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THE PROCESSING OF SEWAGE BY ROTATING BIOCHEMICAL FILTER (BIO-DISC)

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In a paper dated 12 September 1972, dealing with "Technical Aspects of Water Pollution Abatement in the ECAFE Region", prepared for the Tenth Regional Conference on Water Resources Development (Manila, 18-25 September, 1972), the United Nations Economic and Social Council gives a full list of the various recommended ways of processing wastewater in tropical climates.

Special mention is made of the rotating biochemical filter (bio-disc) system, well known for a number of years now in Europe, and especially in Germany, but still virtually unknown in the Pacific.

The document has the following comments to offer on this system: "A relatively new organic waste-treatment device is being adapted for use in tropical countries because of its low capital cost and ease of operation. This process is a cross between activated sludge and biological filtration and has been given the name "biological disc filtration". For tropical application, the unit is comprised of an upper aerobic compartment, in which partially submerged discs continuously rotate, and a lower anaerobic compartment to receive solids. Very high BOD removal efficiencies have been obtained at organic loading levels higher than conventional activated sludge. The advantage of the process for small industry is that it is not sensitive to fluctuations in waste flow or quality, the way activated sludge is, and can be used to treat fairly concentrated wastes. No costly imported equipment is necessary and construction is simple. Small communities can also use the process because it can be installed in minimum space and operated by unskilled labour."

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I. BASIC PRINCIPLE

The basic idea is to grow bacteria on a mobile surface, alternately immersed in the water to be purified and exposed to the open air.

II. MECHANICS OF THE SYSTEM

Bacteria are grown on a series of plastic discs, 6 ft.8 inches to 10 ft. in diameter, depending on the capacity of the plant. Each such disc represents a unit of surface area.

The discs are mounted side-by-side on a horizontal shaft at intervals of roughly four-fifths of an inch. The whole system is laterally braced by struts attached to the end of the shaft and by transverse ribs, so a as to form a rigid drum, turned slowly (at 2 r.p.m.) by a motor plus reduction gear.

A clock can be set to ensure that the drum turns, either throughout the twenty-four hours, or for 22 hours, 20 hours, or 18 hours.

The usual life of the drum is roughly thirty years, and that of the reduction gear 10 years.

III. BIOLOGICAL PROCESSES

The drum turns slowly in a flat-bottomed vat or tank through which the wastewater passes.

Micro-organisms very soon begin to grow on the discs, absorbing atmospheric oxygen when that part of the disc to which they adhere is exposed to the air, and feeding on organic matter in the tank when submerged.

The higher the organic load, the thicker will be the growth, to a maximum of about one-fifth of an inch. The micro-organisms passed through the water in the tank are thus subjected to a permanent rinsing process, and continue to live in the water as though in an oxidation pond.

Beyond a maximum concentration of 50%, the floc is eliminated in the natural way by the rotation of the discs, and expelled through the outlet pipe.

Intercellular transformations take place on the discs; the appropriate enzymes absorb the organic matter close to them. In surroundings rich in O_2, the porous cells absorb waste matter together with the by-products of the transformation.

While intercellular transformation is taking place within the bacteria, a part of the carbon absorbed, and part of the phosphorous substances and organic matter, together with part of the substances produced by the bacteria themselves, are used to form new cells.

The remaining carbon absorbed by the cell is oxidized by atmospheric oxygen which is also absorbed. The carbon dioxide thus formed regenerates the cell and renders possible a further exchange. Such carbon dioxide as is not dissolved in the form of a carbonate disappears as gas.

Nitrogen not used to form new cells may be oxidized in the form of nitrates, such oxidation being connected with the formation of magnesium and calcium from carbonates and bicarbonates.

During aerobic biological purification, the cells absorb and assimilate enough oxygen to transform impurities in the wastewater into minerals (which can be filtered out) and new cells (which will form a floc or attach themselves to the film of living micro-organisms on the discs). The speed of purification will depend on the oxygen-content of the medium and the volume of matter to be assimilated.

IV. DIMENSIONS REQUIRED

The amount of waste treated is directly proportional to the surface area of the discs. A normal figure is 10.8 to 21.6 ft^2 per person, depending on the size of the station and the degree of purity to be achieved.

For instance, one particular station designed to cater for 9,500 persons has the following characteristics:

Volume of primary separator:	2,470 ft^3 (70 m^3)
Volume of secondary separator:	3.883 ft^3 (110 m^3)
Total disc surface:	112,320 ft^2 (10,400 m^2)
Rotation speed:	2 r.p.m.
Sludge storage tank	12,000 ft^3 (340 m^3)
Drying beds:	2,160 ft^2 (200 m^2)

The station, on very flat land, has two Archimeses' screws, one of which can handle 15-35 litres per second and the other 60-90.

The total area covered by the station is 37,450 ft^2 (3,500 m^2), just on the edge of the watercourse into which the effluent is ultimately to be poured.

V. ADVANTAGES OFFERED BY A PLANT OF THIS KIND IN THE TROPICS

Apart from the fact that the plant takes up so little land, there are other reasons which make it very suitable for the tropical areas of the South Pacific, to wit:

- Very little motive power is required: between 2 and 4 Kw/h a year;
- Because the drum rotates so slowly (2 r.p.m.), it requires renewal only every thirty years or so;
- The system works exceedingly well in high temperatures (+ 40°C without noisome odours);
- No reduction in head needed between intake and outlet (so that the system is very suitable for flat, low-lying islands);
- In the event of high peak loads, or if chemicals, oils, detergents and the like, introduced into the effluent, impose anaerobiosis, the micro-organisms begin to grow again in the normal way as soon as these substances have been got rid of. Contrary to what happens with activated-sludge plants, no fresh inoculation is required. Hence neither supervision nor special precautions are needed;
- The plant is very simple to run, in fact it virtually runs itself. There is no need for measurement of sludge-content.
- The outcome is fully in accordance with health regulations, and peak pollution loads are readily absorbed.

Another point of interest to the tropical countries - a storm, accompanied by a torrential rain, will not wash the micro-culture off the discs. The culture, remaining as it does on the discs, starts developing again as soon as things return to normal.

The plant may from time to time stop working, either momentarily or for longer periods, because of staff unreliability or because, in the island territories, the electric power supply is not always very dependable. If the stoppage is brief, biological development will start again at once. Should it be longer, development will start again ten to fifteen hours afterwards, without any need for human intervention.

VI. COST/BENEFIT EVALUATION

In Europe, satisfactory results have been obtained with plants of this kind. The overall results of a survey undertaken in the Rhine-Meuse area of France give the following reduction percentages:

- Matter in suspension, total 87%
- BOD_5 93%
- COD 81%

In Europe, the capital cost amounts to some 20 U.S. dollars per inhabitant (for a plant catering for between 2,000 and 10,000 people).

It is not easy to estimate the results, the investments required and the operating costs in the South Pacific, but there is no reason why the process should not be as attractive as in Europe, providing suitable adaptations are made. What kind of adaptations will be required will of course depend on the outcome of trials with a few pilot plants.

VII. CONCLUSION

For technical and economic reasons, but for human reasons too, the South Pacific islands should have no difficulty in adopting modern processes or processes recently re-discovered.

The means used for combatting pollution should be devised with an eye to local ecological conditions. Hence, in the developing countries, it will be normal to use processes which are simple to operate and demand little in the way of imported equipment.

An attempt will be made to adopt methods combining high efficiency with strict economy.

Hence in the Pacific the choice will increasingly lie between two different ways of treating sewage (industrial waste, be it remembered, is a very different matter).

- In territories where land is plentiful but staff and equipment are none too easy to come by, recourse will be had to:
  - Oxidation ponds (as in Melbourne, Auckland, Port Moresby, etc.);
  - Oxidation pits and channels (Pasveer system), as in Fiji;
  - Digesters and algae ponds from which methane can be recovered. From the algae, a substance containing 50% protein can be obtained and used instead of flour meal for the feeding of poultry, cattle, sheep and pigs.
- In territories where there is very little land, but average resources in the way of capital and skilled personnel:
  - All sewage-treatment plants could make use of large aeration basins for total oxidation; and
  - Use could be made of biodiscs.

Whatever be the process chosen, it will put an end to the uncontrolled proliferation of individual purification systems (still, unhappily, all too characteristic of the islands), thus simplifying the achievement of that overall control which is so important if the battle against pollution is to be effectively waged.

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1 Economic Commission for Asia and the Far East

NOTE

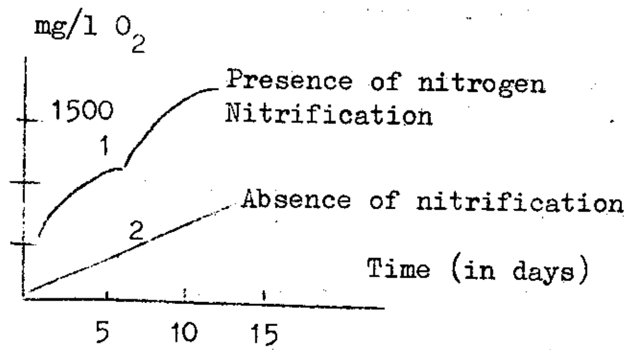
The following definitions of terms used in this circular may prove useful to the layman:

BOD and BOD_5

The biochemical oxygen demand (BOD) is the amount of oxygen (in mg/l) consumed under test conditions (incubation at 20°C and in darkness) during a given time, to ensure the biological oxidation of the biodegradable organic matter present in the wastewater.

To be complete, biological oxidation requires from 21 to 28 days, the final BOD then being expressed as BOD_{21} or BOD_{28}.

The curves showing oxygen consumption against time are as in the following graph:



Curve 1 was obtained with water containing carbonaceous and nitrogenous products. It will be observed that the carbonaceous products are oxidized first. The oxidation of nitrogenous products, which follows, leads to the phenomenon of nitrification.

BOD_{21} takes too long to obtain, and the custom is to replace it by BOD_5, i.e., the amount of oxygen consumed after five days of incubation.

COD

This is the chemical oxygen demand, representing the range of anything likely to require oxygen, especially the oxidizable mineral salts (sulphides, metallic salts of lower valency) and the greater part of the organic compounds, whether biodegradable or not. (The mineral hydrocarbons resist this powerful oxidation).

The standard method makes use of potassium bichromate in a sulphuric medium.

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