0.6
8/21	13	11	12	rains	0.2	0.2	0.2	0.3	0.2	0.3	0.9	0.9	0.7
8/22	16	12	14	rains	0.2	0.2	0.2	0.3	0.3	0.2	0.8	0.6	0.7
8/23	20	10	15	dry	0.2	0.1	0.1	0.3	0.4	0.2	0.4	0.4	0.2
8/24	21	8	15	rains	-	-	-	-	-	-	-	-	-
8/25	11	1	6	rains	-	-	-	-	-	-	-	-	-
8/26	11	-4	4	dry	0.1	0.2	0.1	0.3	0.2	0.2	0.4	0.5	0.6
8/27	13	-2	5	dry	0.2	0.2	0.1	0.2	0.7	0.7	0.4	0.6	0.2
8/28	14	-1	7	dry	0.1	0.1	0.1	0.6	1.1	1.2	0.6	0.3	0.3
8/29	12	3	9	dry	.04	.02	.00	0.2	0.1	0.1	0.7	0.2	0.2
8/30	15	8	12	dry	0.2	0.2	0.1	0.4	0.2	0.2	0.6	0.6	0.6
8/31	17	10	13	dry	-	-	-	-	-	-	-	-	-
9/01	20	9	14	dry	-	-	-	-	-	-	-	-	-
9/02	22	8	13	dry	0.1	0.2	0.1	0.5	1.5	0.6	0.5	0.3	0.4
9/03	23	4	13	dry	0.4	.08	.06	0.3	0.4	0.4	0.8	0.2	0.2
9/04	23	4	14	dry	0.2	0.1	.08	0.3	0.2	0.6	0.7	0.3	0.3
9/05	24	4	14	dry	0.1	.05	.04	0.1	0.2	0.3	0.4	0.2	0.3
mean	18	7	12	---	.21	.19	.15	.35	.39	.36	.62	.69	.53

Table IV. Nitrate, Nitrite, Phosphate and Local Data

Date	Air temperature in °C			Rain mm/day w.cond	NO_2^- in mg/L			NO_3^- in mg/L			PO_4 in mg/L		
	max	min	mean		inf	pri eff	sec eff	inf	pri eff	sec eff	inf	pri eff	sec eff
1/01	27	14	20	clouds	-	-	-	-	-	-	-	-	-
1/02	28	15	20	sunny	-	-	-	-	-	-	-	-	-
1/03	26	14	19	sunny	-	-	-	-	-	-	-	-	-
1/04	28	13	20	sunny	-	-	-	-	-	-	-	-	-
1/05	28	16	21	cloudy	-	-	-	-	-	-	-	-	-
1/06	27	16	21	cloudy	-	-	-	-	-	-	-	-	-
1/07	25	17	20	1	-	-	-	-	-	-	-	-	-
1/08	25	15	19	19	-	0.1	0.1	-	0.2	0.1	-	1.2	1.2
1/09	23	11	16	dry	-	-	-	-	-	-	-	-	-
1/10	23	10	16	dry	.06	.04	.03	0.4	0.4	0.4	0.9	0.4	0.5
1/11	27	10	17	dry	.00	-	-	0.5	0.7	0.7	0.9	0.9	0.9
1/12	28	8	17	dry	0.0	0.0	0.0	0.4	0.7	0.7	0.8	1.0	0.9
1/13	28	10	19	dry	.04	-	.01	0.1	-	0.2	0.7	-	0.3
1/14	25	15	17	dry	0.3	0.2	0.2	0.1	0.2	0.5	0.9	0.9	0.9
1/15	28	16	21	dry	0.3	0.2	0.2	0.1	0.2	0.2	1.0	0.9	0.9
1/16	25	17	21	4	-	-	-	-	-	-	-	-	-
1/17	24	15	18	dry	0.4	0.2	0.2	0.5	1.1	0.8	0.9	0.8	0.8
1/18	24	13	17	dry	0.4	0.1	0.2	0.5	0.6	0.7	1.8	1.6	1.4
1/19	24	13	18	dry	0.5	0.1	0.1	0.5	0.7	0.7	1.6	1.6	1.4
1/20	24	15	19	dry	0.4	0.1	0.2	0.4	0.7	0.6	1.4	1.4	1.6
1/21	25	17	20	24	0.4	0.2	0.2	0.5	0.9	0.7	1.8	1.6	1.4
1/22	25	18	20	dry	0.4	0.1	0.1	0.5	0.7	0.6	0.9	1.0	1.0
1/23	23	11	16	cloudy	-	0.1	0.1	-	0.7	0.1	-	0.8	0.7
1/24	24	14	18	cloudy	0.3	0.1	0.1	0.2	0.7	0.9	1.0	0.9	0.9
1/25	23	15	17	dry	0.2	.06	.03	0.3	0.8	0.6	0.8	0.7	0.7
1/26	22	13	17	dry	0.1	.04	.03	0.4	0.6	0.6	0.9	0.9	0.8
1/27	24	15	19	dry	0.1	.05	.05	0.3	0.9	0.7	0.7	0.8	0.9
1/28	28	15	21	dry	0.1	.04	.05	0.5	0.9	0.8	0.8	0.8	0.9
1/29	29	17	22	dry	.09	.03	.02	0.4	1.2	1.4	1.0	0.9	1.0
1/30	28	17	22	dry	0.2	.06	.04	0.2	0.2	0.2	2.0	0.9	0.9
1/31	30	15	22	dry	0.2	.03	.04	0.2	0.3	0.2	1.8	1.6	1.6
2/01	30	16	22	dry	0.2	0.1	0.6	0.1	0.2	0.2	1.4	0.9	1.6
2/02	29	18	23	dry	0.3	0.1	.08	0.1	0.3	0.2	1.4	1.6	1.6
2/03	28	16	21	28	0.2	0.1	0.1	0.1	0.2	0.2	1.6	1.8	1.6
2/04	27	17	21	18	0.2	.06	.07	0.5	0.7	0.6	-	-	-
2/05	28	16	21	dry	.09	.06	.02	0.5	0.9	0.8	-	-	-
2/06	26	16	20	36	-	-	-	-	-	-	-	-	-
2/07	24	16	19	6	0.4	0.2	0.1	0.2	0.6	0.6	-	-	-
mean	26	15	19	3.6	.23	.10	.11	.34	.59	.54	1.2	1.1	1.1

In any way,nitrite and nitrate are routine analysis for the control of the huge Carrousel oxidation ditch of Curitiba,of 25,000 kg BOD_5/day load,in which nitrification and denitrification has to take place to save expensive aeration energy.

It is also presented the data of phosphate concentration for raw sewage,primary and secondary effluents. From the data (including of other months,not presented),it appears that very little phosphate is being removed in primary and secondary unit,but in fact we notice a lot of phosphate in the analysis of primary digested sludge.

One thing interesting about the sewage of Pirai do Sul - is the very low concentration of SULFATES.We do not make routine analysis of sulfates. The drinking water comes from rock mountains (by gravity),and is only filtered and chlorinated, as a general rule. In October 21,1983,it was found that there was less than 1 mg/L of sulfate in the raw sewage. Practical consequences of this,are the very low concentration of hydrogen sulphide in the biogas (needing to add THT-tetrahydrothiophen as odoriser),little (if any) smell around the plant, and a very vivid brown color in the sludge (instead of the usual black sludge). It was the first time we saw "brown" anaerobic sludge. Also the smell is not typical of the "black" sludge.

Next we have the Tables V and VI,which could be prepared only for February,when such tests started. As they were not - "routine",it was difficult to implement them (at the cost of suppressing other tests). But such tests are important for us to be able to make some comparisons with the data of Cali (3) and Switzenbaum (4),which are based on "filtered" or "soluble" COD. It is questionable,for pollution control purposes,such utilization of soluble COD,as we discharge not soluble COD which can,slowlly,leach and becomes soluble (as lignin and similar products of pulp and paper industry).

In table V we have the ratio of "total" COD to "total" - BOD_5,and we can see that such ratio appears to increase from raw sewage to primary effluent and to secondary effluent,and so,chemically oxidizable matter becomes more difficult to the biochemicall oxidization (BOD_5 test). Probably,for pollution control,we will remain with the utilization of BOD_5 instead - of COD,which will be interesting mainly for making mass balance around the plant (envolving conversion of COD into methane of biogas and methane lost in effluent, and into excess sludge escaping and piling up,and into not degraded COD in effluent). Such type of COD balance will be made in this paper.

In table VI we have the continuation of Table V. Here it

Table V. Unfiltered ("T") and Filtered ("S") BOD and COD Data

Date	$T.BOD_5$ mg/L			$SBOD_5$ mg/L		T.COD mg/L			SCOD mg/L		$T.COD \div TBOD_5$		
	inf	pri eff	sec eff	prim effl	sec. effl	inf	pri eff	sec eff	prim effl	sec. effl	inf	pri eff	sec eff
2/01	298	138	39	56	15	633	255	97	120	48	2.1	1.8	2.5
2/02	214	121	79	24	16	607	312	222	117	53	2.8	2.6	2.8
2/03	253	70	131	37	12	679	310	327	94	50	2.7	4.4	2.5
2/04	402	114	42	68	9	829	272	119	157	61	2.1	2.4	2.8
2/05	283	95	15	70	8	575	203	51	137	57	2.0	2.1	3.4
2/06	-	-	-	-	-	-	-	-	-	-	-	-	-
2/07	200	77	18	35	13	467	248	68	103	43	2.3	3.2	3.8
2/08	202	85	61	45	15	591	226	174	100	46	2.9	2.7	2.9
2/09	280	52	53	28	19	472	132	111	79	62	1.7	2.5	2.1
2/10	349	80	32	45	19	653	215	100	96	45	1.9	2.7	3.1
2/11	177	63	20	56	31	295	163	69	95	53	1.7	2.6	3.5
2/12	182	75	34	55	23	388	172	50	84	35	2.1	2.3	1.5
2/13	314	77	13	46	15	659	214	87	98	55	2.1	2.8	6.7
2/14						567	186	107	97	49			
2/15	-	-	-	-	-	-	-	-	-	-	-	-	-
2/16	-	-	-	-	-	-	-	-	-	-	-	-	-
2/17						434	206	134	79	43			
2/18						564	205	154	106	61			

Table VI. Ratio of Unfiltered ("T") and Filtered ("S") Data

Date	$T.BOD_5 \div SBOD_5$ prim	sec.	$T.COD \div SCOD$ prim	sec.	$SCOD \div SBOD_5$ prim	sec.	BOD_5 Nonfiltrable mg/L prima	second	COD Nonfiltrable mg/L prima	second
2/01	2.46	2.60	2.13	2.02	2.14	3.20	86	24	135	49
2/02	5.04	4.94	2.67	4.19	4.88	3.31	97	63	195	169
2/03	1.89	10.9	3.30	6.54	2.54	4.17	33	119	216	277
2/04	1.68	4.67	1.73	1.95	2.31	6.78	46	33	115	58
2/05	1.36	1.88	1.48	.895	1.76	7.13	25	7	66	-6
2/06	-	-	-	-	-	-	-	-	-	-
2/07	2.20	1.38	2.41	1.58	2.94	3.31	42	5	145	25
2/08	1.88	4.07	2.26	3.78	2.22	3.07	40	46	116	128
2/09	1.67	1.79	1.67	1.79	2.82	3.26	53	49	53	49
2/10	2.24	2.22	2.24	2.22	2.13	2.37	119	55	119	55
2/11	1.72	1.30	1.72	1.30	1.70	1.71	68	16	68	16
2/12	1.36	1.48	2.05	1.43	1.52	1.52	20	11	88	15
2/13	1.67	0.87	2.18	1.58	2.13	3.67	31	-2	116	32
2/14			1.92	2.18					89	58
2/15	-	-	-	-	-	-	-	-	-	-
2/16	-	-	-	-	-	-	-	-	-	-
2/17			2.61	3.12					127	91
2/18			1.93	2.52					99	93

is presented the ratio of "total" BOD_5 to the "soluble" or "filtered" BOD_5, for the primary and secondary effluent. It appears that sometimes most of the T.BOD_5 is in the soluble fraction but in other times we have the opposite. Probably the data available is not enough for long range evaluations.

The same we have with the "total" COD concentration in relation to the "soluble" COD concentration. At least for the secondary effluent, it appears that most of the COD load is in the undissolved (or suspended) phase, and represent mainly sludge being removed from the sludge bed.

Such aspects can be seen in the comparison of Nonfiltrable BOD_5 and COD data of table VI with the "total" and "filtered" BOD_5 and COD data of table V.

Secondary effluent quality is not so good in February in relation to what we had in January. It is difficult to know what is the reason. This is one problem of the anaerobic treatment of sewage. It would be related to addition of molasses and comminuted onions? Temperature increased.

Tables VII are the start of an attempt to make some mass balances around the primary and secondary reactors. Here concentration and flow (of influent) are combined to produce the daily load entering or leaving the primary and secondary unit and here the results are related mainly to the sewage load, if possible excluding the load from leachate, molasses, onions, etc. Also was started the recycle of thick sludge (grity) from the bottom of primary unit to the raw sewage upstream grit removal unit, and so such sludge is going to "leach" and settle over digesting (fresh) sludge.

As we can see in the tables VII, it is only possible to get a "load data" for a day in which we have both the flow and the concentration of pollutants. At the bottom of the table we have the daily mean of the above available data. If we divide such "mean" load by the corresponding "mean" flow, we get a "mean" concentration, which is not exactly the "mean" of daily mean concentrations presented in Table I. In any way it is interesting to notice that the variation is only minor.

It is interesting to notice that in January we had the smallest BOD_5 load in raw sewage (only 224 kg BOD_5/day or only 37.3 g BOD_5/inhabitant.day), and the best BOD/COD removal efficiency of the plant. The general average of BOD_5 load, 6 months, is 345.5 kg/day or 57.6 g BOD_5/inhabitant.day. The largest value of BOD_5 load of raw sewage, 460 kg/inhab.day, for August, is supposed to reflect the effects of taking "grab" samples mainly during hours of high concentration of BOD in the sewage.

Table VII. BOD_5, COD and SS Load Balance Data

Date	BOD_5 Load kg/day influ	prima efflu	secon efflu	COD Load kg/day influ	prima efflu	secon efflu	SS Load kg/day influ	prima efflu	secon efflu
8/01	1,047	302	245	2,011	770	487	309	138	152
8/02	-	-	-	-	-	-	-	-	-
8/03	-	-	-	-	-	-	-	-	-
8/04	-	-	-	-	-	-	-	-	-
8/05	-	-	-	-	-	-	-	-	-
8/06	650	173	93	1,273	372	278	681	174	152
8/07	-	-	-	-	-	-	-	-	-
8/08	145	134	64	441	256	169	200	106	128
8/09	974	-	60	1,773	-	241	593	-	214
8/10	85	106	50	351	174	100	106	106	75
8/11	-	-	-	-	-	-	-	-	-
8/12	-	-	-	-	-	-	-	-	-
8/13	-	185	63	-	370	177	-	275	194
8/14	268	-	35	542	-	69	188	-	111
8/15	761	-	235	1,684	-	388	580	-	439
8/16	254	142	165	654	356	397	203	215	254
8/17	-	-	-	-	-	-	-	-	-
8/18	-	-	-	-	-	-	-	-	-
8/19	-	-	-	-	-	-	-	-	-
8/20	738	264	258	1,645	638	589	565	417	242
8/21	425	255	269	876	576	413	273	212	279
8/22	335	99	68	607	178	135	152	90	127
8/23	205	102	75	405	219	156	122	103	82
8/24	-	-	-	-	-	-	-	-	-
8/25	-	-	-	-	-	-	-	-	-
8/26	388	316	123	836	644	480	710	328	316
8/27	420	213	196	828	411	341	348	259	237
8/28	272	99	125	531	312	168	272	233	155
8/29	401	200	162	801	412	257	374	207	187
8/30	448	289	282	946	589	485	335	255	160
8/31	-	-	-	-	-	-	-	-	-
MEAN	460	192	143	953	418	296	354	208	195
mg/L	349	146	108	723	317	224	268	158	148

Table VII. BOD_5, COD and SS Load Balance Data

Date	BOD_5 Load kg/day influ	prima efflu	secon efflu	COD Load kg/day influ	prima efflu	secon efflu	SS Load kg/day influ	prima efflu	secon efflu
9/01	-	-	-	-	-	-	-	-	-
9/02	291	213	160	584	362	291	162	173	144
9/03	364	369	214	917	618	375	283	186	152
9/04	292	270	113	1,100	594	488	461	252	198
9/05	372	282	93	883	350	211	306	224	187
9/06	929	264	60	2,329	481	144	259	182	149
9/07	252	145	68	565	261	118	177	194	171
9/08	-	-	-	-	-	-	-	-	-
9/09	281	136	401	571	182	1,090	216	170	129
9/10	-	-	-	-	-	-	-	-	-
9/11	328	150	183	598	408	448	219	142	169
9/12	334	154	68	958	364	236	488	209	164
9/13	650	358	132	1,344	895	292	622	223	203
9/14	265	152	92	619	298	203	341	187	159
9/15	-	-	-	-	-	-	-	-	-
9/16	255	141	59	546	338	156	270	172	176
9/17	-	-	-	-	-	-	-	-	-
9/18	477	139	131	801	298	247	354	338	190
9/19	411	137	82	833	398	234	385	213	132
9/20	370	-	196	761	-	482	386	-	282
9/21	345	223	100	690	525	250	348	225	131
9/22	327	190	141	779	474	260	331	205	114
9/23	298	329	-	652	701	-	257	322	-
9/24	312	223	267	1,242	590	583	-	-	-
9/25	-	-	-	-	-	-	-	-	-
9/26	-	-	-	-	-	-	-	-	-
9/27	-	-	-	-	-	-	-	-	-
9/28	775	253	135	1,614	707	300	-	-	-
9/29	437	210	39	1,133	483	243	-	-	-
9/30	419	66	27	1,183	121	118	-	-	-
MEAN	399	210	131	941	450	322	326	213	168
mg/L	253	133	83	595	285	204	206	135	106

Table VII. BOD_5, COD and SS Load Balance Data

Date	BOD_5 Load kg/day influ	prima efflu	secon efflu	COD Load kg/day influ	prima efflu	secon efflu	SS Load kg/day influ	prima efflu	secon efflu
10/01	379	255	168	920	449	394	-	-	-
10/02	293	199	70	553	421	198	-	-	-
10/03	472	167	104	880	425	290	-	-	-
10/04	347	118	122	937	378	161	-	-	-
10/05	392	368	122	710	600	275	-	-	-
10/06	140	106	86	253	208	246	-	-	-
10/07	237	113	43	378	303	221	-	-	-
10/08	-	-	-	-	-	-	-	-	-
10/09	-	-	-	-	-	-	-	-	-
10/10	-	-	-	-	-	-	-	-	-
10/11	-	-	-	-	-	-	-	-	-
10/12	-	-	-	-	-	-	-	-	-
10/13	-	-	-	-	-	-	-	-	-
10/14	188	231	132	918	323	260	-	-	-
10/15	283	196	100	822	438	173	-	-	-
10/16	377	159	100	983	378	227	-	-	-
10/17	-	-	-	-	-	-	-	-	-
10/18	402	177	77	606	299	155	-	-	-
10/19	467	89	95	741	248	188	-	-	-
10/20	161	37	16	400	96	63	-	-	-
10/21	165	69	6	539	147	47	-	-	-
10/22	310	89	31	766	231	146	-	-	-
10/23	377	95	31	656	337	174	-	-	-
10/24	-	-	-	-	-	-	-	-	-
10/25	367	126	118	946	278	184	-	-	-
10/26	268	136	89	713	347	258	159	219	114
10/27	287	169	137	742	488	309	255	237	166
10/28	156	56	93	420	281	226	198	46	93
10/29	265	78	21	436	213	66	196	83	63
10/30	339	66	54	1,015	322	255	455	170	175
10/31	-	-	-	-	-	-	-	-	-
MEAN	303	141	83	697	328	205	253	151	122
mg/L	209	97	57	480	226	141	207	123	100

Table VII. BOD_5, COD and SS Load Balance Data

Date	BOD_5 Load kg/day influ	prima efflu	secon efflu	COD Load kg/day influ	prima efflu	secon efflu	SS Load kg/day influ	prima efflu	secon efflu
11/01	67	93	25	171	260	99	256	172	61
11/02	86	75	26	275	257	251	298	162	201
11/03	157	78	63	309	159	260	224	116	188
11/04	-	-	-	-	-	-	-	-	-
11/05	404	208	179	672	330	316	220	239	210
11/06	264	79	31	1,028	444	98	269	193	173
11/07	170	103	82	295	250	200	320	236	189
11/08	379	116	29	986	371	166	170	193	147
11/09	417	94	32	853	145	42	155	184	85
11/10	187	45	57	207	79	115	264	98	158
11/11	192	-	85	345	48	159	271	155	224
11/12	295	95	50	529	191	138	171	93	193
11/13	62	47	19	180	121	25	84	100	76
11/14	183	151	25	495	281	97	96	90	58
11/15	531	238	154	1,678	321	301	455	354	243
11/16	351	125	131	1,219	334	545	167	234	189
11/17	180	236	586	533	715	1,497	157	109	195
11/18	-	-	-	-	-	-	-	-	-
11/19	-	-	-	-	-	-	-	-	-
11/20	150	70	92	376	121	159	280	147	172
11/21	-	-	-	-	-	-	-	-	-
11/22	289	83	108	427	461	235	255	245	83
11/23	2,610	535	344	5,800	911	745	4,299	393	393
11/24	365	279	279	872	412	514	341	313	300
11/25	422	104	78	622	369	253	286	323	194
11/26	420	103	63	924	284	429	447	290	278
11/27	-	-	85	355	-	157	290	-	45
11/28	287	168	65	737	463	222	260	358	269
11/29	346	220	50	1,049	784	312	357	252	231
11/30	-	-	-	-	-	-	-	-	-
MEAN	367	145	110	837	338	293	416	210	182
mg/L	173	69	52	395	159	138	196	99	86

Table VII. BOD_5, COD and SS Load Balance Data

Date	BOD_5 Load kg/day influ	prima efflu	secon efflu	COD Load kg/day influ	prima efflu	secon efflu	SS Load kg/day influ	prima efflu	secon efflu
12/01	480	146	66	527	242	174	596	141	192
12/02	281	116	64	669	140	125	397	274	132
12/03	498	272	143	792	378	246	355	297	194
12/04	403	167	83	828	338	173	491	242	169
12/05	176	74	76	290	126	101	370	176	235
12/06	452	147	112	1,362	419	257	684	158	149
12/07	-	-	-	470	130	92	213	228	264
12/08	-	117	34	295	209	54	183	217	122
12/09	150	41	29	398	103	134	76	-	106
12/10	249	180	67	1,319	505	270	490	201	282
12/11	-	104	30	263	186	48	163	194	109
12/12	154	224	82	418	403	222	176	198	238
12/13	220	316	96	591	568	421	146	220	151
12/14	-	-	-	-	-	-	-	-	-
12/15	211	159	37	528	479	244	248	334	206
12/16	186	133	52	514	383	180	207	242	207
12/17	286	148	183	798	509	408	318	228	302
12/18	416	158	26	946	483	178	476	368	229
12/19	246	279	171	817	675	421	308	408	246
12/20	638	167	113	1,352	473	357	458	299	248
12/21	314	212	132	986	603	374	370	230	257
12/22	386	162	141	930	441	350	396	256	263
12/23	268	174	174	759	416	447	-	-	-
12/24	384	149	13	866	372	108	-	-	-
12/25	313	160	66	796	459	155	-	-	-
12/26	-	-	-	-	-	-	-	-	-
12/27	-	-	-	-	-	-	-	-	-
12/28	-	-	-	-	-	-	-	-	-
12/29	-	-	-	-	-	-	-	-	-
12/30	-	-	-	-	-	-	-	-	-
12/31	-	-	-	-	-	-	-	-	-
MEAN	320	165	87	730	377	231	339	246	205
mg/L	161	84	44	368	190	117	171	124	103

Table VII. BOD_5, COD and SS Load Balance Data

Date	BOD_5 Load kg/day influ	prima efflu	secon efflu	COD Load kg/day influ	prima efflu	secon efflu	SS Load kg/day influ	prima efflu	secon efflu
1/01	-	-	-	-	-	-	-	-	-
1/02	-	-	-	-	-	-	-	-	-
1/03	-	-	-	-	-	-	-	-	-
1/04	-	-	-	-	-	-	-	-	-
1/05	-	-	-	-	-	-	-	-	-
1/06	-	-	-	-	-	-	-	-	-
1/07	-	-	-	-	-	-	-	-	-
1/08	-	321	70	-	918	224	-	-	-
1/09	-	-	-	-	-	-	-	-	-
1/10	311	120	18	816	309	65	-	-	-
1/11	156	87	46	680	317	148	-	-	-
1/12	224	182	34	610	402	93	-	-	-
1/13	154	-	14	341	-	80	-	-	-
1/14	172	86	30	423	207	65	-	-	-
1/15	107	121	16	226	260	32	-	-	-
1/16	-	-	-	-	-	-	-	-	-
1/17	456	143	23	982	404	132	-	-	-
1/18	232	154	44	624	337	171	-	-	-
1/19	184	94	18	578	311	101	-	-	-
1/20	155	124	44	415	275	157	-	-	-
1/21	282	115	72	792	275	166	-	-	-
1/22	194	84	21	930	225	156	-	-	-
1/23	-	86	17	-	236	88	-	-	-
1/24	208	112	27	764	247	66	-	-	-
1/25	263	103	15	615	239	74	-	-	-
1/26	205	96	16	439	239	81	-	-	-
1/27	152	53	11	313	169	58	-	-	-
1/28	258	71	14	503	169	66	-	-	-
1/29	436	117	19	935	247	91	-	-	-
1/30	169	87	3	456	120	12	232	77	56
1/31	167	29	42	282	151	114	234	59	96
MEAN	224	114	28	586	288	102	233	68	76
mg/L	217	110	27	567	279	99	230	67	75

Table VII. BOD_5, COD and SS Load Balance Data

Date	BOD_5 Load kg/day influ	prima efflu	secon efflu	COD Load kg/day influ	prima efflu	secon efflu	SS Load kg/day influ	prima efflu	secon efflu
2/01	274	127	36	582	234	89	287	414	20
2/02	208	118	77	590	303	216	144	29	43
2/03	225	62	116	604	276	291	156	46	34
2/04	359	102	37	739	243	106	193	30	80
2/05	239	80	13	484	171	43	253	99	42
2/06	-	-	-	-	-	-	-	-	-
2/07				438	232	64	154	92	107
2/08				565	216	166	214	111	90
2/09				530	148	125	328	58	137
2/10				685	226	105	239	185	69
2/11				337	187	79	440	108	82
2/12				466	206	60	307	178	134
2/13				629	204	83	344	78	55

Table VIII. Soluble and NonSoluble BOD_5 and COD Load Balance

Date	$SBOD_5$ kg/day prima. efflu.	secon. efflu.	$NSBOD_5$ kg/day prima. efflu.	secon. efflu.	SCOD kg/day prima. efflu.	secon. efflu.	NSCOD kg/day prima. efflu.	secon. efflu.
2/01	51	14	76	22	110	44	124	45
2/02	23	16	95	61	114	52	189	155
2/03	33	11	29	105	84	44	192	247
2/04	61	8	41	29	140	54	103	52
2/05	59	7	21	6	115	48	56	0
2/06	-	-	-	-	-	-	-	-
2/07					97	40	135	24
2/08					96	44	120	122
2/09					89	70	59	55
2/10					101	47	125	58
2/11					109	61	78	18
2/12					101	42	105	18
2/13					94	53	110	30

Next highest value was in September, with 399 kg BOD_5/day in - the influent (raw sewage), worth some 66.5 g BOD_5/inhab.day. It is interesting to notice that in Brazil generally it is used the value 54 g BOD_5/inhabitant.day, for raw sewage, suggested by Imhoff, Karl (5), for Germany conditions. If we exclude the data for August, the raw sewage load average is 322.6kgBOD_5/d or 53.8 g BOD_5/inhab.day.

The load data for COD also present large variations, with the lowest value being for January, with 586 kg COD/day in raw sewage (or 98 g COD/inhab.day), and the largest value being in the month August (953 kg COD/day), followed by September with 941 kg COD/day or 157 g COD/inhab.day. The average (mean) for September to January is 758.2 kg COD/day or 126 gCOD/inhab.d.

The load data for SS also present large variations, with the lowest value being for January, with 233 kg SS/day (only 2 data available) or 38.8 g SS/inhab.day. The largest load data were for November (416 kg COD/day or 69.3 g COD/inhab.day) and August (354 kg SS/day). The average (mean) of the monthly data availabe is 320 kg COD/day or 53.3 g SS/inhab.day, which is almost equal the data for BOD_5, for raw sewage.

Table VIII is one attempt to make a mass balance for soluble BOD_5 and non-soluble BOD_5, soluble COD and non-soluble COD, for primary and secondary effluent, for the month of February, to make it feasible to make comparisons with the "total" load of BOD_5 and COD for the month of February presented in - Table VII. In this way should be possible to evaluate better how much of the load of pollutants is soluble and non-soluble.

Tables IX were done to evaluate several external conditions which affected (other than domestic sewage) the performance of the anaerobic treatment in the primary and secondary units treating domestic sewage. Most of the conditions are related to the loading with leachate, molasses, onions, transfer of sludge, effluent recycle, etc. The most important conditions, by chronologic dates, are listed in such tables IX. It is interesting to explain that the recycle of secondary effluent was started to increase the "leaching" of pollution from the sludge, making it to have more chance to be digested. Also the recycle was intended to make it easier for lightweight particles to be removed from the sludge bed. Also recycle was idealized as a way to post-treat anaerobically the organics of secondary effluent making them filter through the thick and old sludge bed of primary digested sludge, and so making the primary unit work as an UASB reactor. This is taking place mainly now in February 1985. Probably more SS will be in effluent.

Table IX. Operational Data of Non-Sewage Organic Loading

Date	Load conditions
8/10	9.7m³ molasses (11,185.kgCOD / 9,564.kgBOD_5) introduced at the very bottom of primary unit,under sludge bed. Next days influent sewage was partly diverted because much biogas was being flared (11 to 14 Aug.84).
8/14	Collected sample of leachate of batch digestor nr.4 with municipal solid wastes+primary digested sludge. The result was 3.22 kg BOD_5/m³ and 7.526 kg COD/m³
8/15	Collected sample of leachate of batch digester nr.3 with municipal solid wastes+primary digested sludge. The result was 2.01 kg BOD_5/m³ and 5.090 kg COD/m³.
8/16	Started addition of leachate of batch digesters nr.3 - and 4 to the bottom of secondary UASB unit. This could means an initial load of some 250. kg COD/day and 105. kg BOD_5/day and 32. kg SS/day and 51. kg ($CaCO_3$)/day alkalinity added directly to the secondary UASB unit.
8/22	In this day some 50 m³ of primary sludge from the very bottom of primary unit was transfered to batch digester nr.3. The same was done to the top of batch digester nr 4. Then some 50 m³ of primary sludge from the very bottom of primary unit was trasnfered to over the very bottom of secondary UASB unit. The sludge from the bottom of primary unit was so "sweet" (due to molasses) that it attracted bees,and was smelling "sweet". In this day was started the recycle of secondary UASB effluent to the very bottom of primary unit and to the very bottom of secondary UASB unit. Recycling to the primary unit - may cause the water level in primary unit to raise much
8/26	Added some 100 liters (115.kg COD) molasses to the bottom of primary unit. Reason:gas holders wilting.
8/29	Added some 600 liters (692.kg COD) molasses to the bottom of primary unit. Reason:gas holders wilting.
9/03	Leachate was going to the bottom of primary unit. In - this day some 70.m³ of "sweet" sludge from the very bottom of primary unit was trasnfered to over the very bottom of secondary UASB unit. It was started full recycle of secondary UASB effluent to the very bottom of primary unit,but this caused flooding of the primary unit.So this was discontinued. Biogas production declining.
9/04	Started full recycle capacity of secondary effluent to the very bottom of secondary UASB unit. Started the daylly addition of some 25 m³ to each of the two batch di-

Table IX. Operational Data of Non-sewage Organic Loading (≠2)

Date	Load conditions
	gesters of municipal solid wastes inoculated with primary digested sludge. The leachate was drained during the night and pumped to the very bottom of secondary unit.
9/08	Added some 400 liters (460.kg COD) molasses to the very bottom of primary unit,because the gas holders were wilted. It was being added secondary UASB effluent to over the batch digesters in early morning,up to filling up the digesters. During the whole day organic acids and other compounds leach to the added liquid,which is drained during the night. The final pump station was kept running 24 hour/day,returning secondary UASB effluent to the batch digesters or to the inlet of secondary UASB
9/12	Leachate of digester nr.3 had BOD_5=323mg/L,COD=563mg/L, SS=292mg/L and alkalinity=246.5mg/L($CaCO_3$).Leachate of digester nr.4 had BOD_5=330mg/L,COD=814mg/L,SS=336mg/L, alkalinity=239.3mg/L.Probably some 55.kg COD/day and 26. kg BOD_5/day and 25.kg SS/day and 19.4 kg alkalinity were being sent to the bottom of secondary unit,being the "leachate" a non-sewage organic loading.
9/30	Added some 400 liters (460.kg COD) molasses to the very bottom of primary unit,because of wilted gas holders.
10/04	Added some 400 liters (460.kg COD) molasses to the very bottom of primary unit,because of wilted gas holders.
10/31	Leachate of digester nr.3 had BOD_5=107mg/L,COD=244mg/L, SS=148mg/L and alkalinity=789.0mg/L($CaCO_3$).Leachate of digester nr.4 had BOD_5=211.mg/L,COD=460mg/L,SS=224 mg/L pH=6.8,Alkalinity=811mg/L.Secondary UASB effluent recycled to fill and "leach" the batch static digesters had BOD_5=43.mg/L,COD= 204mg/L,SS=140mg/L,pH=6.6,alkalinity= 88.3mg/L(data of nov.30/1984). The conclusion is that very little organic load was being "leached",but biogas production was good in the batch digesters.
11/03	It was decided to check the leachate.Leachate of batch digester nr.3 had BOD_5=87.mg/L,COD=171.mg/L,SS=124.mg/L pH=6.8,alkalinity=256.1mg/L($CaCO_3$).Leachate of batch digester nr.4 had BOD_5=43.mg/L,COD=88.mg/L,SS=64.mg/L,pH= 6.4,alkalinity=171.1mg/L.The secondary UASB effluent recycled to fill and "leach" the batch static digesters had BOD_5=35.mg/L,COD=144.mg/L,SS=104.mg/L,pH=7.0,alkalinity=143.7mg/L($CaCO_3$).Again the conclusion is that a minimal organic load was being "leached" from the batch

Table IX. Operational Data of Non-Sewage Organic Loading (≠3)

Date	Load conditions
	digesters to be pumped to feed the secondary UASB unit, but biogas production was good in the batch digesters.
11/27	Arrived one truck with 13,860.kg of molasses. Some 7,000 kg of molasses (7,000.kgCOD) were introduced at the very bottom of primary unit (making a "sweet" sludge bed).The balance was stored in 22 steel drums (of 200 liters each)+asbest cement tank of 150 liters + concrete tank of 1.4m³ capacity. Slowly the molasses of the concrete tank leached into the raw sewage flow passing under such tank
12/06	Started addition of 200 liters (230.kg COD) per day of molasses into the pit which feeds the very bottom of secondary UASB unit,mixed with primary effluent. But sampling of primary effluent is made upstream of this pit. Molasses was added at a constant flow of some 10.L/hour.
12/09	200 liters (230.kgCOD)molasses into secondary UASB unit.
12/10	200 liters (230.kgCOD)molasses into secondary UASB unit+ 200 liters (230.kgCOD) of molasses was added to the raw sewage feeding the upper part of the primary unit.
12/11	The same as previous day
12/12	The same as previous day 12/10.
12/16	It was made a balance.Already some 2,950 liters (3,400.kg COD) stored in tanks have already been added or leached to the primary and secondary unit from Nov.27 to Dec.15. Some 15 steel drums (3,000 liters of molasses - with 3,450.kg COD) were yet full and to be used.
12/17	200 liters of molasses (230.kgCOD)was mixed with primary effluent (downstream of sampling point) and fed to the very bottom of secondary UASB unit.
12/18	It was added 100 liters (115.kgCOD)molasses to the bottom of secondary UAS unit (mixed with primary effluent)
12/19	The same as previous day.
12/20	The same as 12/18.
12/21	The same as 12/18.
12/22	The same as 12/18
12/23	The same as 12/18.
12/24	Some 200 liters (230.kgCOD) molasses have been mixed to raw sewage and added through the upper part of primary.
12/26	It was added 100 liters (115.kgCOD)molasses to the bottom of secondary UASB unit (mixed with primary effluent)
12/27	No molasses added. Reason:excess biogas in gas holders.

Table IX. Operational Data on Non-Sewage Organic Loading (≠4)

Date	Load conditions
12/29	It was added 100 liters of molasses to the bottom of secondary unit (115.kg COD) and 100 liters of molasses (115.kgCOD)mixed with raw sewage to the primary unit.
1/01	It was added 100 liters of molasses into the primary.
1/02	The same as previous day.
1/05	It was added 100 liters (115.kgCOD)molasses to the primary unit and 100 liters (115.kgCOD)molasses to the secondary unit.
1/11	It was added 200 liters (230.kgCOD)molasses to the bottom of primary unit and 200 liters (230.kgCOD)molasses to the bottom of secondary unit.
1/12	It arrived one truck with 16,220.kg of molasses,which was stored in tanks and in 59 steel drums of .2m³ each. Nothing was added into the bottom of primary unit,because gas holders were fully inflated. Molasses had a COD of 618.8 kg/m³ and 626.6mg/L Organic Nitrogen (as N) - and 215.0mg/L of NH_4^+ as N. Such molasses would be worth a COD load of 10,000.kg.
1/16	Added some .1m³ molasses (62.kgCOD) to the primary unit.
1/17	Added some .1m³ molasses (62.kgCOD)to the primary unit, but gas holders are fully inflated.
1/18	Added some .1m³ molasses (62.kgCOD) to the primary unit and some .1m³ molasses (62.kgCOD) to the secondary unit
1/20	Added some .1m³ molasses (62.kgCOD) to the secondary unit. (mixed with primary effluent).
2/01	Excess biogas producion being flared to atmosphere.
2/12	Some 40 kg (wet) of onions (some 10.kg COD) comminuted and diluted with water and added to the raw sewage.

Table X is an attempt to evaluate the sewage load and - non-sewage load (molasses,leachate,onions,etc),both expressed as COD,entering into the primary and secondary units. In this way we found the total load applied both in the primary and secondary unit,and so we evaluated the mean OVLR-organic volumetric loading rate,in kg COD/m³.day,of the primary and secondary unit. Also it was evaluated the mean HRT-hydraulic retention time in the primary and secondary unit.

As we could expect,the least OVLR took place in January, with 0.32 kg COD/m³.day in the primary unit and 0.37 kgCOD/m³. day in the secondary unit,exactly when we got the best efficiency of BOD and COD removal. Obviously the largest HRT also - took place in January 1985 with 41.3 hours in the primary unit and 17.6 hours in the secondary unit.

But here we have one problem. In the primary unit we are computing as "useful" volume the whole reactor volume.But in practice,one reactor that could be just 16m diameter was made 28m diameter at water surface in order to exchange one vertical and reinforced concrete wall for an inclined at 45º and not reinforced concrete wall of a trunk cone,in which there - is no flow or sludge deposition (or minimal of both). Also it is to point out that a great part of the digestion compartment of primary unit is filled up with digested (inactive) sludge.

The same type of reasoning is possible for the secondary unit,in which the volume of reactor is much larger than the - required or effective,just because of construtive reasons.And the settling compartment is over the bottom of the reactor,in which are the diffusers. So the flow is mainly vertical,from the bottom to the settling compartment,and not flowing through the trunk-cone part made for constructive reasons.

Well, it is a "guess",but it could be assumed the useful volume for settling (and also detention time) in the primary unit,the volume of 420 m³ (over the sludge layer),and a total reactor volume of 1,005 m³ for the "reaction" or digestion of the sewage in the primary unit (settling +digestion effective volume). With such reasoning,the more "true" OVLR would be of 0.608 kg COD/m³ in the primary unit and 8.98 hours HRT in the primary unit. In the case of secondary unit,the effective volume would be of 441 m³,and the "true" OVLR would be of 0.687 kg COD/m³.day and HRT would be of 9.43 hours. In any way,such problems are related to the "shape" of the reactors,which is quite ineffective for biological reactions.(See RALF reactors)

In the opposite case,of higher loading,we have the situation for August (highest,but having "grab" samples results),

Table X. Evaluation of Total (Sewage and Non-Sewage) Loading

Date	COD Sewage kg/day prima	secon	COD Non-Sewage kg/day prima	secon	COD Total Load kg/day prima	secon	Mean OVLR kgCOD/m³d prim	seco	Mean HRT hours prim	seco
8/01	2,011	770	-	-	2,011	770	1.04	0.94	39.0	16.6
8/02	-	-	-	-	-	-	-	-	-	-
8/03	-	-	-	-	-	-	-	-	-	-
8/04	-	-	-	-	-	-	-	-	-	-
8/05	-	-	-	-	-	-	-	-	37.6	16.0
8/06	1,273	372	-	-	1,273	372	0.66	0.45	33.0	14.0
8/07	-	-	-	-	-	-	-	-	35.3	15.0
8/08	441	256	-	-	441	256	0.23	0.31	34.8	14.8
8/09	1,773	-	-	-	1,773	-	0.92	-	35.0	14.9
8/10	351	174	11,185	-	11,536	174	5.97	0.21	66.5	28.3
8/11	-	-	-	-	-	-	-	-	116.7	49.6
8/12	-	-	-	-	-	-	-	-	228.3	97.1
8/13	-	370	-	-	-	370	-	0.45	41.0	17.5
8/14	542	-	-	-	542	-	0.28	-	70.1	29.8
8/15	1,684	-	-	-	1,684	-	0.87	-	40.0	16.2
8/16	654	356	-	250	654	606	0.34	0.74	37.2	15.8
8/17	-	-	-	-	-	-	-	-	37.6	16.0
8/18	-	-	-	250	-	?	-	?	40.4	17.2
8/19	-	-	-	-	-	-	-	-	41.8	17.8
8/20	1,645	638	-	250	1,645	888	0.85	1.08	34.4	14.6
8/21	876	576	-	-	876	576	0.45	0.70	33.2	14.1
8/22	607	178	-	250	607	428	0.31	0.52	65.7	27.9
8/23	405	219	-	-	405	219	0.21	0.27	62.3	26.5
8/24	-	-	-	250	-	?	-	?	23.2	9.8
8/25	-	-	-	-	-	-	-	-	20.2	8.6
8/26	836	644	115	250	951	894	0.49	1.09	14.7	6.2
8/27	828	411	-	-	828	411	0.43	0.50	25.0	10.6
8/28	531	312	-	250	531	562	0.27	0.68	28.6	12.2
8/29	801	412	692	-	1,493	412	0.77	0.50	27.8	11.8
8/30	946	589	-	250	946	839	0.49	1.02	29.1	12.3
8/31	-	-	-	-	-	-	-	-	27.0	11.5
MEAN	953	418	387	65	1,340	483	0.69	0.59	35.1	14.9
mg/L	723	317	293	49	1,015	366	-	-	-	-
kg/mo.	29,543	12,958	11,992	2,000	41,535	14,958	-	-	-	-

Note: Mean HRT of primary unit (settling compartment) may be effectivelly 7.65 hours and OVLR may be 1.33kgCOD/m³.d(whole unit). HRT= 8.03 h and OVLR=1.09kgCOD/m³.d whole sec.unit effect.

Table X. Evaluation of Total (Sewage and Non-Sewage) Loading

Date	COD Sewage kg/day prima	secon	COD Non-Sewage kg/day prima	secon	COD Total Load kg/day prima	secon	Mean OVLR $kgCOD/m^3 d$ prim	seco	Mean HRT hours prim	seco
9/01	-	-	-	100	-	?	-	?	28.3	12.0
9/02	584	362	-	-	584	362	0.30	0.44	34.8	14.8
9/03	917	618	100	-	1,017	618	0.53	0.75	26.9	11.4
9/04	1,100	594	-	100	1,100	694	0.57	0.85	25.7	10.9
9/05	883	350	-	100	883	450	0.46	0.55	27.3	11.6
9/06	2,329	481	-	100	2,329	581	1.21	0.71	28.6	12.2
9/07	565	261	-	100	565	361	0.29	0.44	32.5	13.8
9/08	-	-	460	100	?	?	?	?	33.6	14.3
9/09	571	182	-	50	571	232	0.30	0.28	36.1	15.3
9/10	-	-	-	50	-	?	?	?	27.0	11.5
9/11	598	408	-	50	598	458	0.31	0.56	33.9	14.4
9/12	958	364	-	50	958	414	0.50	0.50	29.2	12.4
9/13	1,344	895	-	50	1,344	945	0.70	1.15	27.4	11.7
9/14	619	298	-	50	619	348	0.32	0.42	32.7	13.9
9/15	-	-	-	50	-	?	-	?	33.2	14.1
9/16	546	338	-	50	546	388	0.28	0.47	37.8	16.1
9/17	-	-	-	50	-	?	-	?	34.7	14.7
9/18	801	298	-	50	801	348	0.41	0.42	35.1	14.9
9/19	833	398	-	50	833	448	0.43	0.55	36.6	15.6
9/20	761	-	-	50	761	?	0.39	?	17.8	7.6
9/21	690	525	-	50	690	575	0.36	0.70	25.5	10.9
9/22	779	474	-	50	779	524	0.40	0.64	32.5	13.8
9/23	652	701	-	50	652	751	0.34	0.91	34.6	14.7
9/24	1,242	590	-	50	1,242	640	0.64	0.78	32.7	13.9
9/25	-	-	-	50	-	?	-	?	29.1	12.3
9/26	-	-	-	50	-	?	-	?	36.7	15.6
9/27	-	-	-	50	-	?	-	?	-	-
9/28	1,614	707	-	30	1,614	737	0.84	0.90	16.5	7.0
9/29	1,133	483	-	30	1,133	513	0.59	0.62	24.9	10.6
9/30	1,183	121	460	30	1,643	151	0.85	0.18	30.9	13.1
MEAN	941	450	34	55	975	484	0.50	0.59	29.3	12.5
mg/L	595	285	22	35	617	306	-	-	-	-
kg/mo.	28,230	13,500	1,020	1,640	29,250	14,520	-	-	-	-

NOTE: Great part of volume of primary and secondary unit isn't effective for biological reactions. OVLR=0.93kgCOD/m³.d and HRT =6.38 h for primary unit (effective) and OVLR=1.10kgCOD/m³.d and HRT=6.70 h for secondary unit (effective for reaction).

Table X. Evaluation of Total (Sewage and Non-Sewage) Loading

Date	COD Sewage kg/day		COD Non-Sewage kg/day		COD Total Load kg/day		Mean OVLR kgCOD/m³ d		Mean HRT hours	
	prima	secon	prima	secon	prima	secon	prim	seco	prim	seco
10/01	920	449	-	30	920	479	0.48	0.58	27.7	11.8
10/02	553	421	-	30	553	451	0.29	0.55	27.2	11.6
10/03	880	425	-	30	880	455	0.46	0.55	26.7	11.3
10/04	937	378	460	30	1,397	408	0.72	0.50	26.7	11.3
10/05	710	600	-	30	710	630	0.37	0.77	27.4	11.7
10/06	253	208	-	30	253	238	0.13	0.29	26.6	11.3
10/07	378	303	-	30	378	333	0.20	0.41	31.3	13.3
10/08	-	-	-	30	-	?	-	?	-	-
10/09	-	-	-	30	-	?	-	?	-	-
10/10	-	-	-	30	-	?	-	?	-	-
10/11	-	-	-	30	-	?	-	?	-	-
10/12	-	-	-	30	-	?	-	?	-	-
10/13	-	-	-	30	-	?	-	?	-	-
10/14	918	323	-	30	918	353	0.48	0.43	34.3	14.6
10/15	822	438	-	30	822	468	0.43	0.57	31.9	13.6
10/16	983	378	-	30	983	408	0.51	0.50	32.1	13.6
10/17	-	-	-	30	-	?	-	?	35.2	15.0
10/18	606	299	-	30	606	329	0.31	0.40	25.1	10.7
10/19	741	248	-	30	741	278	0.38	0.34	25.4	10.8
10/20	400	96	-	30	400	126	0.21	0.15	32.5	13.8
10/21	539	147	-	30	539	177	0.28	0.22	36.5	15.5
10/22	766	231	-	30	766	261	0.40	0.32	35.9	15.2
10/23	656	337	-	20	656	357	0.34	0.43	34.7	14.7
10/24	-	-	-	20	-	?	-	?	33.9	14.4
10/25	946	278	-	20	946	298	0.49	0.36	34.8	14.8
10/26	713	347	-	20	713	367	0.37	0.45	37.3	15.9
10/27	742	488	-	20	742	508	0.38	0.62	31.2	13.3
10/28	420	281	-	20	420	301	0.22	0.37	44.0	18.7
10/29	436	213	-	20	436	233	0.23	0.28	42.6	18.1
10/30	1,015	322	-	20	1,015	342	0.53	0.42	37.0	15.7
10/31	-	-	-	20	-	?	-	?	41.1	17.5
MEAN	697	328	15	27	711	355	0.37	0.43	31.9	13.6
mg/L	480	226	10	19	491	245	-	-	-	-
kg/mo.	21,607	10,168	460	840	22.067	11,008	-	-	-	-

NOTE: Considering the volume effective for reactions, possible true values for primary: OVLR=0.71 kgCOD/m³ .d; HRT=6.95h (set.compartiment); for secondary: OVLR=0.81 kgCOD/m³ .d; HRT=7.29 hours.

Table X. Evaluation of Total (Sewage and Non-Sewage) Loading

Date	COD Sewage kg/day		COD Non-Sewage kg/day		COD Total Load kg/day		Mean OVLR $kgCOD/m^3 d$		Mean HRT hours	
	prima	secon	prima	secon	prima	secon	prim	sec.	prim	sec.
11/01	171	260	-	10	171	270	0.09	0.33	33.4	14.2
11/02	275	257	-	10	275	267	0.14	0.33	28.6	12.2
11/03	309	159	-	0	309	159	0.16	0.19	25.7	10.9
11/04	-	-	-	0	-	-	-	-	58.7	24.9
11/05	672	330	-	0	672	330	0.35	0.40	19.4	8.2
11/06	1,028	444	-	0	1,028	444	0.53	0.54	26.8	11.4
11/07	295	250	-	0	295	250	0.15	0.30	24.3	10.3
11/08	986	371	-	0	986	371	0.51	0.45	24.0	10.2
11/09	853	145	-	0	853	145	0.44	0.18	26.2	11.2
11/10	207	79	-	0	207	79	0.11	0.10	24.6	10.5
11/11	345	48	-	0	345	48	0.18	0.06	23.9	10.2
11/12	529	191	-	0	529	191	0.27	0.23	25.9	11.0
11/13	180	121	-	0	180	121	0.09	0.15	46.3	19.7
11/14	495	281	-	0	495	281	0.26	0.34	34.9	14.8
11/15	1,678	321	-	0	1,678	321	0.87	0.39	18.3	7.8
11/16	1,219	334	-	0	1,219	334	0.63	0.41	16.7	7.1
11/17	533	715	-	0	533	715	0.28	0.87	34.2	14.5
11/18	-	-	-	0	-	-	-	-	19.3	8.2
11/19	-	-	-	0	-	-	-	-	21.6	9.2
11/20	376	121	-	0	376	121	0.19	0.15	14.5	6.2
11/21	-	-	-	0	-	-	-	-	-	-
11/22	427	461	-	0	427	461	0.22	0.56	18.9	8.0
11/23	5,800	911	-	0	5,800	911	3.00	1.11	17.0	7.2
11/24	872	412	-	0	872	412	0.45	0.50	13.6	5.8
11/25	622	369	-	0	622	369	0.32	0.45	20.1	8.5
11/26	924	284	-	0	924	284	0.48	0.35	15.3	6.5
11/27	355	-	7,000	0	7,355	-	3.81	-	18.6	7.9
11/28	737*	463	-	0	737	463	0.38	0.56	20.7	8.8
11/29	1,049*	784	-	0	1,049	1,049	0.54	0.95	17.7	7.5
11/30	- *	-	-	0	-	-	-	-	18.0	7.6
MEAN	837	338	233	1	1,070	339	0.55	0.41	21.9	9.3
mg/L	395	159	110	0	505	160	-	-	-	-
kg/mo.	25,110	10,140	7,000	20	32,110	10,160	-	-	-	-

(*)-Molasses were leaching directly into raw sewage;1.5m³ tank
NOTE:True values for primary:OVLR=1.07 kgCOD/m³.d;HRT=4.75 h (settling compartment of septic tank).For Secondary unit:OVLR= 0.77 kg COD/m³.d and HRT= 4.99 hours (effective reactor volume)

Table X. Evaluation of Total(Sewage and Non-Sewage) Loading

Date	COD Sewage kg/day		COD Non-Sewage kg/day		COD Total Load kg/day		Mean OVLR kgCOD/m³ d		Mean HRT hours	
	prima	secon	prima	secon	prima	secon	prim	sec.	prim	sec.
12/01	527*	242	-	-	527	242	0.27	0.29	18.4	7.8
12/02	669*	140	-	-	669	140	0.35	0.17	19.6	8.3
12/03	792*	378	-	-	792	378	0.41	0.46	16.2	6.9
12/04	828*	338	-	-	828	338	0.43	0.41	23.0	9.8
12/05	290*	126	-	-	290	126	0.15	0.15	22.1	9.4
12/06	1,362*	419	-	230	1,362	649	0.71	0.79	21.1	9.0
12/07	470*	130	-	-	470	130	0.24	0.16	25.3	10.7
12/08	295*	209	-	-	295	209	0.15	0.25	27.3	11.6
12/09	398*	103	-	230	398	333	0.21	0.41	31.5	13.4
12/10	1,319*	505	230	230	1,549	735	0.80	0.90	26.3	11.2
12/11	263	186	230	230	493	416	0.26	0.51	30.7	13.0
12/12	418	403	230	230	648	633	0.34	0.77	25.3	10.7
12/13	591	568	-	-	591	568	0.31	0.69	20.2	8.6
12/14	-	-	-	-	-	-	-	-	19.5	8.3
12/15	528	479	-	-	528	479	0.27	0.58	22.5	9.5
12/16	514	383	-	-	514	383	0.27	0.47	26.9	11.4
12/17	798	509	-	230	798	739	0.41	0.90	17.5	7.4
12/18	946	483	-	115	946	598	0.49	0.73	21.4	9.1
12/19	817	675	-	115	817	790	0.42	0.96	22.2	9.5
12/20	1,352	473	-	115	1,352	588	0.70	0.72	23.9	10.2
12/21	986	603	-	115	986	718	0.51	0.87	24.5	10.4
12/22	930	441	-	115	930	556	0.48	0.68	25.7	10.9
12/23	759	416	-	115	759	531	0.39	0.65	27.7	11.8
12/24	866	372	230	-	1,096	372	0.57	0.45	24.9	10.6
12/25	796	459	-	-	796	459	0.41	0.56	28.2	12.0
12/26	-	-	-	115	-	?	-	?	23.8	10.1
12/27	-	-	-	-	-	-	-	-	28.1	12.0
12/28	-	-	-	-	-	-	-	-	25.9	11.0
12/29	-	-	115	115	?	?	?	?	23.8	10.1
12/30	-	-	-	-	-	-	-	-	26.1	11.1
12/31	-	-	-	-	-	-	-	-	23.8	10.1
MEAN	730	377	33	74	763	451	0.40	0.55	23.4	9.9
mg/L	368	190	17	37	385	228	-	-	-	-
kg/mo.	22,630	11,687	1,035	2,300	23,665	13,987	-	-	-	-

(*)Molasses of concrete tank leaching into raw sewage.
NOTE: True values for primary: OVLR=0.76kgCOD/m³ d; HRT=5.08 hours (setl.compart.). For secondary: OVLR=1.06kgCOD/m³ d; HRT=5.34 h

Table X. Evaluation of Total (Sewage and Non-Sewage) Loading

Date	COD Sewage kg/day		COD Non-Sewage kg/day		COD Total Load kg/day		Mean OVLR $kgCOD/m^3 d$		Mean HRT hours	
	prima	secon	prima	secon	prima	secon	prim	sec.	prim	sec.
1/01	–	–	115	–	–	?	–	?	32.1	13.6
1/02	–	–	115	–	–	?	–	?	28.8	12.2
1/03	–	–	–	–	–	–	–	–	31.6	13.4
1/04	–	–	–	–	–	–	–	–	32.9	14.0
1/05	–	–	115	115	?	?	?	?	34.5	14.7
1/06	–	–	–	–	–	–	–	–	37.5	15.9
1/07	–	–	–	–	–	–	–	–	35.9	15.2
1/08	–	918	–	–	–	918	–	1.12	35.8	15.2
1/09	–	–	–	–	–	–	–	–	38.2	16.2
1/10	816	309	–	–	816	309	0.42	0.38	37.1	15.8
1/11	680	317	230	230	910	547	0.47	0.67	40.3	17.1
1/12	610	402	–	–	610	402	0.32	0.49	38.2	16.3
1/13	341	–	–	–	341	–	0.18	–	47.1	20.0
1/14	423	207	–	–	423	207	0.22	0.25	40.7	17.3
1/15	226	260	–	–	226	260	0.12	0.32	40.9	17.4
1/16	–	–	62	–	?	–	?	–	45.0	19.1
1/17	982	404	62	–	1,044	404	0.54	0.49	44.3	18.8
1/18	624	337	62	62	686	399	0.36	0.49	48.4	20.6
1/19	578	311	–	–	578	311	0.30	0.38	47.7	20.3
1/20	415	275	–	62	415	337	0.21	0.41	50.8	21.6
1/21	792	275	–	–	792	275	0.41	0.33	42.8	18.2
1/22	930	225	–	–	930	225	0.48	0.27	45.9	19.5
1/23	–	236	–	–	–	236	–	0.29	45.4	19.3
1/24	764	247	–	–	764	247	0.40	0.30	45.6	19.4
1/25	615	239	–	–	615	239	0.32	0.29	49.1	20.9
1/26	439	239	–	–	439	239	0.23	0.29	51.7	22.0
1/27	313	169	–	–	313	169	0.16	0.21	55.0	23.4
1/28	503	169	–	–	503	169	0.26	0.21	51.3	21.8
1/29	935	247	–	–	935	247	0.48	0.30	48.1	20.5
1/30	456	120	–	–	456	120	0.24	0.15	43.4	18.4
1/31	282	151	–	–	282	151	0.15	0.18	48.4	20.6
MEAN	586	288	25	15	611	303	0.32	0.37	41.3	17.6
mg/L	567	279	22	13	590	294	–	–	–	–
kg/mo.	18,166	8,928	761	469	18,927	9,397	–	–	–	–

NOTE: Possible true values for primary septic tank unit: OVLR= 0.608 $kgCOD/m^3 d$; HRT=8.98 hours (settling compartment); for secondary UASB unit: OVLR=0.687 $kgCOD/m^3 d$; HRT=9.43 hours (mean).

Table X. Evaluation of Total (Sewage and Non-Sewage) Loading

Date	COD Sewage kg/day prima	secon	COD Non-Sewage kg/day prima	secon	COD Total Load kg/day prima	secon	Mean OVLR kgCOD/m³ d prim	sec.	Mean HRT hours prim	sec.
2/01	582	234	-	-	582	234	0.30	0.29	50.4	21.4
2/02	590	303	-	-	590	303	0.31	0.37	47.7	20.3
2/03	604	276	-	-	604	276	0.31	0.34	52.1	22.2
2/04	739	243	-	-	739	243	0.38	0.30	52.0	22.1
2/05	484	171	-	-	484	171	0.25	0.21	55.0	23.4
2/06	-	-	-	-	-	-	-	-	51.0	21.7
2/07	438	232	-	-	438	232	0.23	0.28	49.5	21.0
2/08	565	216	-	-	565	216	0.29	0.26	48.5	20.6
2/09	530	148	-	-	530	148	0.27	0.18	41.3	17.5
2/10	685	226	-	-	685	226	0.35	0.28	44.2	18.8
2/11	337	187	-	-	337	187	0.17	0.23	40.5	17.2
2/12	466	206	10	-	467	206	0.24	0.25	38.6	16.4
2/13	629	204	-	-	629	204	0.33	0.25	48.5	20.6

and for September. In this month we had in the primary unit an OVLR=0.50 kg COD/m³.day (0.93 kg COD/m³.day excluding dead volume) and HRT=29.3 hours (6.38 h excluding dead volume), and in the secondary unit we had an OVLR=0.59 kg COD/m³.day (1.10 kg COD/m³.day excluding dead volume) and HRT=12.5 hours (6.70 hours excluding dead volume).

Unhappily there is not a direct relationship of HRT and OVLR with efficiency of removal of BOD, COD and SS.

The detention time of 41.3+17.6=58,9hours=2.45 days for the primary unit + secondary unit, during the month the January 1985, is in the range of detention time used in anaerobic ponds, and excessive to be for practical use in "compact" sewage treatment plants (if we consider the "total volume reactor" for anaerobic treatment).

But, for a month with larger flow, as it was the case of november 1984, we had a detention time of 21.9+9.3=31.2 hours= =1.3 days for the primary unit + secondary unit. Such detention time is too short for an anaerobic pond, but it is in the range of detention time for oxidation ditchs, as the large one (25,000 kg BOD_5/day) for Curitiba, with 83,330 m³ (aeration tank Carrousel) + 19,000 m³ (settling tank)=102,330 m³ for a daily average (dry) flow of 74,300 m³ or 33.1 hours=1.38 days.

In the best month, January 1985, we had a COD reduction of 308 kg COD/day in the primary unit, or 0.16 kg COD/m³.day (total volume of primary) for an applied loading of 0.32 kg COD/m³.day (some 50% COD load reduction), for an HRT of 41.3 hours.

Also in the month of January 1985, we had a COD reduction of 303-102=201 kg/day (tables X and VII) in the secondary unit, or 0.245 kg COD/m³.day (removed) for an applied COD load of 0.37 kg COD/m³.day (total volume of secondary), and this means that some 66.2% of the applied COD loading was removed. It was better in COD removal than the primary unit, if we also consider that this was for an HRT of 17.6 hours (total volume).

In such month of January 1985 we had a BOD_5 reduction of 110 kg/day (only sewage load) or 0.057 kg BOD_5 removed/m³.day at HRT of 41.3 hours for an applied load of 0.116 kg BOD_5/m³d and so with a load reduction of 49%, in the primary unit. In the secondary unit the load reduction was 86 kg BOD_5/day or 0.105 kg BOD_5/m³.day for an applied load of 0.139 kg BOD_5/m³d and with a load reduction of 75.4% at HRT=17.6 hours and 22ºC.

In the case of a month with larger flow, as it was the case of november 1984, we had a COD reduction of 1,070-339=731 kg COD/day or 0.379 kg COD/m³.day for an applied load in the primary unit of 1,070 kg COD/day or 0.55 kg COD/m³.day or a 68.3% reduction of the applied load for an HRT of 21.9 hours (total volume reactor). This is much better than the load applied (kg COD/m³ day) in January, of only 0.32 kg COD/m³.day, and also with a better COD reduction of 68.3% against 50%. So hydraulic detention time and temperature do not appear to be the main limiting effect in the primary efficiency removal.

But, for the secondary unit, the HRT appears to have a more pronounced effect in the case of november 1984. In this case we had a removed COD load of 339-293=46 kg COD/day or .056 kg COD/m³.day for an applied load of 0.41 kg COD/m³.day or only 13.6% COD removal of the applied load for an HRT=9.3 hours. It is possible that the lightweight particles of sludge of secondary unit (sludge bed) had been removed by the higher upflow velocities of the primary effluent flow.

In the case of December, also with a large influent flow and small HRT, we had a removed COD load of 451-231=220 kg/day or 0.268 kg COD/m³.day for an applied load of 0.549 kg COD/m³.day or 48.8% COD removal of the applied load for an HRT=9.9 hours (only slightly larger than the HRT=9.3 hours of november). In this case it is possible that the lightweight particles of sludge bed of UASB secondary unit already had been removed in the previous month, and so, it was possible to have a good COD removal due to the activity of the anaerobic bacteria in treating the primary effluent. Also the efficiency of BOD_5 removal in December was better than in November, for the secondary unit.

Table XI is the results of % BOD, COD and SS removal efficiency of primary and secondary units and of the whole treatment plant (primary+secondary). This was prepared only for some months. One difficulty in preparing it is that sometimes the effluent is worst than the influent, and so, we have a negative efficiency, which makes it difficult to evaluate the "mean" monthly average value of each column of the table. Because of this, at the bottom of the tables XI we have a computation based in the "mean" of daily mean % removal (of BOD, COD, SS), and based in the "load" (kg/day) removed as a monthly mean.

The data of removal efficiency for January 1985 would be quite typical for an activated sludge plant (aerobic), except the data for SS removal. It appears that to get a secondary level treatment is necessary to have a post-treatment mainly for SS removal. But the suspended solids (matter) leaving the plant, with the secondary effluent, appears to be quite stable, and difficult to degrade, as shown by the low BOD_5 values.

Table XI. Evaluation of Mean % BOD_5, COD and SS Removal

Date	Mean %BOD Removal prima unit	secon unit	prim+ secon	Mean %COD Removal prima unit	secon unit	prim+ secon	Mean % SS Removal prima unit	secon unit	prim+ secon
10/01	32.7	34.2	55.8	51.2	12.3	57.2	-	-	-
10/02	32.0	65.0	76.2	24.0	53.0	64.3	-	-	-
10/03	64.7	37.5	77.9	51.7	31.8	67.1	-	-	-
10/04	66.0	-2.9	65.0	59.6	57.3	82.8	-	-	-
10/05	6.0	67.0	69.0	15.5	54.1	61.2	-	-	-
10/06	23.8	19.7	38.8	17.9	-15.6	2.8	-	-	-
10/07	52.5	61.8	81.9	20.0	27.0	41.6	-	-	-
10/08	54.3	56.5	80.1	54.3	30.5	68.3	-	-	-
10/09	60.0	42.3	76.9	48.1	41.3	69.6	-	-	-
10/10	27.8	35.1	53.1	22.0	18.1	36.1	-	-	-
10/11	52.4	-15.6	43.6	41.4	24.0	55.5	-	-	-
10/12	38.9	44.8	66.2	57.8	28.3	69.8	-	-	-
10/13	59.1	32.2	72.3	51.3	38.9	70.3	-	-	-
10/14	-18.7	42.7	29.5	64.8	19.7	71.7	-	-	-
10/15	30.8	48.9	64.6	46.7	60.6	79.0	-	-	-
10/16	57.9	37.3	73.6	61.5	40.1	76.9	-	-	-
10/17	-	-	-	-	-	-	-	-	-
10/18	56.0	56.3	80.7	50.8	48.1	74.5	-	-	-
10/19	80.9	- 6.1	79.7	66.6	24.3	74.6	-	-	-
10/20	77.0	57.7	90.3	76.1	34.3	84.3	-	-	-
10/21	58.5	90.7	96.2	72.6	68.1	91.3	-	-	-
10/22	71.3	65.2	90.0	69.8	36.9	80.9	-	-	-
10/23	74.8	67.6	91.8	48.7	48.4	73.5	-	-	-
10/24	-	-	-	-	-	-	-	-	-
10/25	65.6	6.3	67.8	70.6	34.0	80.6	-	-	-
10/26	49.5	33.9	66.7	51.4	25.4	63.8	-27.3	47.7	28.1
10/27	40.9	19.3	52.3	34.2	36.8	58.4	7.0	30.0	34.9
10/28	64.2	-39.8	40.5	33.1	19.5	46.1	76.6	-50.0	53.2
10/29	70.5	73.6	92.2	51.1	68.9	84.8	57.8	23.7	67.8
10/30	80.4	18.9	84.1	68.3	20.6	74.8	62.6	-2.9	61.5
10/31	-	-	-	-	-	-	-	-	-
MEAN	51.1	37.5	69.9	49.3	35.2	66.5	35.3	9.7	49.1
From December Data Average values in mg/L	52.4	39.0	71.0	51.7	38.2	70.1	42.7	16.9	52.4
From October BOD_5, COD (Sewage and Non-Sewage) and SS Load balance	53.5	41.1	72.6	53.9	42.3	72.3	40.3	19.2	51.8

Table XI. Evaluation of Mean % BOD_5, COD and SS Removal

Date	Mean %BOD Removal prima unit	secon unit	prim+ secon	Mean %COD Removal prima unit	secon unit	prim+ secon	Mean % SS Removal prima unit	secon unit	prim+ secon
12/01	69.4	55.2	86.3	54.1	28.1	67.0	76.3	-26.3	67.8
12/02	58.8	44.9	77.3	79.2	10.2	81.3	31.0	51.7	66.7
12/03	45.4	47.4	71.3	52.3	34.8	69.0	16.1	34.6	45.2
12/04	58.5	50.6	79.5	59.1	48.8	79.1	50.8	30.0	65.6
12/05	58.3	-2.8	57.1	56.5	20.0	65.2	52.3	-25.0	36.4
12/06	67.5	23.9	75.2	69.2	38.7	81.1	76.9	5.6	78.2
12/07	-	-	-	72.2	29.6	80.5	-6.5	-13.9	-19.4
12/08	-	71.0	-	29.3	74.0	81.6	-15.6	43.8	33.3
12/09	72.5	28.6	80.4	74.2	-23.1	66.4	-	-	-27.8
12/10	27.7	62.7	73.0	61.8	46.5	79.5	59.0	-28.8	42.4
12/11	-	71.0	-	29.3	74.0	81.6	15.6	43.8	33.3
12/12	31.1	63.1	46.4	3.5	45.0	46.9	-11.1	-16.9	-26.2
12/13	-30.4	69.6	56.3	3.8	25.8	28.7	-33.3	31.3	-3.0
12/14	-	-	-	-	-	-	-	-	-
12/15	24.5	76.6	82.4	9.4	49.1	53.9	-25.9	38.3	16.7
12/16	28.7	61.0	72.2	25.5	53.2	65.1	-14.3	14.3	0.0
12/17	48.1	-18.8	36.1	36.2	19.8	48.8	28.3	-24.6	5.0
12/18	62.0	83.6	93.8	50.0	63.2	81.2	22.7	37.6	51.8
12/19	-11.9	38.8	30.5	17.3	37.7	48.5	-24.5	39.8	20.3
12/20	73.9	32.6	65.0	65.0	24.6	73.6	34.7	16.9	45.8
12/21	32.5	37.5	57.8	38.9	37.9	62.1	37.8	-10.3	30.6
12/22	57.9	13.3	63.6	52.5	20.8	62.4	35.5	-2.7	33.6
12/23	35.0	0.0	35.0	45.3	-7.1	41.1	-	-	-
12/24	61.2	91.3	96.6	57.0	71.0	87.5	-	-	-
12/25	48.9	58.8	78.9	42.4	66.3	80.6	-	-	-
12/26	-	-	-	-	-	-	-	-	-
12/27	-	-	-	-	-	-	-	-	-
12/28	-	-	-	-	-	-	-	-	-
12/29	-	-	-	-	-	-	-	-	-
12/30	-	-	-	-	-	-	-	-	-
12/31	-	-	-	-	-	-	-	-	-
MEAN	43.8	46.1	67.4	45.2	37.0	67.2	20.3	12.0	28.4
From December Data Average values in mg/L	47.7	47.6	72.6	48.4	39.8	68.9	26.7	15.7	38.2
From December BOD_5, COD (Sewage and Non-Sewage) and SS Load balance	48.4	47.3	72.8	50.6	48.8	72.4	27.4	16.7	39.5

Table XI. Evaluation of Mean % BOD_5, COD and SS Removal

Date	Mean %BOD Removal prima unit	Mean %BOD Removal secon unit	Mean %BOD Removal prim+ secon	Mean %COD Removal prima unit	Mean %COD Removal secon unit	Mean %COD Removal prim+ secon	Mean % SS Removal prima unit	Mean % SS Removal secon unit	Mean % SS Removal prim+ secon
1/01	-	-	-	-	-	-	-	-	-
1/02	-	-	-	-	-	-	-	-	-
1/03	-	-	-	-	-	-	-	-	-
1/04	-	-	-	-	-	-	-	-	-
1/05	-	-	-	-	-	-	-	-	-
1/06	-	-	-	-	-	-	-	-	-
1/07	-	-	-	-	-	-	-	-	-
1/08	-	78.2	-	-	75.6	-	-	-	-
1/09	-	-	-	-	-	-	-	-	-
1/10	61.4	85.4	94.4	62.2	78.9	92.0	-	-	-
1/11	44.1	47.4	70.6	53.3	53.3	78.2	-	-	-
1/12	18.9	81.3	84.9	34.0	76.8	84.7	-	-	-
1/13	-	-	91.1	-	-	76.7	-	-	-
1/14	50.3	65.3	82.8	50.9	68.7	84.6	-	-	-
1/15	-13.8	86.9	85.1	-15.1	87.7	85.9	-	-	-
1/16	-	-	-	-	-	-	-	-	-
1/17	68.6	83.9	95.0	58.8	67.4	86.6	-	-	-
1/18	33.5	71.4	81.0	46.0	49.1	72.5	-	-	-
1/19	48.9	80.4	90.0	46.2	67.5	82.5	-	-	-
1/20	20.0	64.7	71.8	33.6	43.0	62.2	-	-	-
1/21	59.2	37.7	74.6	65.3	39.3	78.9	-	-	-
1/22	56.8	74.7	89.1	75.8	30.5	83.2	-	-	-
1/23	-	79.8	-	-	62.8	-	-	-	-
1/24	46.3	75.5	86.8	67.7	73.3	91.4	-	-	-
1/25	60.9	85.3	94.3	61.2	68.8	87.9	-	-	-
1/26	53.3	83.2	92.1	45.4	66.3	81.6	-	-	-
1/27	65.0	79.4	92.8	46.1	65.5	81.4	-	-	-
1/28	72.3	81.0	94.7	66.4	61.0	86.9	-	-	-
1/29	73.3	83.5	95.6	73.6	62.9	90.2	-	-	-
1/30	48.7	96.3	98.1	73.8	90.2	97.4	67.0	27.8	76.1
1/31	82.9	-46.7	74.9	46.4	24.7	59.7	74.6	-61.3	59.0
From month mean (average) in mg/L	51.5	74.8	87.8	52.4	63.7	82.7	71.0	-13.4	67.1
Mean of Data of % Removal of January	49.5	70.2	87.0	52.2	62.5	82.2	70.8	-16.8	67.6
From January BOD_5, COD (Sewage and Non-Sewage) and SS Load balance	49.1	75.4	87.6	52.9	66.3	83.7	70.8	-11.8	67.4

Table XI. Evaluation of Mean % BOD_5, COD and SS Removal

Date	Mean %BOD Removal prima unit	secon unit	prim+ secon	Mean %COD Removal prima unit	secon unit	prim+ secon	Mean % SS Removal prima unit	secon unit	prim+ secon
2/01	53.7	71.7	86.9	59.7	62.0	84.7	-44.2	95.1	92.9
2/02	43.5	34.7	63.1	48.6	28.8	63.4	79.7	-46.7	70.3
2/03	72.3	-87.1	48.2	54.3	- 5.5	51.8	70.5	26.9	78.4
2/04	71.6	63.2	89.6	67.2	56.3	85.6	84.3	-164.7	58.3
2/05	66.4	84.2	94.7	64.7	74.9	91.1	60.7	57.6	83.3
2/06	-	-	-	-	-	-	-	-	-
2/07	61.5	76.6	91.0	46.9	72.6	85.4	59.8	-16.3	30.5
2/08	57.9	28.2	69.8	61.8	23.0	70.6	48.2	19.0	58.0
2/09	81.4	-1.9	81.1	72.0	15.9	76.5	82.2	-134.6	58.2
2/10	77.1	60.0	90.8	67.1	53.5	84.7	22.8	62.5	71.1
2/11	64.4	68.3	88.7	44.7	57.7	76.6	75.5	23.4	81.3
2/12	58.8	54.7	81.3	55.7	70.9	87.1	42.2	24.3	56.3
2/13	75.5	83.1	95.9	67.5	59.3	86.8	77.2	29.2	29.3

We should monitor the coliform reduction in the anaerobic treatment,but the bacteriology laboratory of SANEPAR is refusing to make such type of analysis,because in the last attempt some sewage samples from Pirai do Sul caused heavy contamination of drinking water samples (from several towns) in the laboratory. Next month probably it will be installed another laboratory in the sewage treatment plant to make such type of analysis (coliform),in a regular basis. Also it is planned that the Catholic University will make one year laboratory control of the anaerobic treatment plant of Pirai do Sul, in all aspects,but the money for such has not yet been provided by brazilian government. Results of last samples,are from December 9,1983,and shown in Table XII.

TABLE XII. TOTAL COLIFORM CONCENTRATION

TYPE OF SAMPLE	COLIFORM CONCENTRATION coli/ 100 mL	% REMOVAL
Raw sewage	3,000,000,000	
Primary effluent	1,000,000	99.9667
Secondary effluent	500,000	50% sec. 99.983%total

Next samples,for coliform,are from March 19,1984,and are presented in Table XIII.

TABLE XII. TOTAL COLIFORM CONCENTRATION

TYPE OF SAMPLE	COLIFORM CONCENTRATION coli/100 mL	% REMOVAL
Raw sewage	28,000,000,000	
Primary effluent	2,100,000,000	92.50
Secondary effluent	600,000,000	71% sec. 97.86% total

Probably we have one order of magnitude in coliform reduction,both in the primary unit and in the secondary unit,as a general rule.We have no algae at the surface of the anaerobic reactors because they are covered by an opaque gas holder and the border of the reactors is covered by a type of weed (not water hyacinth) which do not breed mosquitos (or little).

Next we will try to finish the "balance" for the process of anaerobic treatment of PIRAI DO SUL. Remember that this -

plant was born to be a BIOGASIFICATION PLANT (before in importance to be an anaerobic treatment plant) and that the COD load of domestic sewage was expected to be a minor COD load source in relation to the total COD load to be biogasified. This would means that the plant is very oversized for treating only domestic sewage, as is being the case.

The idea here is to make a COD balance, considering the COD input load (from domestic sewage, from leachates of batch digestors and from added molasses and onions) and considering the COD load discharged in the secondary effluent and the balance being the COD stored in the excess sludge + COD converted in methane present in biogas + COD converted in methane discharged dissolved in the secondary effluent.

It is very difficult to evaluate the COD stored in excess sludge, as it is difficult to make a good sampling to evaluate the sludge stored in the primary and secondary units (this was not foreseen in the project).

Also it is difficult to evaluate the COD converted to methane in each unit (primary and secondary) because we haven't used a gas macrometer in the plant. Having it, we could draw biogas from just one unit, up to wilting completelly the gas holder of such unit, and taking note of the biogas removed. In the time we could make an accounting of the volume removed of biogas of each unit. But only in November 1984 the gas macrometer was installed, but delivering a meaningless result because it was installed in a line with variable pressure. In late January 1984 it was installed a BPI corrector, so we now have results corrected to a base pressure, but very soon the gas macrometer became out of service. Such type of procedure was done for the biogas produced in the batch digesters, because such biogas produced was removed with the help of small capacity compressors and the volume of gas removed was measured in gasmeters of small flow capacity installed in parallel. Some of the biogas from batch digester was drawn without being measured in July and August 1984, and probably later on, also.

The only way we have to evaluate the biogas produced in the sewage treatment is making the difference of biogas measured in home gas meters (at 1.5 PSIG) and of biogas measured in gas meters of batch digesters. But we have one problem of under-measuring, because several home gas meters are "stuck" or under-measuring and with biogas passing freely through such gas meters.

To make a COD balance we need also to know the composition of the biogas produced/delivered. This was done taking sam ples of biogas in flexible inflatable PVC gas holders,and making gas chromatograph analysis in the laboratory of Catholic University of Parana. But we had some problems of air (oxygen +nitrogen) not completelly removed from the samples gas holders or infiltrated during sampling. Also some of the air is present in biogas and originally such air was dissolved into the raw sewage influent to the plant,and when such influent travelled through the anaerobic compartment of primary unit, such dissolved air becomes over-saturated and is stripped by the rising bubbles of biogas. But,for sure,it appears difficult to believe that oxygen may be present in the biogas of secondary unit (UASB),because such oxygen had a long chance - and time of being stripped or consumed in the primary unit by facultative bacteria,and again such any remaining dissolved oxygen in the primary effluent should be consumed by facultative bacteria present in the sludge bed of secondary UASB unit.

TABLE XIII. BIOGAS PRODUCTION

Month	Biogas distributed as measured in m^3	Biogas from solid waste m^3	Biogas from sewage m^3 local conditions
August	4,650÷2=2,325	-	2,325 (1.5 PSIG)
September	3,223	137x1.3=178	3,045 "
October	3,235	56x1.3= 73	3,162 "
November	4,732	482	4,250 "
December	4,516	44 ?	4,516 "
January	5,068	83	4,985 "
March/Jan.	31,576	860 ?	30,716 "

Such volume of biogas should be considered measured at 20ºC (average ground temperature) and in a place 1,000 m above sea level (679mmHg barometric pressure) but with biogas - being measured at 1.5 PSIG (78mm Hg),or total absolute pressure of 757 mm Hg (almost sea level pressure). To convert such volumes to STP (Standard Temperature and Pressure) of 0ºC and 760mm Hg,it is necessary to multiply by 0.928 the volumes of biogas as measured.

It is necessary to point out that the effective period - for garbage digestion was August to January (6 full months), in which biogas was produced. But great part of such biogas - was not measured or leaked away (most of the data was not written,probably). Some data (october) are also missing.

Now we will consider the biogas composition.

TABLE XIV. BIOCAS COMPOSITION BY VOLUME

Date	Biogas Source	CH_4 %	CO_2 %	N_2 %	O_2 %	Other %
05-21/84	Primary unit	83.05	7.39	8.47	1.09	-
08-13/84	Prim.+second.	74.00	9.86	13.34	2.80	-
08-13/84	Batch dig.old	24.50(*)	34.28	38.92	2.30	-
08-13/84	Batch dig.new	50.77	40.53	7.08	1.62	-
10-04/84	Primary unit	79.74	8.86	11.39	0.01	-
10-04/84	Secondary unit	81.48	7.41	11.11	0.01	-
11-07/84	Primary unit	78.20	5.70	12.60	3.40	-
11-07/84	Secondary unit	78.80	4.70	12.90	3.50	-
11-07/84	Batch dig.old	78.20	12.60	5.70	3.40	-
01-30/85	Secondary unit	75.50	3.50	15.19	5.74	-

Such analysis were made by the laboratory of Catholic University of Parana. The sample marked with (*) is to point out that the biogas compressor was making such unit under slight vacuum and making some air leaking into it,mainly through the bottom PVC drain,as we verified later on.

It is interesting to notice the relativelly high methane content,typically in the range of 75 to 80%,in the biogas produced in the anaerobic treatment of sewage. Such value is much larger than the usually reported for sludge digesters (55% to 65%,typically). Only some UASB type reactors treating diluted industrial wastes have shown such high methane percentage.

Much more interesting is the very low concentration of carbon dioxide (CO_2) in biogas,in relation to the usual concentration found in sludge anaerobic digesters (35% to 45%), and the reason for this is very simple. CO_2 is quite very soluble gas in water. As we have much more water availabe for dissolving CO_2 in the case of sewage anaerobic treatment than we have in the case of sludge anaerobic digestion,by Henry's law for reactive and easy to dissolve gas,we must have a smaller CO_2 content in the gas phase. Exactly for this scrubbing effect,we have a very low concentration of CO_2 in the batch - digestor (sample of 11-07/1984) which was being daily flooded by recycled secondary effluent. Notice that such added water decreased CO_2 concentration to only 12.60% in the biogas, and the usual concentration would be 55% for a batch digester filled with solid wastes.

But the most interesting aspect is related to the high - concentration of nitrogen (and oxygen) gas in the biogas, in concentrations larger than CO_2. In the usual sludge/landfill biogas,generally nitrogen (and oxygen) generally is present only in trace concentrations (except if air is leaking into vacuum kept anerobic reactors,as biogas being drawn at a rate larger than produced in a landfill). Biogas like the one sampled in October 10,1984,would be considered "natural gas" (from underground deposits) because of such unusual composition,typicall of some natural gas. The biogas of such day had a very low O_2 concentration (0.01%). It is possible that the larger O_2 concentrations (1.09 % to 5.74%) is more related to problems of O_2 (air) infiltration during gas sampling (fill - of an inflatable gas holder) or during compressor running in which suction gas pipelines are under vacuum. Also some contamination may take place in the injection of biogas in the cromatograph. It is difficult to believe that any oxygen would - be left dissolved in the primary effluent (which travels through the anaerobic compartment of primary unit,and becomes "septic"),and so,that the biogas of secondary unit has more than traces of oxygen. The reason is that oxygen should be used by facultative bacteria present in primary unit and sludge bed - of secondary UASB unit.

We didn't expect so high nitrogen concentration in biogas. But a somewhat larger CH_4 concentration should be expected in the primary unit,because in the Imhoff's tank some of the raw sewage travels through the digestion chamber and so, scrub some of the primary biogas,which may have 70 to 80% methane content. About larger nitrogen concentration in a biogas,we have a mention of Karl Imhoff,of a research of FAIR, that the biogas collected in a river over a digesting sludge settled in the bottom of the river may have 69% nitrogen and 17% methane and 14% CO_2. For this,see ref.(5),pp.129 and 202.

One problem related to the high nitrogen concentration - in biogas,is: it is very difficult to remove such nitrogen, from the biogas, and so,it is very difficult to get pure methane gas from such biogas. The interest for almost pure methane gas is to power vehycles,with high pressure gas (CNG) or cryogenic liquefied gas (LNG),as is being used in several sewage treatment plants in Brazil,and which is very profitable (today,gasoline is costing over 0.50 US$/liter). Methane as gasoline substitute in sanitation,save 80% of the cost in each liter of gasoline not consumed by the use of methane.So the pay-back of the investment is just some 6 months. Nitrogen do not cause problems (up to 15%) in using biogas in stoves or in furnaces/boilers,etc,but this is not as profitable.

After we noticed so high concentration of nitrogen in - biogas,we decided to study the removal of nitrogen at its origin,which is dissolved AIR in the raw sewage to treat. One way devised to remove such dissolved AIR is to "degasify" the raw sewage,and for such,in the Bracatingas'pilot plant we installed a barometric vacuum siphon,kept running with the help of a vacuum pump,which is to remove the dissolved AIR which - become oversaturating at the reduced pressure and is stripped by the water vapor evaporating/bubbling from the sewage. We don't have the results,yet. We may have foam and smell problems.

Now,we can make a kind of transformation of the volumes of biogas in volumes of methane and in quilograms of methane and in COD quilograms converted to methane,originated from sewage treatment.This was done in Table XV,next presented.

TABLE XV. COD LOAD CONVERTED TO BIOGAS

Month	Biogas m^3 STP useful	Methane m^3 STP useful	Methane kg useful	COD of CH_4 kg useful	COD of sewage and non- " load kg/month	Useful conversion in %
08/84	2,158	1,597	1,143	4,570	41,535	11.0
09/84	2,991	2,312	1,655	6,619	29,250	22.6
10/84	3,002	2,420	1,732	6,927	22,067	31.4
11/84	4,391	3,447	2,467	9,868	32,110	30.7
12/84	4,191	3,227	2,309	9,237	23,665	39.0
01/85	4,703	3,551	2,541	10,164	18,927	53.7

Next we will try to evaluate how much methane was lost - dissolved in the secondary effluent. For this we will suppose that the secondary effluent is just "saturated" with dissolved methane,in equilibrium with the absolute partial pressure of the biogas in secondary unit and for the effluent temperature (use of Henry's law). Probably this is not true,and more methane is lost in the effluent. When we take a grab sample of the secondary effluent,before the rectangular weir (where it is aerated), a 500 ml glass cylinder sampler becomes with the internal walls covered with adhering gas bubbles and very large number of "tiny" bubbles are present in the water,and are released to atmosphere in 10 to 20 minutes when the "turbidity" of the sample improves very much. It is planned to construct a barometric vacuum siphon degasifier at such discharge pit. So none effluent will spill over the rectangular weir.

A sample computation is made for August 1984. In such month the effluent temperature was 15.79C (Table I). We would have 26.32 g CH_4/m³ for 760 mm Hg partial pressure, as dissolved methane. The local pressure is 679 mm Hg and methane is 74 % of biogas. Partial pressure of methane is 502.5mm Hg. The amount of methane dissolved at saturation is (502/760)x26.32= 17.40 g/m³. The average influent flow (or effluent flow) was 40,889 m³ (table I). The amount of methane dissolved (lost) in secondary effluent should be 40,889x17.4=711 kg, worth some 2,846 kg COD. Total methane production would have been 711+ 1,143=1,845 kg and 38% of the methane produced was lost in effluent (dissolved). Total methane would worth 7,380 kg COD gasified + 9,176 kg COD present in secondary effluent (Table VII) =16,556 kg COD removed from the treatment plant for an incoming COD load of 41,535 kg COD. The amount of COD "missing" and/or "stored" in the treatment would be 41,535-16,556=24,979 kg COD. This is just a sample computation of next Table.

TABLE XVI. TOTAL COD BALANCE OF THE TREATMENT PLANT

Month	COD of Methane produced as gas kg COD	dissolved kg COD	total kgCOD	COD of effluent sewage+non-sew. kg COD	COD "removed" (gas+effluent) kg COD
08/84	4,570	2,846	7,416	9,176	16,592
09/84	6,619	3,441	10,060	9,660	19,720
10/84	6,927	3,325	10,252	6,355	16,607
11/84	9,868	4,471	14,339	8,790	23,129
12/84	9,237	3,971	13,208	7,161	20,369
01/85	10,164	2,157	12,321	3,162	15,483

TABLE XVII. EFFICIENCY OF GASIFICATION

Month	COD influent	COD effluent	COD stored	%COD Biogasified
08/84	41,535	16,592	24,943	17.85
09/84	29,250	19,720	9,530	34.39
10/84	22,067	16,607	5,460	46.46
11/84	32,110	23,129	8,981	44.66
12/84	23,665	20,369	3,296	55.81
01/85	18,927	15,483	3,444	65.10

It appears to have a direct relationship between the con version of COD load of influent and the temperature,with the largest part of COD influent load being biogasified at the - highest temperature (January),for our data. Also the least a mount of methane is lost at higher water temperatures,and with more concentrated wastewaters. Taking into account such aspects,the ideal place of direct sewage anaerobic treatment is the tropical or equatorial (warm) parts of the world,mainly Latin America countries,Africa,Australia,etc.

It is quite possible that the anaerobic treatment will - produce very little excess sludge (COD storage),as is shown - in Table XVII.If we exclude the data for August (as it envolved non representative grab samples,instead of composite proportional flow samples), we have that only 24.4% of the influent COD load was stored as "excess sludge". But also it is - true that some "excess sludge" was removed with the effluent, as evident in the large SS concentration in the effluent.In any way,one advantage is that the excess sludge is already stable and having a low BOD load in it (difficult to degrade material),and is easy to drain/dry,and is concentrated and easy to pump away and to spread on agricultural land,etc.

The discussion about the sludge is the last one related to the plant of Pirai do Sul.

One important feature for an anaerobic sludge is the sludge specific activity (related to the concentration of active anaerobic bacteria) and the concentration and settleability of such sludge (which determines the sludge retention and the OVLR-Organic Volumetric Loading Rate which can be imposed).We did a research (6), in which we took a sample from the sludge bed of the secondary UASB unit. Such sludge,from the bottom of the UASB unit,had 10,475 mg/L Volatile Suspended Solids - (filtered volatile residue),and was sampled in Dec.1984. We reproduced,somewhat,the procedures of Valcke-Verstaete (7) - and Guillermo Parra (8) for the determination of methanogenic activity,but at the digestion temperature of 37ºC because such was to be the operative temperature of an UASB type digester to treat an industrial wastewater (from a very large orange juice processing industry) and to use the sludge from the plant Pirai do Sul as seed sludge. We would like to know if - such diluted type of wastewater could be treated and what activity the sludge would have. Also we made use of acetic acid as substrate and a blend of acetic+propionic+butiric acids as a substrate in the batch tests of anaerobic digestion. The - conclusion is that the sludge from the secondary unit of Pirai had a methanogenic activity (total) of 1.0 to 1.1 g COD/gSSV.d

It is interesting to mention that some crushed granular sludge (from an UASB reactor treating dairy wastewater) was added some months before such test. We noticed that most of the very large (up to 3 to 4 mm diameter) granular sludge particles were present in a small pit at the very center and under the bottom of secondary unit, where the influent is distributed to several pipes which feed 12 difusers. Such pit works as an upflow reactor with a large flow velocity (and so, very large pressure selection). The sludge bed do not have, yet, a typical granular sludge. Flocs or granules are fragile, yet. Addition of molasses to the influent of secondary unit was done in the attempt to stimulate granulation.

Sludge from the very bottom of secondary unit, in 01-14 of 1985, had COD=10.34g/L; BOD_5=6.48g/L; Org.N=374.8mg/L; NH_4-N=88.0mg/L; NO_2=.08mg/L; NO_3=.1mg/L; pH=7.1; Settleable solids=450. mL/L; Cl=27.7mg/L; Total solids=32.56g/L; Alkalinity=335.6mg/L.

In such day, sludge from 1 m above the bottom of secondary unit, had COD=9.83 g/L; BOD5=.87g/L; Org.N=10.7mg/L; NH_4-N=64.5 mg/L; NO_2=.5mg/L; NO_3=.1mg/L; PO_4=1.0mg/L; pH=7.2; Settleable solids=350.mL/L(30 minutes); Cl=22.4mg/L; Total solids=12.03g/L; Alkalinity=440.0 mg/L. From the same point (1 m over bottom) we took another sample in Jan.22,85 and we got: COD=159.6g/L(total) and COD=.191g/L(filtrate); pH=7.0; Alkalinity=486.3mg/L, and settleable solids=28.0 mL/L.

Again, another sample was taken from bottom to surface of secondary unit in Jan.30,85, and results are in Table XVIII.

TABLE XVIII. SLUDGE PROFILE IN THE SECONDARY UASB UNIT

paramater	prim.efl. composite mg/L	4m deep bottom mg/L	3m deep active bed mg/L	2m deep blanket mg/L	1m deep mg/L	sec.efl. composite mg/L
COD total	112	71,400	32,800	2,085	324	11
COD filt.	-	365	187	114	49	-
Susp.Solid	72	-	-	236	300	52
Setl.Solid	.3mL/L	920mL/L	750mL/L	5.0	7.0	0.0
pH	7.0	7.7	7.4	6.5	7.0	-
Alkalinity	175.4	380.4	287.6	212.4	206.3	-
Total Solid	324	52,354.	40,062.	527	620	261
BOD_5 total	81	-	-	-	-	3

Probably the sludge bed is some 1.5m thick (dense) and is covered by a sludge blanket, less dense, but also active in anaerobic bacteria,which probably are "dispersed" (not making - large flocs or granules),and responsible for a quite large - soluble COD removal. When we have a flow shock load such bacteria of sludge blanket is removed as suspended solids in effluent,deteriorating also the COD and BOD removal efficiency.

One sample from 3m deep,diluted with 50% water,was mixed as a "sludge material" in a 1,000 L glass cylinder of 36 cm - height with liquid. Let to rest, in 1 minute the sludge-clear supernatant interface was at 950mL. With 2 minutes settling, the interface was at 900mL. With 5 minutes,at 290mL,and with 10 minutes at 228 mL,and with 15 minutes 208 ML. During the period of 2 to 5 minutes settling,the interface settled at - the velocity of 4.4 m/hour or 105. m/day. This is a quite nice settling sludge. In other tests with the settling characteristics of the sludge bed, it has been found a settling velocity up to 9.9 m/hour for anaerobic sludge,of sludge BED.

One sample from the very bottom of primary unit,taken with the help of the pumping station,in January 30,1985,showed a sludge yet smelling molasses (sugar),and with Total solids 29,057 mg/L;COD=55,300 mg/L (total) a SCOD=14,715mg/L(filtrate);pH=4.2;Alkalinity=278mg/L;Settleable solids=350 mL/L.This was one reason to start to recycle primary sludge from the - bottom of primary unit to the influent of the primary unit(to remove grit from the sludge) and to recycle secondary effluent to the bottom of primary unit making it work as an UASB - reactor and so,creating a better sludge-food contact.

Other sample of sludge from the very bottom of primary unit,took in November 1984,showed COD=202,800 mg/L,BOD_5=67,600 mg/L and pH=6.1. This is a quite "thick" sludge. The primary sludge that was transfered in late June 1984 to over the bottom of secondary unit, to increase the depth of the sludge - bed, had a total solids concentration of 84,249 mg/L. At such time the concentration of total solids in the sludge in the - bottom of secondary unit was only 18,698 mg/L. As we can see in Table XVIII such concentration increased very much (3 times)

SOME RESULTS OF THE PILOT PLANT AT THE CATHOLIC UNIVERSITY

For sure this report is already very lengthy,and already there is a detailed report (9) available about such pilot - plant, and updated up to December 1984. Here only domestic sewage have been treated. Domestic sewage has an average 308 mg/L Total Solids content, and 194 mg/L Volatile Solids content (63% of TS),and 246 mg/L COD and 130 mg/L BOD_5. Other pa rameters of interest: SS=158mg/L;VSS=111 mg/L;Set.Solids=5.7 mL/L;Alkalinity=112 mg/L;Organic N=7.8mg/L;NH_4-N=13mg/L.

In the last 6 months the first reactor (true two-story septic Imhoff tank) has worked as an Imhoff tank and the second reactor has worked as an UASB unit.

The primary unit (Imhoff tank type) has about 35% COD - reduction with a detention time of .56 hours in the settling compartment. Digester compartment has vertical walls, perpendicular to the settling compartment, to avoid raw sewage travelling in the digester compartment. The average biogas production, as collected and measured, is about 50 liters of biogas per kg COD removed or 96 liters of biogas per kg of Volatile suspended solids removed. Biogas has about 75% methane, with only 1 to 5% (mean 3%) CO_2, some 20% nitrogen and about 2% oxygen. The primary unit was treating a flow of 3.0 to 3.4 liters/second (constant flow). Influent COD was 246 mg/L and VSS was 111 mg/L. Plant is treating a load equivalent to some 1,500 inhabitants and biogas production is very small: 0.67 L/inhabitant x day (mean) up to 1.18 L/inhab.day (maximum). It appears that the PVC inflatable gas holders are badly leaking.

The secondary unit, also an Imhoff type tank without compartimentalization in the digestion compartment, started to - work as an UASB unit in June 12,1984. Before this it was working as a settler-digester for the effluent of a high-rate - trickling filter, trying to digester the "slimes". Active anaerobic sludge was so little, that sludge from septic tanks was introduced in the unit to make the sludge bed (as in Pirai do Sul). Gas holders are also badly leaking. Because of this the biogas collected is very little, of only 42 liters per kg COD removed or 0.28 liter biogas/inhabitant x day (mean). Biogas has only 30% methane (as mean), going from 20 to 44%. Very little (1 to 2%) is CO_2. Nitrogen is in high concentration (some 50 to 60%, typically) in biogas. Also oxygen concentration is somewhat high (up to 23%, down to 1.8%, mean 5 to 8%). Efficiency of COD removal is about 40% with an hydraulic detention time of 6 hours (some 4 m^3/m^3 digester per day).

It is planned that both units, primary and secondary, will work as UASB type units, starting in this time.

The secondary UASB unit is working now with 3.5 L/second. One great advantage of this plant in relation to Pirai do Sul or Bracatingas is that the influent flow to the plant can be changed at will (changing the influent pump and by-passing some of the flow). The original design flow was 1.16 L/Second. Also here it is necessary a reasonable supply of concentrated wastewater (like molasses,stillage,etc) to increase the orga nic volumetric loading rate without increasing the hydraulic loading rate (detention time). The upflow unit is now working with a surface upflow velocity of 1.2 to 2.6 m^3/m^2.day.

Both primary and secondary anaerobic sludge have a settling velocity (at interface sludge-supernatant) of 1.4 m/hour, for a sludge concentration of 24,313 mg/L total solids - for primary and 31,839 mg/L total solids for secondary unit.

Sludge methanogenic activity (total) for the secondary unit was made during the experiments with the sludge of the secondary unit of Pirai do Sul. The sludge from the bottom - of the UASB unit of the Catholic University had a total methanogenic activity of .1 to .2 kg COD/gVSS.day,which is very - small in relation to the methanogenic activity of the sludge of Pirai do Sul (1.0 kg COD/gVSS.day),both at 37ºC temperature,as presented in a report (6) .Sludge of UASB unit of Catholic University (ISAM) had 6.338 g Volatile suspended solids per liter,in the samples used in the experiment (meth.activ.)

It is interesting to notice that the secondary UASB unit of Catholic University (ISAM) is with a very high efficiency of SS removal (90%) for a reasonable efficiency of COD removal (40%),both for 7.1 hours hydraulic detention time. This is a very good result in relation to what we had in Pirai do Sul. Secondary effluent is very "clear" (little color and little turbidity),as clean water. But the surface of the secondary unit,open to the sun light,is very large,and it works as an algae pond. There is a lot of Daphnia predating algae.Also this may explain the COD removal,partly.It needs more study.

Also here there is no smell problems around the plant.

SOME RESULTS OF THE "RALF-UASB TYPE PROCESS"

In year 1980 it started the construction of quite large (few hundred to several thousand inhabitants) collective neighborhoods for middle class and poor class people in the middle or nearby large towns. The State Environmental Water Pollution Control Agency (SURHEMA) required some treatment for - the sewage of such large neighborhoods,and it was decide that SANEPAR was to construct and operate the sewerage and the sewage treatment plant. For most of such neighborhoods there - was no place to construct a pond (aerated or facultative) as a treatment plant,or the land was too expensive or the pond - should have to be located very far away. And most of the towns itself had no sewage treatment and little sewerage system.

At first it was required a kind of secondary treatment level for such plants. Utilization of "compact" aerobic treatment plants appeared to be out of question because of investment costs and operational costs (it was difficult to keep in operation even an aerated lagoon in Paranavai). Also it was required to disinfect the effluent. The idea,to solve such situation, was the utilization of a "compact" anaerobic treatment process. Imhoff tank would not suffice and was expensive.

The solution,which started to be constructed in early of 1981,was the utilization of septic tanks followed by anaerobic filter. In this way,we reasoned we could have good efficiency treatment with little problems with filter clogging. In fact, such arrangement proved to be very efficient for COD, BOD and SS removal,but soon started the problems of filter clogging. In the first design the anaerobic filters had not a bottom discharge drain, to empt the filter and to try to "wash" or "backwash" the stones of the filter media. Several plants were adapted for such discharge system,which was incorporated in all new designs. But even in this way, problems continue, as generally people "forget" about the operation of the plant, mainly about the discharge of excess sludge from the septic tank (made to the river,in rainny days) to avoid carry over of sludge to clogg the anaerobic filter media. It appears such problem will happen also in case we exchange the "usual septic tank" by the UASB type (or RALF) reactors,as is being studied as solution for SS post-treatment in Cali (10). Also the sludge drained from the anaerobic filter was discharged in the river with the effluent,from time to time,in some existing plants of SANEPAR. It was noticed,by the operators, the producion of a combustible biogas in the anaerobic filter,and some "flares" were improvised for demonstration (in Ponta Grossa). None of such biogas was analysed for composition. In none place we had complaints about smells. The disinfection system,with hypochlorite solution,proved to be unoperative,also. Probably some 20 to 30 such type of plants (septic tank followed by anaerobic filter) have been constructed across the State of Parana,from warmer places to cold places,as the town of Palmas,where every wintertime is snowy some days. For such town I collected one sample,in September 27,1984 and influent was at 15.8ºC (1:40 PM).Final effluent was at 16.6ºC(1:45 PM). Raw sewage had:Total solid=337mg/L;COD=338mg/L;pH=7.4;alkalinity=289.2mg/L;Chloride=51.6mg/L. Final effluent had:Total solids=148 mg/L;COD= 9 mg/L; pH=6.9;Alkalinity=102.5mg/L. It is a quite nice effluent. Unhappilly little data are available a bout such anaerobic treatment process used at up some 1 or 2 thousand inhabitants neighborhoods, because they are not considered a "regular" sewage treatment plant.

Just to give an idea of how such units of anaerobic treatment were constructed, we will mention the dimensions of one plant. I intended to present the drawings, but there is no more time for such. Design was from November 1981, for one neighborhood of 54 homes (270 inhabitants) of the town of Candido de Abreu, and prepared by Eng. Luis C.Barea. Raw sewage entered the plant by gravity, and passed a bar screen 20mm free openings between bars. No grit removal. Flow entered into a 2 chamber septic tank, 9.90m long (6.5m first chamber + 3.3m second compartment) by 3.4m wide by 2.m water depth (total depth of 2.7m). Digested sludge could be removed by trucks (with vacuum or pump filling device) from the first and second compartment of the septic tank. Primary effluent, removed from 50 cm underwater, of second chamber, is introduced at the bottom of the anaerobic filter, which is a cylinder concrete tank of 4.40m diameter (internal) by 2.15m height (inside tank), being .10m free board and 2.05m water depth. Influent (primary) is introduced at the bottom, periphery, in a compartment made by a false floor .15m thick with a free distance of .3m from the bottom. Such false floor has holes of 25mm diamter spaced each 150mm (.15m), in all false floor, and over it we have a 1.20 m thick filter media made of nr.4 gravel (some 3 to 5 cm diameter), which is quite very expensive. Over the filter media we have .4m water column depth, and filter effluent is removed by a PVC pipe, 100mm diameter cut on the 25mm top part, making rectangular weir .2m long and spaced each .1m. Effluent was discharged in the disinfection contact chamber. There was a pipe, installed in the bottom of the filter, and discharging in the river, to drain the filter (and discharge sludge), and of 100mm diameter, with a valve at the end. One problem is that SANEPAR has none truck to remove liquid sludge. This makes it more difficult to "clean" the septic tanks, as generally it is not provided money for renting trucks to clean up the sludge.

Because of the problems of filter clogging, and because such anaerobic filter is quite expensive (and difficult to unclog), it was devised the utilization of an UASB type unit to treat anaerobically the raw sewage, directly. As such reactors use sludge as "filter media" (costing nothing), and appears to be clog-free, such idea was well received and detailed by Dr.Arvid Ericsson, a very long experienced sanitary engineer (over 30 years experience with domestic and industrial sewage treatment plants,including aerobic activated sludge).For such idea went on, we received a good help from Dr. Lettinga (who stressed,in letter and literature,that it was possible the "direct" anaerobic sewage treatment) and from Dr.Switzenbaum,who sent as one old and interesting paper (11),in which is discussed (in year 1911) the results of an upflow anaerobic reactor treating directly raw sewage,and having no settling compartment on it (so it was not an UASB unit,strictly) and being trunk-pyramid shapped, square at the top and 7 feet across,with a hopper with slope of about 55 degrees with the horizontal,with capacity of 1,540 gals.,and the flow period of 8.5 hours. The sewage enters through a 2 inch pipe about 9 inches from the bottom and the effluent is skimmed off at the surface by four 60-degree triangular metal weirs,placed at the corners and discharging into 2-inch channels in the walls.Scum boards protect these weirs. At the bottom of the tank is a 2 inch effluent drain for sludge. Such tank was named "biolytic" and was first put in operation in July 1909. The most important feature was mentioned in page 283,that after 8 months of use it was drained the unit to measure the volume of sludge in the reactor and to study the sludge. It was concluded that there was no obvious accumulation of sludge and the weekly analyses showed no tendency to deterioration. "In fact no accumulation of sludge was apparent by probing from the top of the tank". It presented removal of about half the suspended solids in the crude sewage,and an elimination of 72% of total solids and 81% of the volatile solids deposited by "septic" action.

With this type of information available it was constructed in the end of year 1982 the first "RALF" unit,"conical tank with upward flow for septic treatment",for a neighborhood named CAIÇARAS,in Curitiba,of some 800 inhabitants. Such plant started up in early 1983,before the plant of PIRAI DO SUL,and it was a clear sucess. None smell,whatsoever. Reasonable quality effluent. No problem with diffuser clogging (as they were having with anaerobic filters,and we had later in the diffuser system of the secondary UASB unit of Pirai do Sul),and most important,a very simple and inexpensive reactor with only 3 hours (dry weather flow,daily average) detention time.In fact,such process was expected to give only primary treatment level,as the local "EPA" (SURHEMA) relaxed the standards for the sewage treatment plants for neighborhoods. For secondary treatment purposes we are using 8 hours in plants under construction or to be constructed in Brazil.Even so,construction cost of the unit can be in the range of 3 to 5 US$/inhabitant.

A typical RALF unit is shown in Figure 9. It can be just a trunk-cone reactor (with walls slopped at 45º with horizontal) over a flat-cone bottom. In some cases we have a cylinder section in between such two parts. The whole unit can be covered by a concrete floor or can be covered by a flexible inflatable gas holder with the border imersed into a water - channel. Such gas holder,made in butyl rubber,has caused several troubles in the two largest units constructed in neighborhoods of Curitiba, one for some 13,000 inhabitants and other for some 19,000 inhabitants. Water and/or ice may pile - up over it,causing it to collapse. (There are several drains on such gasholders). Raw sewage can reach the plant by gravity (as the unit for 13,000 inhabitants) or can be pumped (as the unit for 19,000 inhabitants) and in this case there is an equalization unit to avoid a large peak flow (it is possible that this is not necessary,as the peak flow is of short duration). Next raw sewage pass through a bar screen (before the - pump station) and next to a grit chamber. Flow enters at the very bottom of the RALF unit in just one point (as in the unit for 13,000 inhabitants) or in a diffuser length which makes the inflow spread in such a way that the sludge bed is - forced to rotate (the whole unit have the water rotating),as is the case for the unit 19,000 inhabitants. One advantage of the cone shapped reactor is that it self-adjust the position of the sludge bed to the influent flow,and we have a very low upflow velocity at the water surface (0.7 to 0.8 m/hour for - the desing flow,in a half dry-wet day flow),which makes it more difficult to escape sludge. Most of biogas is produced at the very center of the unit,and toward the periphery weir lifted sludge has chance to settle down and slide back to the - sludge bed at the center. In large units there is provision - to remove,by vacuum truck,the sludge from the very bottom of the unit (to remove grit,which cause more flow to short-circuit by large density difference),but it is intended to remove the excess sludge from the top of the sludge bed,because such sludge is already digested. One great problem we have is with the removal of excess sludge by vacuum trucks,because SANEPAR (sanitation company) do not have such type of trucks,and so, it is postponed,as much as possible,the removal of sludge.For knowing when it is to remove excess sludge,it was made a cyclone unit to settle the treated effluent. When such cyclone start to fill up,it is because too much sludge is available, and needing removal. Also an Imhoff cone may suffice. Now that the large RALF units started up,we will have now the chance of by-pass some (or most) of the influent flow,and so,to study the effects of larger detention times on plant efficiency (3 hours to 24 hours,as example). Here we also will have chance of people taking care,more frequently,because in other RALF units just once or twice by week it is cleaned up the bar screen and the grit chamber. For such plants it is being taken some samples,but the results are very variable,as it was the case of Piraí do Sul (before implementing composite flow proportional sampling),mainly because they don't know how to sample. It is usual to scrape sludge from the walls during sampling,or to take large incoming solids,or to take the samples from the surface of the RALF reactor (and so,sampling the scum layer),etc. But we didn't consider in the design the problem of sampling the influent,effluent and position of the sludge bed.

One careful sampling,made by the author himself,on November 23,1984, 4:45PM,good weather conditions,gave:

TABLE XIX. RESULTS OF AN UPFLOW RALF UNIT:CAIÇARAS

parameter	influent	effluent	
Total solids mg/L	470	342	27.2%
Total volatile solids mg/L	312	228	26.9%
Suspended solids mg/L	240	164	31.7%
Susp.volatile solids mg/L	160	108	32.5%
COD (total) mg/L	365	209	42.7%
BOD_5 (total) mg/L	143	103	28.0%
Settleable solids mL/L	.8	.6	25.0%
pH	7.7	7.2	
Alkalinity mg/L $CaCO_3$	130.3	9.85	
NO_2 mg/L	0.4	0.2	
NO_3 mg/L	0.3	0.7	
Organic N mg/L	15.54	5.67	
Ammonia N mg/L	15.0	14.6	
Total N mg/L	31.24	21.1	
Phosphate PO_4 mg/L	0.7	0.5	
Chloride mg/L	38.2	38.4	

This is just a primary treatment level (as intented),in a very compact and inexpensive plant which poor neighborhoods can afford to pay (the cost of the treatment plant is included in the cost of the collective residences). Also it is surelly clog free,as the excess sludge escape with the effluent if not removed regularly,but such excess sludge is already digested (stable) sludge. Also it appears that little or none problem with smell is related to the fact that the unstable organics (smelly) are converted to stable organics before reaching contact with atmosphere on surface of the reactor. Also there is plenty of water to dissolve any H_2S and other reactive and smelly gas products (mercaptans). In any way most of the sulfates present in the wastewaters are the sulfates added in the water treatment plants (not much).

For larger plants,there is interest in collect most of the biogas produced (and to flare it,if it is smelly),and for such,it was just added a cylinder lid on the water surface of a RALF unit over the place where we expect to have more biogas production (over the sludge bed). So,in the radial flow from the border of the lid to the periphery weir,there is space for settling the sludge lifted by biogas and tranported towards the weirs,and with the settled sludge sliding back to the sludge bed. In this way we have a peripheric settling tank around and over the digestion compartment. This shape of construction appears to fully utilize the volume of the reactor for anaerobic treatment,without the dead volumes of the reactors like the one of Pirai do Sul and Catholic University. Instead of having just a cylinder lid (to collect biogas),it was designed a trunk-cone lid,and in this way we can have a small rigid gas holder (concrete lined with rubber) and a quite large settling tank with the two adjacent walls slopping to a slot of gas baffle just over the sludge bed. But such construction is more expensive (desing for new Londrina's RALF units for 55,000 inhabitants in each reactor). For large RALF units it is assumed that it is necessary to have more influent diffusers. To avoid the problems of clogging of the central pit diffuser under the bottom of the secondary UASB unit,as PIRAI DO SUL,it is being used another solution. Raw sewage is introduced (upflow) in a central pit placed over water surface and in the lid structure. In the periphery of such pit it is made several V-notch triangular weirs,each one feeding a very small pit having a pipe in it going to the bottom of the secondary RALF unit. In this way we can be sure about the good distribution of the raw sewage through the bottom of the reactor (1 each $4m^2$ bottom,now horizontal),and it is easy to unclog any influent pipe. Generally there is a bend at the end of the influent pipes to make the sludge bed rotate for a better sludge-influent contact. Also,because the reactor is cone shapped,it has a smaller bottom surface,meaning less influent pipes for feeding the unit (in relation to reactors with vertical walls,as UASB type units for industrial wastewaters),and higher turbulence in the sludge bed at the bottom (better utilization of the more active bacteria). Also the reactor is quite simple to construct,for Latin America.

Any flexible gas holder should be placed outside of the reactor of sewage anaerobic treatment for easy of maintenance.

This is the "state of the art" of domestic sewage anaerobic treatment in the State of Parana, south of Brazil,at the latitude of 22 to 27º South.

Sorry for so long and lengthy paper,which only express the personal opinions of the authors (mainly Mr.Gomes),and none endorsement is made that such are the opinions of any Entity here mentioned,or of theirs employees. We thank FIPEC and FINEP for their financial support for some of above researchs.

REFERENCES

1. Switzenbaum,M.S.,Jewell,W.J.,"Anaerobic attached-film expanded-bed reactor treatment",Journal WPCF,Vol.52,No.7,July of 1980,pp.1953-1965.
2. Gomes,C.S.,"Tratamiento de desagues con la tecnologia tipo flujo ascendente UASB,ejectuado por la Sanepar,Brasil,incluyendose la digestion solida de basura, y la produccion y utilizacion del biogas",Seminario Nacional sobre Tecnologia UASB para Aguas Residuales Domesticas e Industriais, Universidad del Valle, Cali, Colombia, Octubre 18-19,1984.108 pages and 32 figures. (Also available in English version).
3. Schellinkhout,A.,"Resultados de la Planta Piloto en Cali, Marzo 1983 - Septiembre 1984",Seminario Sobre Tratamiento Anaerobio de Aguas Residuales, Universidad del Valle,Cali,Colombia, Octubre 18 y 19 de 1984, 34 pages.
4. Switzenbaum,M.S.,et.al.,"Anaerobic Treatment of Primary Effluent",Environmental Technology Letters,November,1983,pp.18
5. Imhoff,Karl,"Manual de Tratamento de Águas Residuárias",Editora Edgard Blucher Ltda.,1966,Trad.Max Lothar Hess.
6. Gomes,C.S.,et.al.,"Teste de Determinação da Atividade Metanogênica Específica Máxima de Lodos e de Avaliação Preliminar da Tratabilidade Anaeróbia de Despejo Industrial",General Report,January 1985,ISAM-Catholic University of Parana, 62 pages.
7. Valcke-Verstraete,"A Practical Method to Estimate the Acetoclastic Methanogenic Biomass in Anaerobic Sludges",Journal WPCF,Vol.55,No.9,September 1983,pp.1191-1195.

8. Parra,G.R.,"Determination de la Actividad Metanica de un Inoculo por Medio de Reactores Batch", I Taller Nacional Sobre Tecnologia Anaerobia para Aguas Residuales, Universidad del Valle, Cali, Colombia,Octubre 17/1984,pp.16.
9. Aisse,M.M.,Zeny,A.S.,"Estudo Técnico dos Biodigestores - Anaeróbios Alternativos - Relatório Final - Dezembro 1984" ISAM-Instituto de Saneamento Ambiental da Universidade Catolica do Parana.
10. Wildschut,L.R.,et.al.,"Postratamiento del Efluente de un Reactor UASB Tratando Desechos Domesticos",Seminario Nacional sobre Tecnología UASB para Aguas Residuales Domesticas e Industriales",Universidad del Valle,Cali,Colombia, Octubre 18-19 de 1984.12 pages. (see pages 6,7 and 11).
11. Winslow,C.E.A.,Phelps,E.B.,"Investigations on the Purification of Boston Sewage", The Journal of Infectious Diseases, Vol. 8, No.3, April 12,1911, pp.259-288 (page 280).

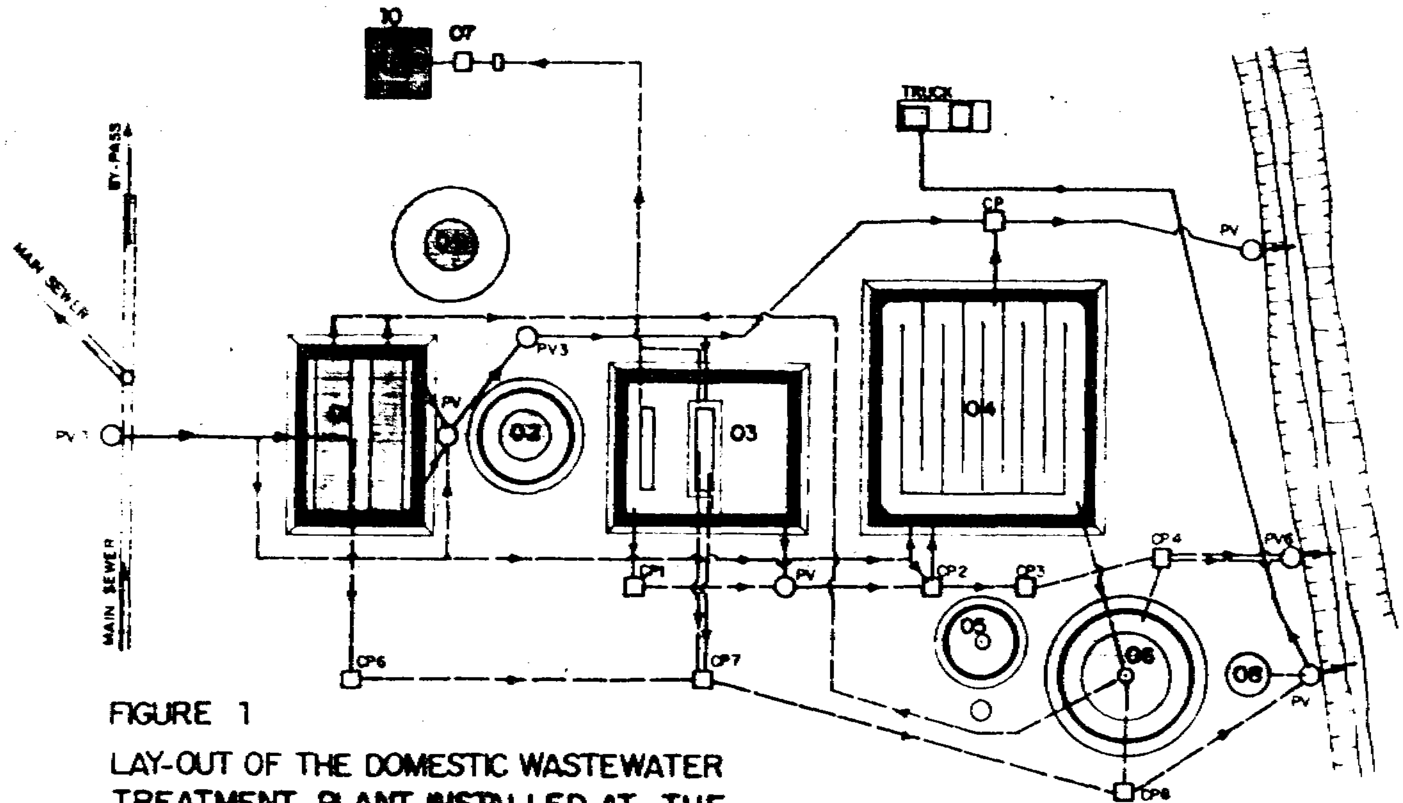


FIGURE 1

LAY-OUT OF THE DOMESTIC WASTEWATER TREATMENT PLANT INSTALLED AT THE "CAMPUS" OF THE CATHOLIC UNIVERSITY

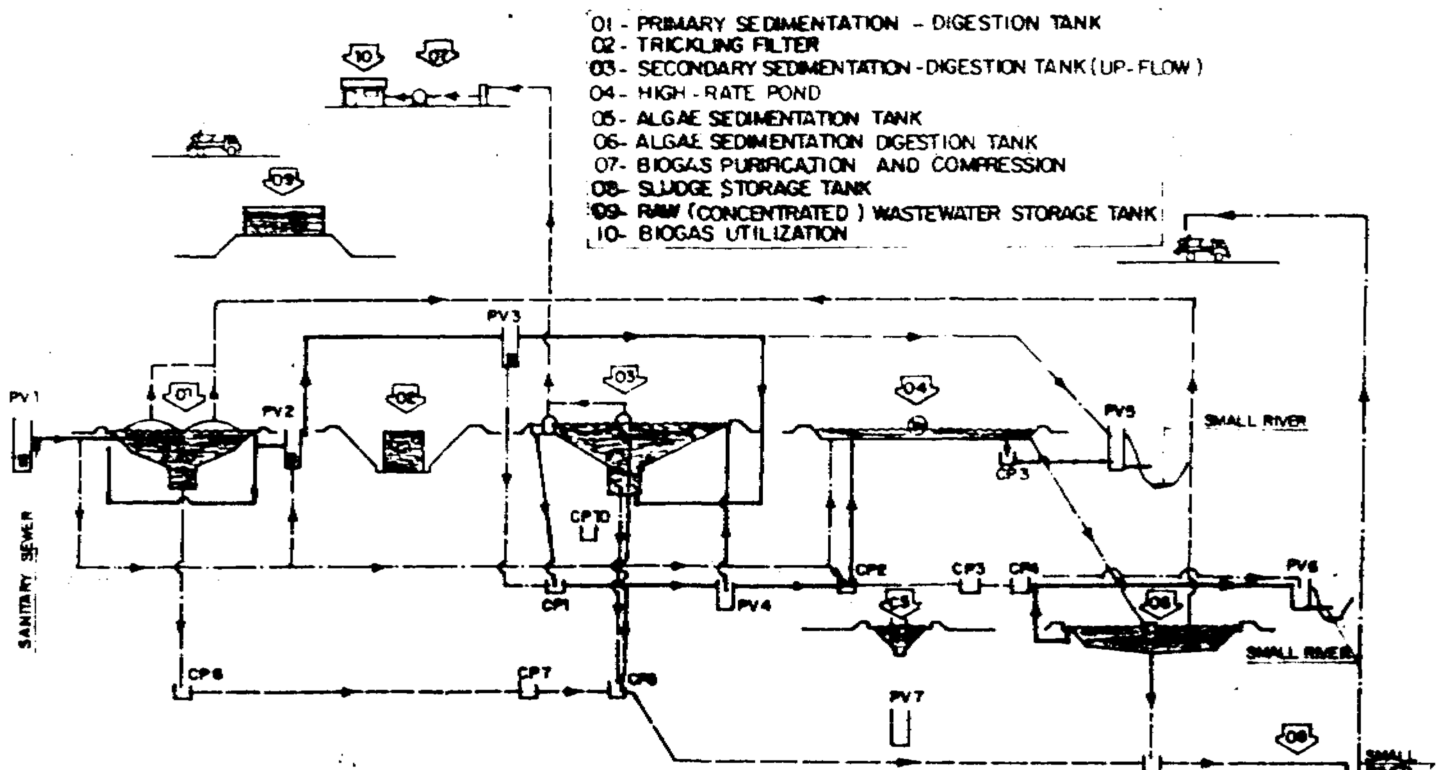


FIGURE 2
LAY-OUT OF THE DOMESTIC WASTEWATER
TREATMENT PLANT INSTALLED AT THE "CAMPUS" OF THE CATHOLIC UNIVERSITY

o

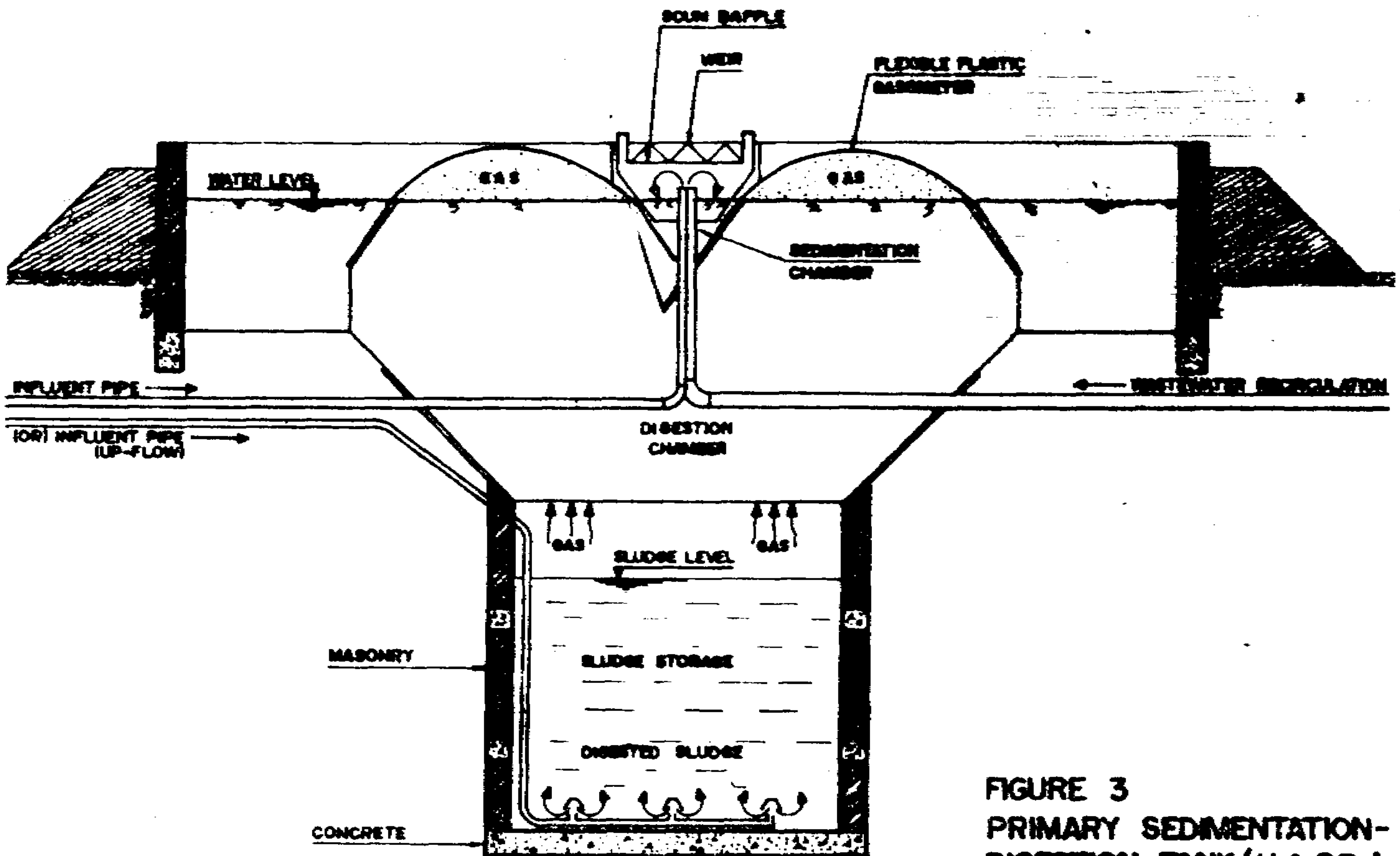


FIGURE 3
PRIMARY SEDIMENTATION-DIGESTION TANK (U.A.S.B.)

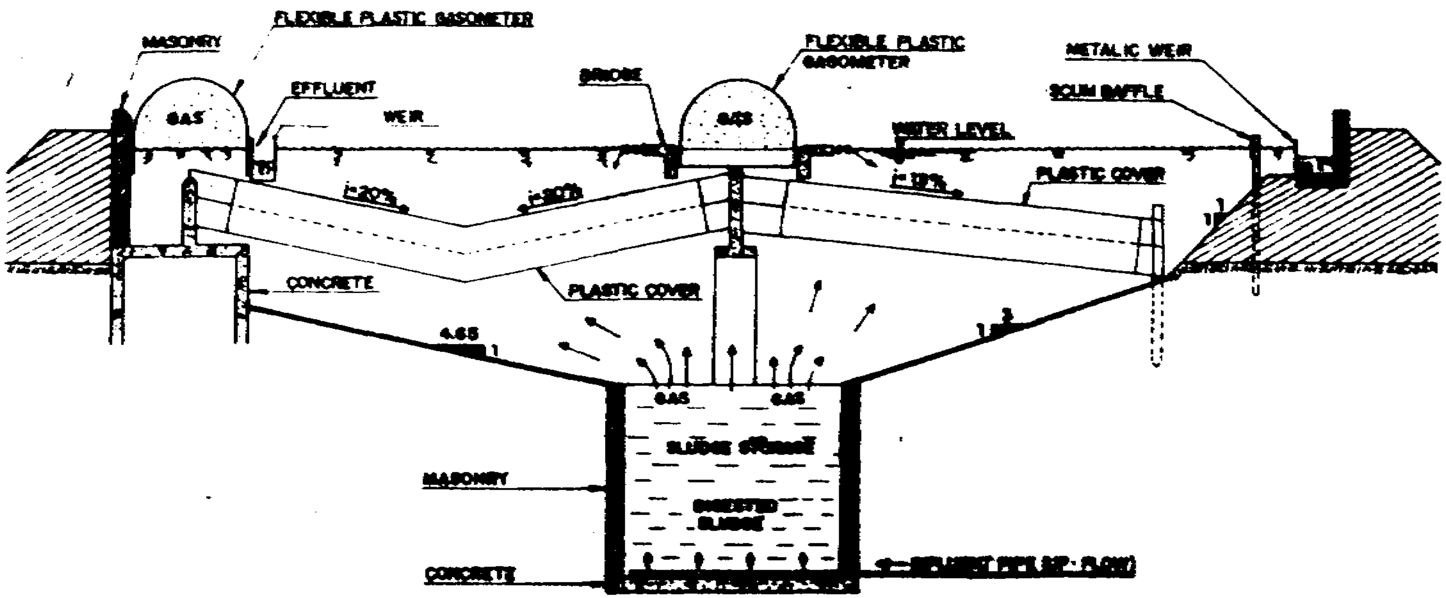
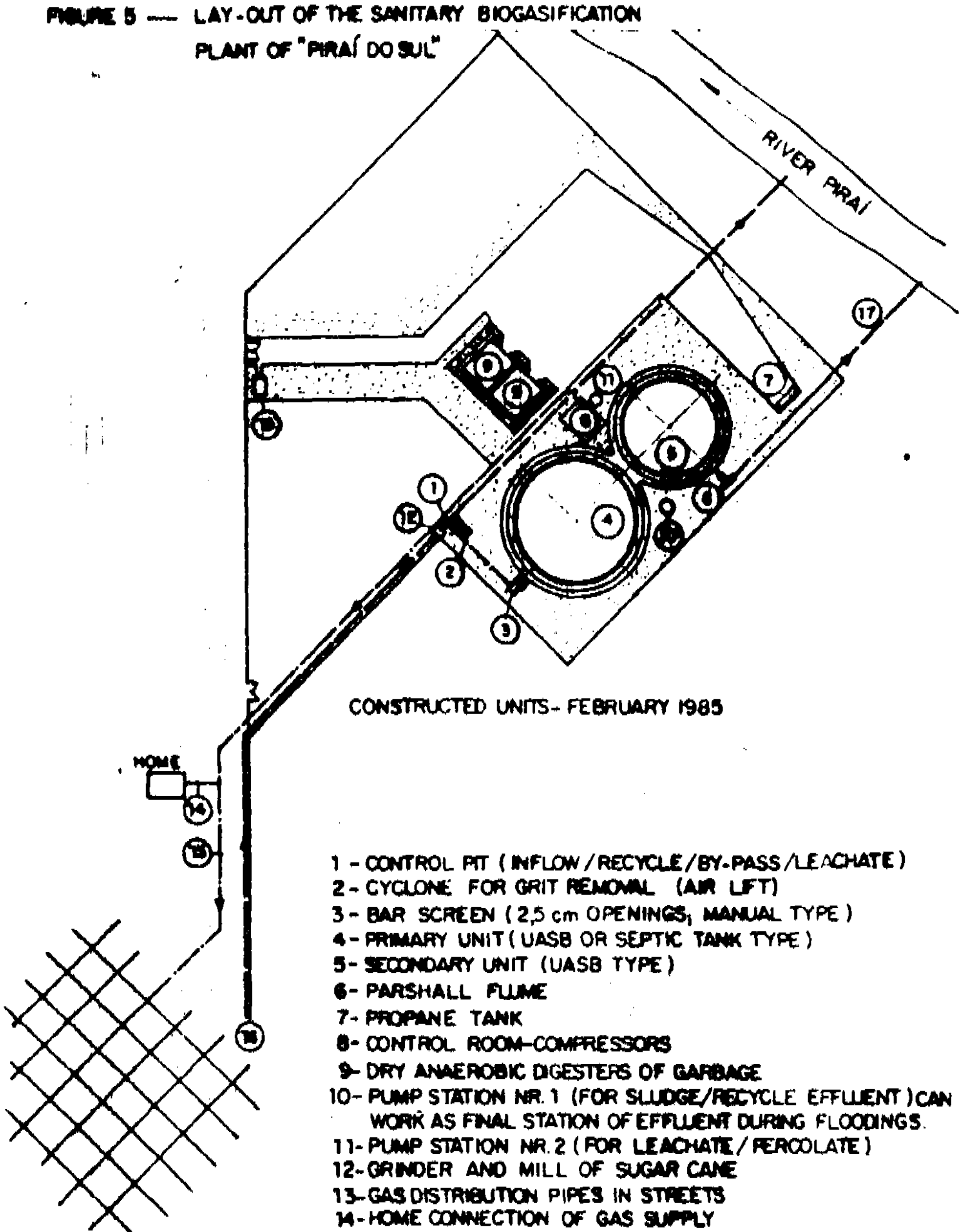


FIGURE 4

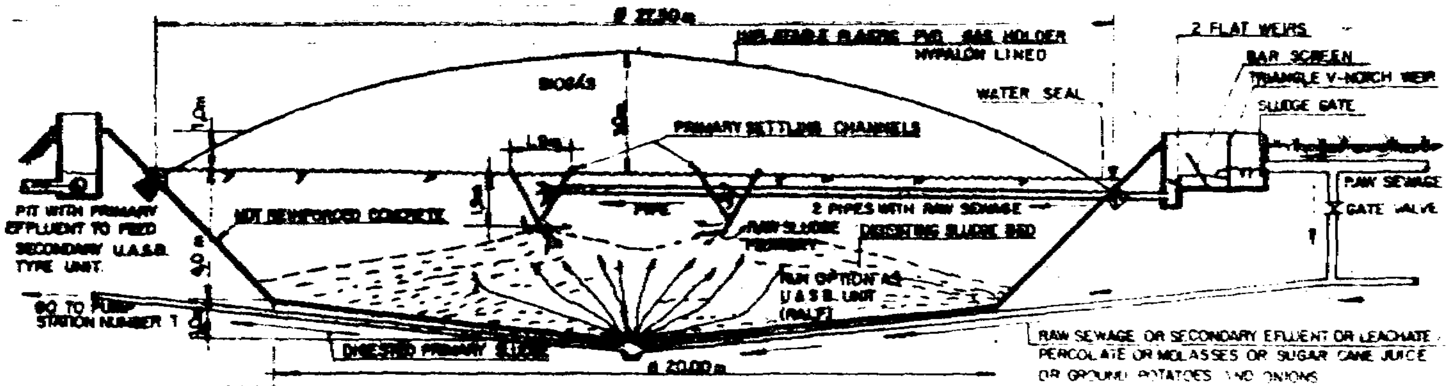
SECONDARY SEDIMENTATION-DIGESTION TANK (OR U.A.S.B.)

FIGURE 5 — LAY-OUT OF THE SANITARY BIOGASIFICATION PLANT OF "PIRAÍ DO SUL"



1 - CONTROL PIT (INFLOW / RECYCLE / BY-PASS / LEACHATE)
2 - CYCLONE FOR GRIT REMOVAL (AIR LIFT)
3 - BAR SCREEN (2,5 cm OPENINGS; MANUAL TYPE)
4 - PRIMARY UNIT (UASB OR SEPTIC TANK TYPE)
5 - SECONDARY UNIT (UASB TYPE)
6 - PARSHALL FLUME
7 - PROPANE TANK
8 - CONTROL ROOM-COMPRESSORS
9 - DRY ANAEROBIC DIGESTERS OF GARBAGE
10 - PUMP STATION NR. 1 (FOR SLUDGE/RECYCLE EFFLUENT) CAN WORK AS FINAL STATION OF EFFLUENT DURING FLOODINGS.
11 - PUMP STATION NR. 2 (FOR LEACHATE / PERCOLATE)
12 - GRINDER AND MILL OF SUGAR CANE
13 - GAS DISTRIBUTION PIPES IN STREETS
14 - HOME CONNECTION OF GAS SUPPLY
15 - SAFETY BUILDING
16 - MAIN SEWER WITH RAW SEWAGE
17 - GRAVITY MAIN TO DISCHARGE SENCONDARY EFFLUENT

FIGURE 6 — CROSS-SECTION OF THE PRIMARY UNIT



— CROSS-SECTION OF SECONDARY U.A.S.B. TYPE UNIT.

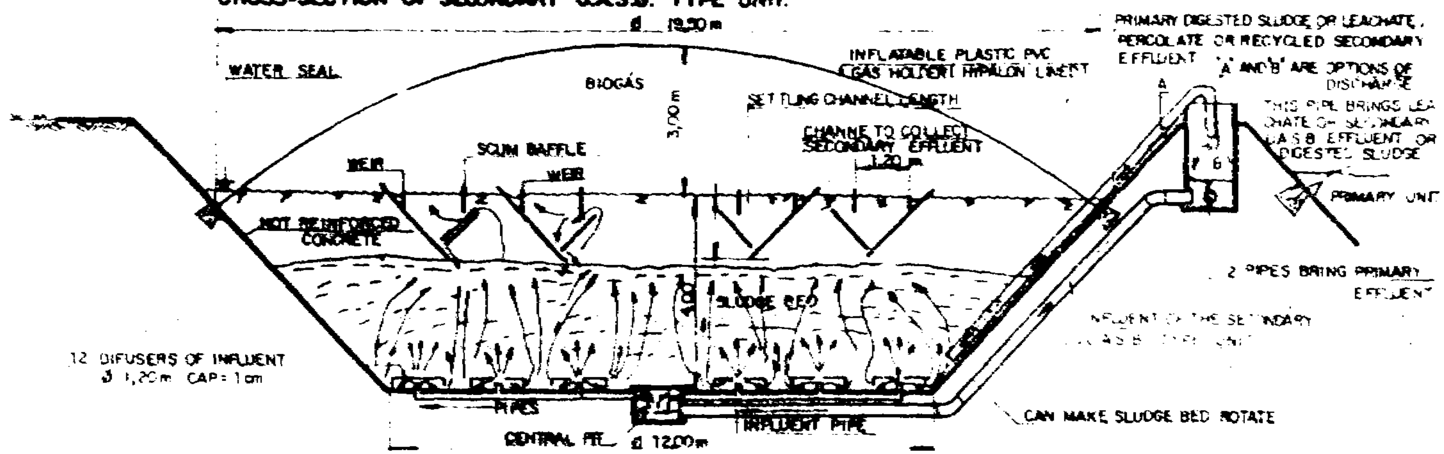
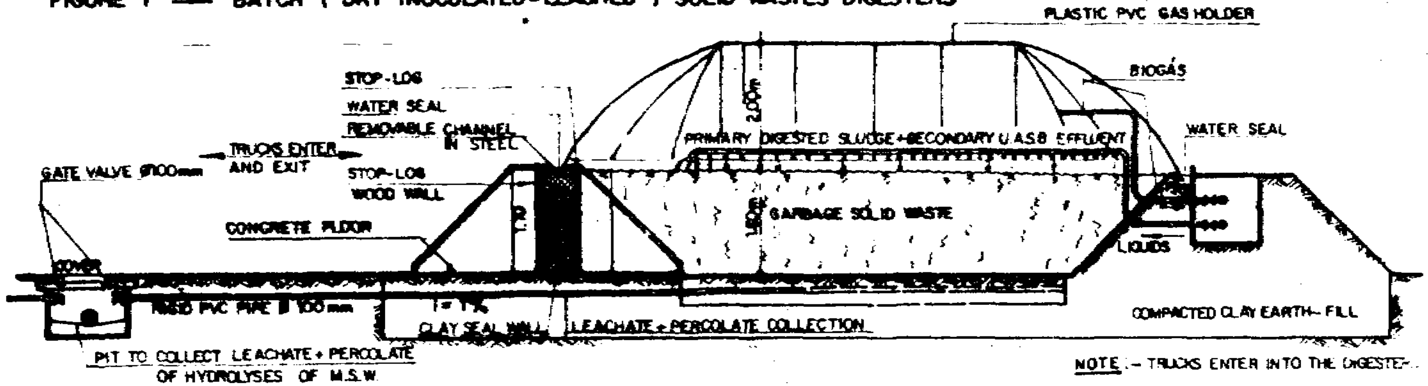
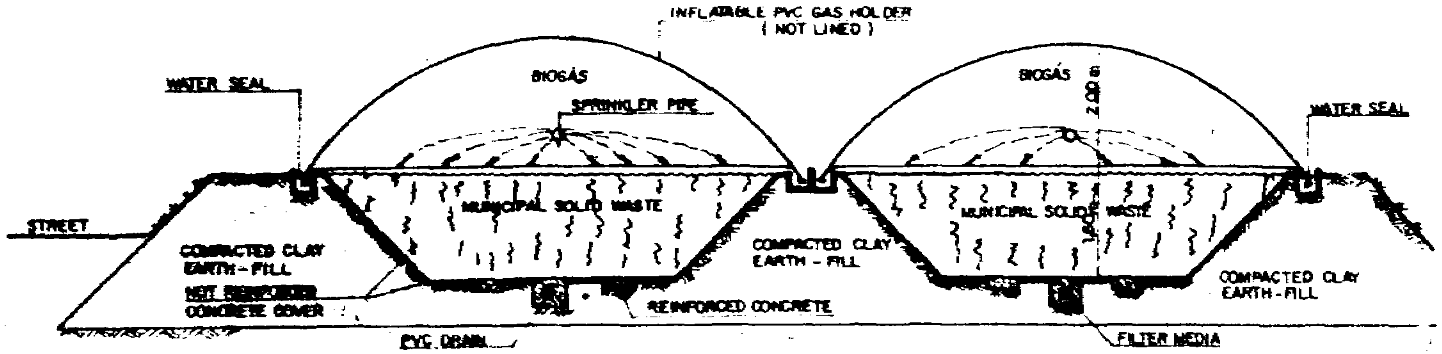


FIGURE 7 —— BATCH ("DRY INOCULATED-LEACHED") SOLID WASTES DIGESTERS



LOGITUDINAL CROSS-SECTION OF DRY DIGESTERS



TRANSVERSAL CROSS-SECTION OF DRY DIGESTERS OF SOLID WASTES

FIGURE 8 — FLOW CHART FOR THE BIOGASIFICATION PLANT

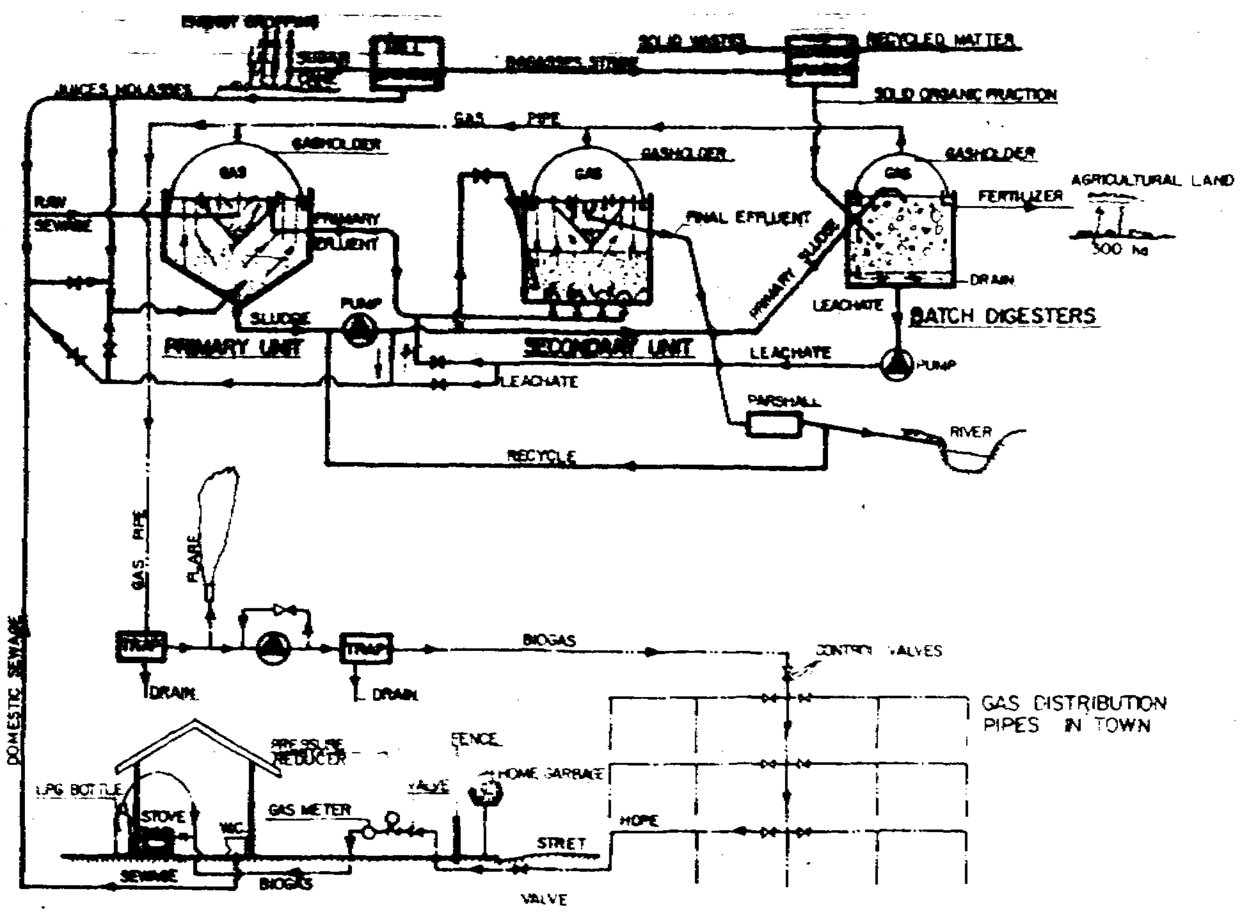


FIGURE 9 —— DESIGN OF A "RALF" REACTOR