Chapter II

THEORETICAL CONSIDERATION

1. Theory for biological waste treatment

The most efficient method for reducing the organic contents in diluted liquid waste is by aerobic biological treatment. Activated sludge system, trickling filter, oxidation pond are the three principle methods of treatment in operation today, and while these system may appear to differ from each other so far as plant and operation are concerned, they are dependent on the same biochemical principle.

The oxidation ditch is the one method modified from activated sludge system, basicaly the organism responsible for treatment possess the ability to decompose complex organic compounds and to use the energy for cell functions, reproduction, growth, locomotion and so on. The part of the end product of carbondioxide, water and the ammonia, while the remainder is converted to new cell which can be settled and thus removed from the liquid before the waste is discharge to the recieving body of the water.

Microbiology

The living organisms found in activated sludge are classified as either plants and animals. The plant consist of bacteria,fungi and animal primarily, rotifers and nemathodes.

Hawker states that bacteria are normally dorminant as primary feeder on organic waste, which different holozoic protozoa - being secondary feeders, rotifers and nematodes are found **at the** higher level in the food chain. Fungi cannot normally complete with bacteria but they may predorminate as primary feeders if certain conditions exist, such as low pH , nitrogen deficiency, or low disolved oxygen. High carbohydrate waste are also reported to stilmulate a fungi growth.

The composition of organics waste determine with bacteria will predorminate. Protein waste favours Alcaligines, flavobacterium and bacillus, while carbohydrate waste favours Psuedomonas. A high population of free swimming bacteria will sustain free swimming ciliate as the predorminat protozoa, however if the food level is lowerd by a reduction in the free swimming bacterial population, the free swimming ciliate will yield the stalk ciliates which required less energy. Rotifers thrive in very stable systems and are better indicators of stable conditions than the nemathode worms.

Metabolism

The metabolic reactions which occured in the activated sludge system can be devided into three phase : (1) Oxidation (2) Synthesis and (3) Endogenous respiration. These three phases reaction can be elustrate with the following general equetions which have been forulated by

Weston and Eckenfelder

(1) Organic matter oxidation

$$C_xH_yO_z \;+\; a\,O_2 \longrightarrow x\,CO_2 + bH_2O + \text{Energy}$$

where
$$a = X + \frac{Y}{4} - \frac{Z}{2}$$
$$b = \frac{Y}{2}$$

(2) Cell matterial synthesis

$$C_xH_yO_z \;+\; NH_3 \;+ dO_2 + \text{Energy} \longrightarrow C_5H_7NO_2 + e\,CO_2 + fH_2O$$

where
$$d = \frac{X + Y}{4} - \frac{Z}{2} - 5$$
$$e = X - 5$$
$$f = \frac{Y}{2} - 2$$

(3) Cell matterial oxidation

$$C_5H_7NO_2 \;+\; 5\,O_2 \longrightarrow 5\,CO_2 \;+ 2\,H_2O \;+ NH_3 + \text{Energy}$$

In the present enzymes produced by living microorganism about one - third of the organic matter removed is oxidized to CO_2 and H_2O to provide energy and synthesis of cell matterial of the other two-thirds of the organic matter removed. The cell matterial is also oxidized to CO_2, H_2O and etc by endogenous respiration(autooxidation).

2. Design criteria for biological waste treatment

The design criteria for the process treatment were derived from various technicial reports (8,9,10) ,jounals,handbook and the auther's experience in the Industrial waste treatment for tropical developing criteria.

Oxidation pond

1^{st} pond BOD loading	=	370	lb / acre / day
2^{nd} pond BOD loading	=	230	lb / acre / day
BOD removal	=	75	%

Aerated lagoon

Hydrualic retention time	=	3	days
Ke	=	1.0	day^{-1}
Oxygen supply	=	1.3	BOD removal
Power required for mixing	=	7.5	Hp/ million gallon
BOD removal	=	75	%

Activated sludge process

1. Primary treatment

Screening : design velocity	=	0.3	metre/sec
Grit chamber : design velocity	=	0.36	metre/sec

2. Primary treatment

Primary aeration tanK loading	=	24.25	m^3/m^2/day
retention time	=	3	hours
SS removal	=	85	%
BOD removal	=	25	%
Anticipate percentage of solid in sludge under flow	=	6	%

3. Secondary treatment

Sludge loading	=	0.35	Kg SS/Kg BOD
Oxygen supply	=	1.5	BOD applied
MLSS	=	3,000	mg/l
BOD removal	=	85	%

4. Clarifier

Loading	=	32.60	m^3/m^2/day
Sludge recycle	=	100	%

5. Sludge treatment

Anaerobic sludge digester

volume required	=	210	litre/ cap
Sludge drying bed	=	0.1	m^2/ cap

Oxidation ditch system

1. Primary treatment

Similar to those of activated sludge process

2. Secondary treatment

Sludge loading	=	0.05	Kg SS / Kg BOD
MLSS	=	5,000	mg/l
Oxygen supply	=	2.0	BOD applied
BOD removal	=	90^+	%

4. Sludge treatment

Sludge drying bed	=	0.1	m^2 / cap

Table 1

Activated sludge design criteria

Process	BOD-Loading		MLSS (ppm)	Sludge Ret. %	Air ratio (air in m³/ sewage m³/)	Aeration Time (hrs)	Sludge age (day)	Remark
	BOD - SS*	BOD - Vol**						
Con activated sludge	20 - 40	0.6 (.3-.8)	1,500-2,000	20 - 30	3 - 7	4 - 8	2 - 4	BOD more 200 ppm in raw waste. 1. primary clarifier 2. High MLSS is need
Step aeration	20 - 40	0.8 (.4-1.2)	2,000-3,000	20 - 30	3 - 7	3 - 6	2 - 4	
Contact stabilized	20	1.0 (.8-1.4)	2,000-8,000	50 - 100	12+	5+	4	
Extended aeration	3 - 5	0.2 (.15-.25)	3,000-6,000	50-150	15+	16 - 24	15 - 30	
Aero accelator	20 - 40	1.5 (.6-2.4)	3,000-6,000	50 - 150	5 - 8	2 - 3	2 - 4	
Oxidation ditch	3 - 5	0.2	3,000-4,000	50 - 150	-	24 - 48	15 - 30	

* Kg/100 KgSS/day ** Kg/m^3/day

" Group training course in waste Processing and Disposal vol.2 by the Ministry of Health and Welfare, Oversea Technician Cooperation Acency, Japan."

3.Literature review of the oxidation ditch system

The method of sewage treatment by provideing extondod aeration in the oxidation ditch was developed by Dr.A.Pasveer of the research institute of public health engineering TNO, Delf in Holland on 1953 and the first plant was installed at Voorschoten in 1954..the oxidation ditch system is the one method of waste water treatment in used. Its efficiency is improved by the addition of aeration systemto supply oxygen to the aerobic biological treatment process.

3.1 Principle of the system

The oxidation ditch system is modified from the acti vated sludge system and can be classified as extended aeration system. The principle part of the system is the unique race track shape ditch which from the aeration tank of the system providing continuous cont act and long detention time of about 1 - 3 days(Daneil.A.Okun). the blade or cage rotor (TNO) provides maximum aeration at minimum cost and also supply the needed propulsion to the liquid in the ditch.

The raw fresh sewage is purified in the oxidation ditch with out any pre treatment being given to the incomming sewage. Raw waste passage directly through the bar screen to the oxidation ditch. The time of the retention of the sewage and of the sludge in the oxid-ation ditch , together with the amount of oxygen that had to be supply are calculated to insure that the sewage become completly purified and the sludge completly oxidized so that it can be drying on drying bed without of given any odors. No anaerobic sludge digestion is required so this expensive and trobble some operation is eliminate.

3.2 Type of the system

There are two main types of the oxidation ditch system

(a) Intermittent or discontinuous **flow** system

(b) Continuous flow system of which there are several posible arrangements.

3.3 Process components

The oxidation ditch or aeration basin requires an area of approximatly 20 % of that needed for an oxidation pond. Its operation is not effected by the temperature to such a degree as a normally experienced with the oxidation pond. Changes in volume loads to meet future demands can be easily handled through ditch expansion without large expenditures in capital fun for new equip mentand plant design. The ditch may be of earth construction alth ough rock lining or concrete is preferd(Daneil . A .Okun)

The key to the sucess of the oxidation ditch system is the the development of the blade or cage rotor. This efficient aer ator can provide from 3 - 7 lbs of the oxygen per kilowatt per hour as compared 2 - 3 lbs per kilowatt per hour for standard force air system. The spinnig of cage rotor mixes air and oxygen to the liquid, break up any large particle in the waste stream and supply the motive power for propelling the waste around the ditch. Sinces oxygen supply is no longer a limiting factor in the design of the system, a highly mixed activated suspened solid concentration us- ually between 4,000 to 8,000 mg/l (Pasveer)(5,000 - 8,000 mg/lfor Daneil A Okun) , can be carried in the ditch afforting the plant ability to handle shock loads and peak load without upsetting the plant. The rotor can be adapted to any waste treatment application that requires efficient mixing and introduction of oxygen into the liquid stream.

The new waste and mixes liquor pass around the ditch and are given instense aeration by the rotor which each passage with a large surface composed to the atmosphere, additional oxygen is absorbed to suplement that given by the rotor. The prolonged aeration and mixing of fresh and aerated waste in the ditch produces a deep brown flocculent liquid typical of activated sludge and pocessing excellent settling characteristics. At higher solids concentration maintained in the system very little difficulty is experienced with foaming from detergents and the settle sludge produce is highly stabilized and non purtressible.

The cross section of the ditch at the place where the rotor is placed is maintained through out the circuit. Over the distance of few metres upstream from the rotor and between 5 to 10 metres downstream, the bottom and the slope of the ditch are protect with stone or layer of concrete insure that the area of the cross section is not decreased. The remainder of the circuit may be simply constructed from properly, compacted earth depending upon soil condition.

The oxidation ditch system has gained acceptance because its ability to handle peak loads and shock loading. The rotor is usually design to have about 5 inches of immersion depth which may be easily adjusted to between 2 to 9 inches by varying the level of sewage in the ditch to suit varying conditions, seasonal or gradualy increasing loads.

A flow velocity 1 fps (.3 mps) measured in the center of the ditch is neccessary in order to maintained all solids in suspension, the speed is attained if the rotor is design for proper BOD loading. The ditch volume should be approximately 8,000 to 10,000 gal per foot lengt of the rotor for small unlined ditches, but may exceed this with the layer plants or if lining is used (Pasveer 1960).

In the sedimentation, the purified water is seperate from the sludge(in some design the ditch itself may be used for final settling basin).The clarified effluent passage over the wier in the sedimentation and is discharge directly to the recieving stream. The surface area of the sedimentation tank is generally 1 m^2 per 1 m^3 of sewage pump capacity.

The tank bottom is design with a number of small inverted pyramids. The sludge settle and it collected in the funnels, from with the sludge flow by hydrostatics head through 10 cm tube into a small cannal. With a small screw pump the settle sludge is returned to the oxidation ditch.

The simple device allows for pumping the excess sludge onto the drying beds. Washing sludge is periodic and is remove from the system when the desired solids concentration in the ditch is exceed. The sludge is odorless and hence can be dried on sludge drying beds.

Drying beds are designed to meet local condition. In sandy soil sludge drying beds need not be drained. In clay soils drained is generally required, but may be omitted if drying is done in thin layer of sludge and using, if neccessary a large area. Each bed has a small wier , over with a surplus of water is discharged and retured to the pumpit. The high of this wier can be regulated.

Care has to be taken that the drying beds are easily accessible, so that there is no difficulty inthe removal of the dried sludge. As previously noted, the sludge is completly oxidised ,then it is odorless and can be easily dried. No sludge equipment is required,the dried sludge may be used as soil conditioner or fertilizer.

3.4 Oxygen suplly

A sufficient supply of oxygen is of course essential, in the oxidation ditch it is desirable to provide an oxygenation capacity of two times he BOD load to be removed. The Baar and Muskut Experiment as shown on Figure 3 are shown oxygenation capacity and energy consumption. The ratio capable to supllying an oxygenation capacity to BOD loading should be two.(Stanley K. smith).

4. The advantages of the oxidation ditch system for hospital sewage.

There are many advantages of an oxidation ditch system for hospital sewage treatment:-

1. Oxidation ditch system requires much less space than aerated lagoon or conventional lagoon and can be built on relatively steep sloping ground. The hospital area is limited and can't expanded, in expensively so oxidation ditch system is suitable for hospital waste treatment. Figure 1 is shown land requirement for sewage treatment.

2. Construction cost is shown in figure 2. The construction cost is lower than activated sludge system,and the constructions design is simplifier than the conventional activated sludge system.

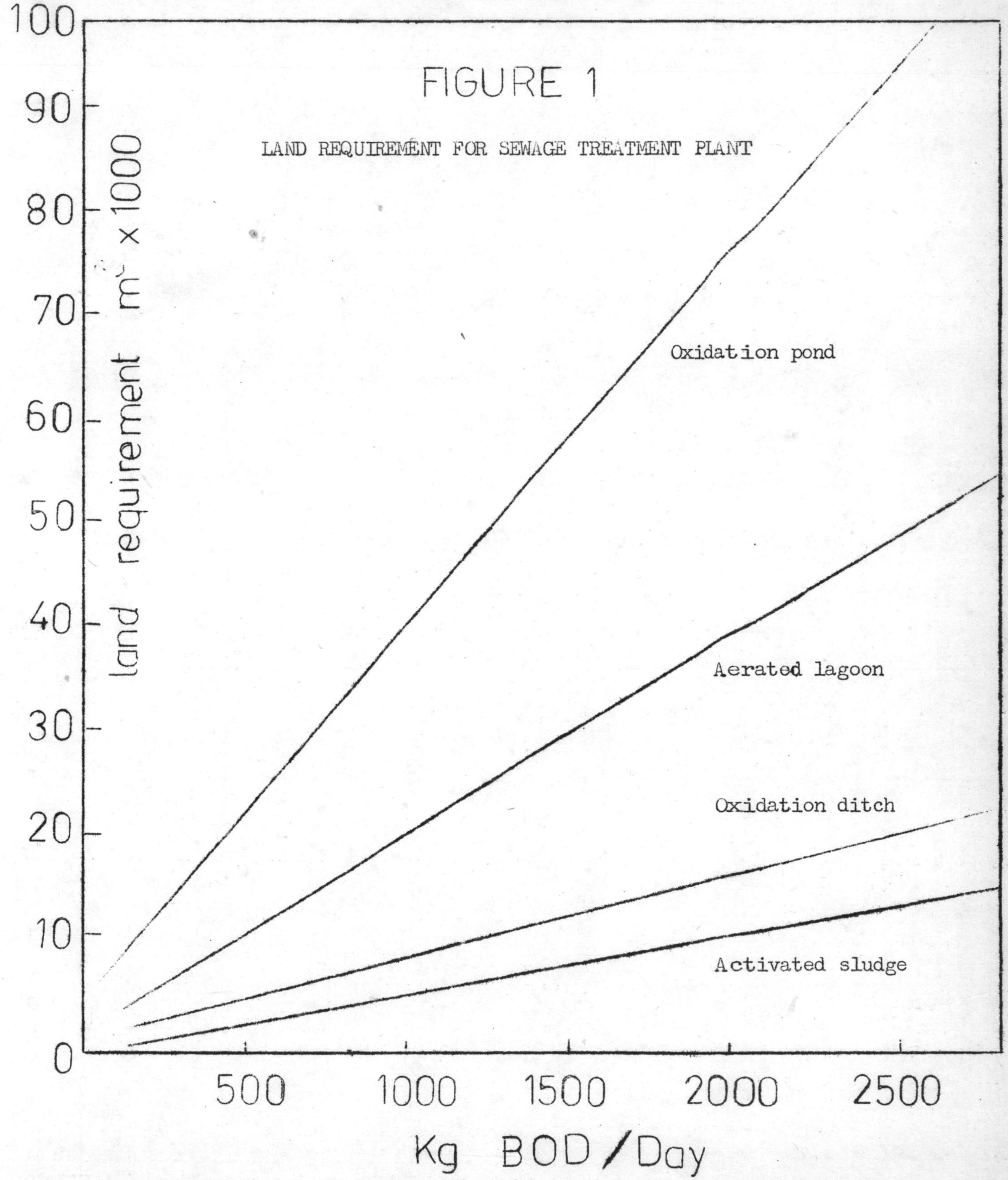
3. It is easy to operation and due to it sized, it can absorb shock loads better than a small package treatment plant and easy to maintainant. The cost of operation is between 18 to 20 Kwh per inhibitant.per year. This is higher than conventional activated sludge system, but itis save for chemical and operation(Stanley K.).

4. It can be designed out of any terial that suitable for the area ie; concrete lining, plastic film, lining and unlined earth.

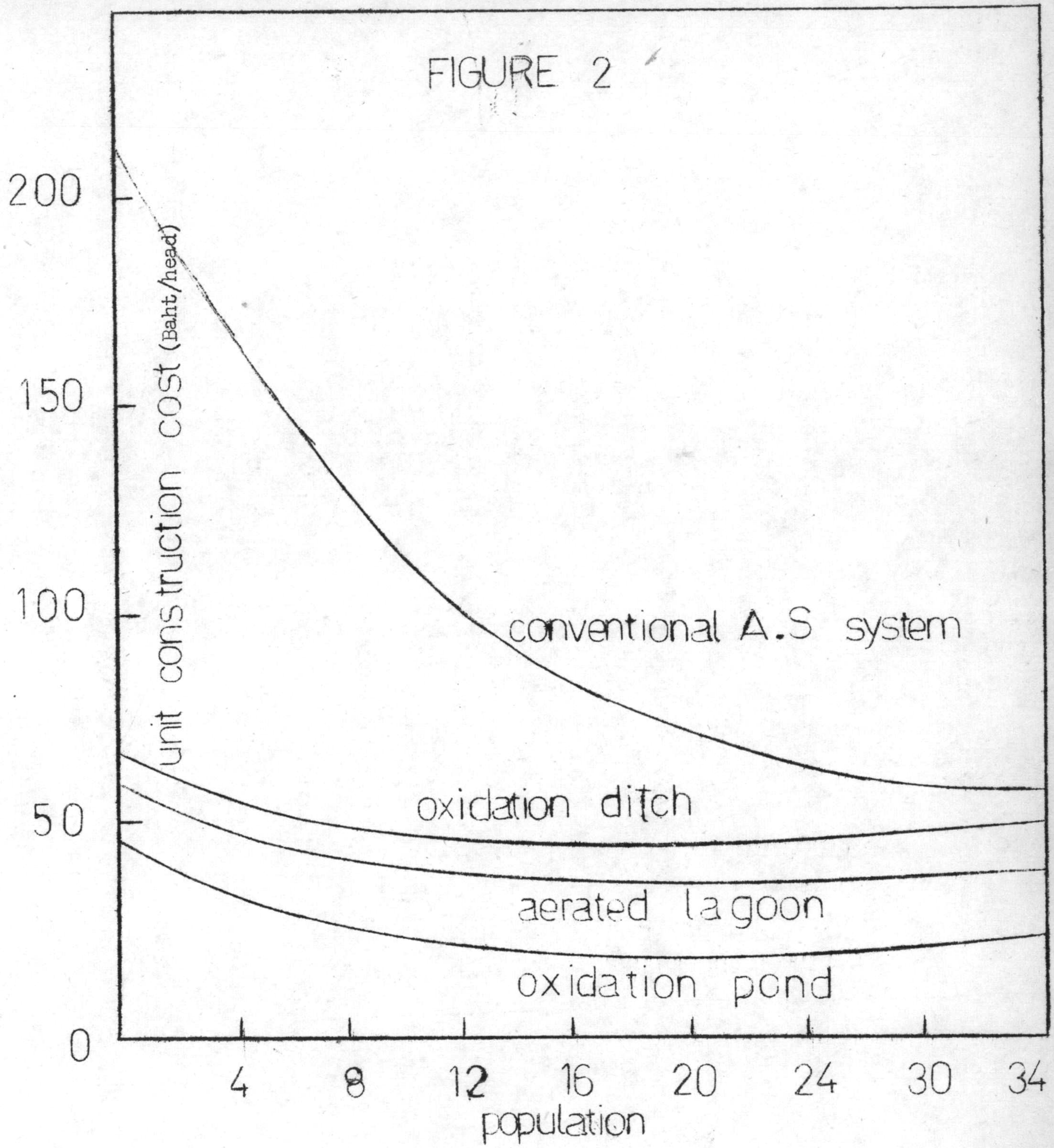
5. It has been used in cold climate , oxidation ditch functions very well in the winter if the wier is protected (Stanley K Smith).

6. The only area requires protection is clarifier, blower and chlorination equipments.

7. The efficiency of the oxidation ditch system for hospital sewage treatment as obtained from Noorwijk, Holland is very excellent and shows in Table 2 .



* From Cost of Sewage Treatment for Housing Estates in Thailand.



SHOWS COST FOR SEWAGE TREATMENT IN INDIA CONSTRUCTION COST Unit

(Cost of Sewage Treatment for Housing Estates in Thailand)

Table 2

SHOWING TREATMENT EFFICIENCY OF THE PASVEER OXIDATION DITCH SYSTEM AT

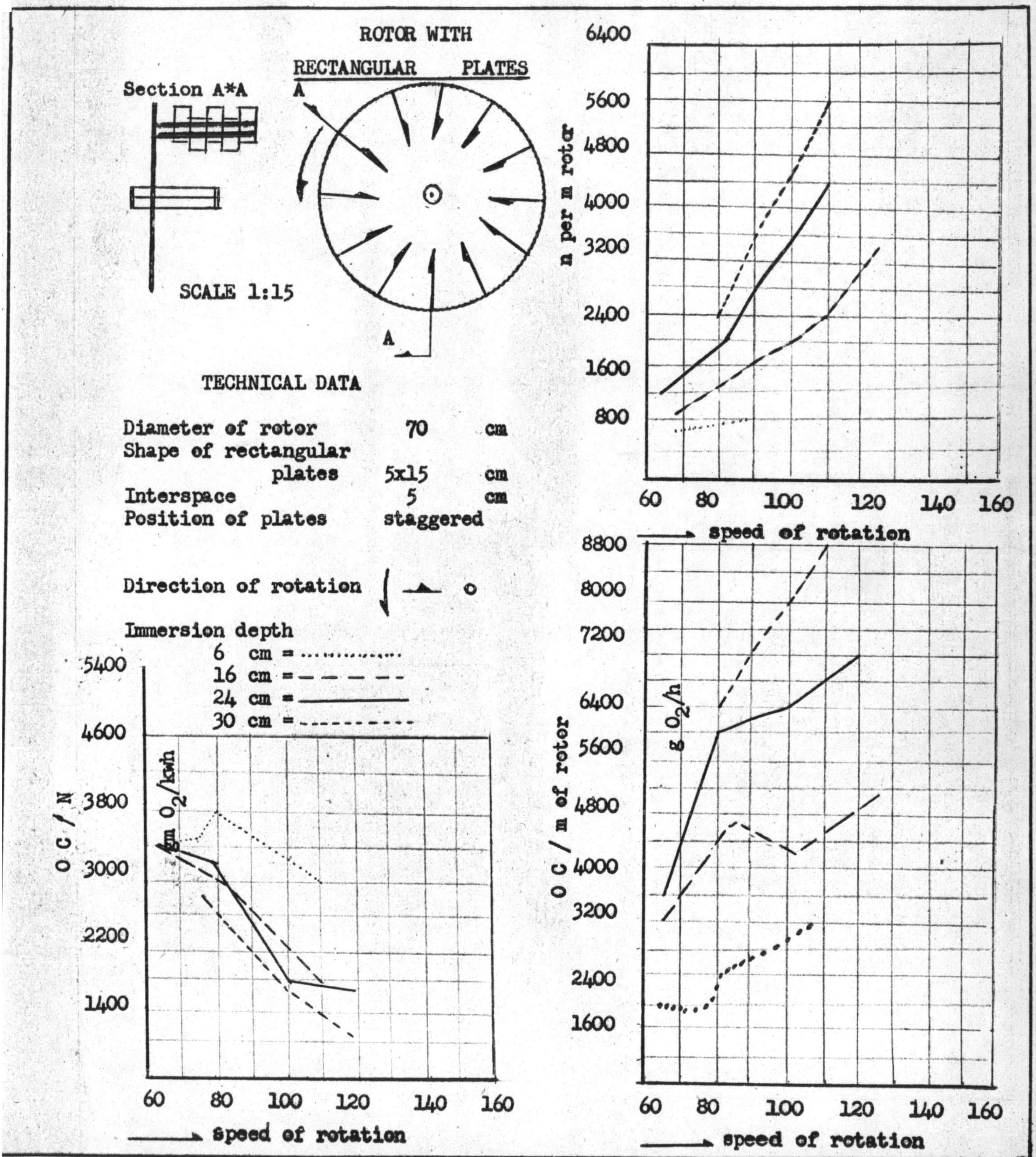
2500 PERSONS HOSPITAL COMPLEX, NOORDWIJK, HOLLAND

Month 1959	Raw waste characteristics*		Effluent quality*		
	Temp ^{o}C	Influent BOD	Disolved O_2	Effluent BOD	%BOD removal
Mar	-	380	3.2	12	97
Apr	12	278	0.4	13	95
May	-	570	2.6	17	98
Jun	19	392	1.3	7	98
Jul	23	310	1.3	3	99
Aug	20	353	4.4	10	97
Sep	17	336	1.6	2	99
Oct	12	324	1.5	12	96
Nov	7	363	2.2	5	98

* All figure are given in mg/l

** Suspended solids content of all samples less than 0.1 mg/l

FIGURE 3



OXYGENATION CAPACITY AND ENERGY CONSUMPTION OF THE CAGE ROTOR AT DIFFERENT OF IMMERSION AND DIFFERENT SPEEDS OF ROTATION(BAAR & MUSKUT EXPERIMENT).