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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with operation and maintenance of rotating biological surface (RBS) wastewater treatment systems. Included are objectives, instructor guides, student handouts and transparency masters. This is the second level of a three module series. The module considers the role and function of the RBS unit, factors affecting unit performance, solutions to adverse situations, design approaches, maintenance and reporting requirements. (Author/RH)

INTERMEDIATE ROTATING BIOLOGICAL SURFACE OPERATION

Training Module 2.121.3.77

Prepared for the

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September, 1977

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INSTRUCTOR GUIDE

for

Training Module II3JWW

Intermediate Rotating Biological Surface

Module No:	Module Title:
I13JWW	Intermediate Rotating Biological Surface Operation
Approx. Time:	Submodule Title:
17.0 Hours	Topic: Summary

Objectives: Upon completion of this module, the participant will be able to

1. Discuss the role and functions of an RBS unit in wastewater treatment in detail.
2. Discuss the factors affecting RBS unit performance and be able to suggest solutions to adverse situations.
3. Briefly comment on the design approaches for RBS systems.
4. Discuss the maintenance requirements for an RBS system.
5. Outline the report requirements for RBS performance and conduct appropriate calculations.

Instructional Aids:

Slides
Transparencies
Handouts

Instructional Approach:

Discussion

References:

1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976
2. Autotrol Corporation, Bio-surf Design Manual, 1972
3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process

Class Assignments:

Reading of assigned references
Study of handout materials
Working sample problems.

Module No: II3JWW	Module Title: Intermediate Rotating Biological Surface Operation
	Submodule Title:
Approx. Time: 3.0 Hours	Topic: Review of Wastewater Treatment Systems and Process Performance Parameters

Objectives: Upon completion of this topic, the participant will be able to

1. Describe the unit operations and processes of wastewater treatment including typical performance and factors affecting the unit's performance e.g. flow, type of wastes, loadings.
2. Relate the place of the RBS system to trickling filters and activated sludge processes.
3. Define the various water quality parameters and cite their significance in biological treatment performance. Parameters included as pH, toxics, temperature, solids spectrum, COD, BOD, NH_3, P and others.

Instructional Aids:

Slides and Transparencies: Typical plant processes. Unit performance: Solids spectrum. Oxygen demand tests.

Handouts

Instructional Approach:

Discussion

References:

1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976
2. Autotrol Corporation, Bio-surf Design Manual, 1972
3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process

Class Assignments:

Reading assigned material.
Supplemental reading--handouts, background operator texts

Module No: II3JWW	Topic: Review of Wastewater Treatment Systems and Process Performance Parameters
Instructor Notes:	**Instructor Outline:**
TRANS ID-1 Wastewater-Treatment Systems TRANS ID-2 Role of RBS Units Note: MOP 11 is quite thorough in this area. Could use personal slides or WPCF Operation Training Course No. 2 slides.	1. Discuss unit operations and processes of wastewater treatment. a. Note typical performance of units especially preliminary and primary units. b. Compare the role and bio-activity of RBS units to those of trickling filters and activated sludge units. c. Comment on the impact of flow changes, BOD loadings and industrial wastes e.g high organic and toxic wastes.
TRANS ID-3 Water Quality Parameters TRANS ID-4 Solids Spectrum TRANS ID-5 Organic Content of Wastewater TRANS ID-6 Biochemical Oxygen Demand	2. Define and cite the significance of water quality parameters associated with a wastewater treatment plant e.g., a. Acceptable pH ranges in aerobic processes. Effluent limits. b. Toxics - e.g. metal inhibition of enzymes. c. Temperature - affect on rate of activity and growth rate. d. Solids accumulation and separation. e. Organics - nutrient requirements e.g., use of NH_3 & P in cell growth.

Module No:	Module Title:
II3JWW	Intermediate Rotating Biological Surface Operation
	Submodule Title:
Approx. Time: 3.0 Hours	Topic: Basic Biology and Biological Systems

Objectives: Upon completion of this topic, the participant will be able to

1. Discuss bacterial growth and factors affecting rates and synthesis aspects.
2. Discuss the interrelationships of organism ecology, e.g. presence of filamentous organisms, nitrifying bacteria, protozoans, rotifers, etc. as they relate to RBS systems.

Instructional Aids:

Transparencies: Growth curves. Population dynamics. Nitrogen cycle.

Handouts

Instructional Approach:

Discussion

References:

1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976
2. Autotrol Corporation, Bio-surf Design Manual, 1972
3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process.

Class Assignments:

Read assigned readings.
Study handout materials.

Module No: II3JWW	Topic: Basic Biology and Biological Systems

Instructor Notes:	Instructor Outline:
TRANS ID-7 Biological Terminology TRANS ID-8 Nitrogen Cycle TRANS ID-9 Nitrification TRANS ID-10 Biological Activity Note: MOP #11 cites examples of bio-populations	1. Discuss bacterial growth. a. Food/Microorganism ratio impact b. Aerobic and anaerobic aspects e.g., DO requirements to maintain aerobic activity. c. Wastewater contains a very diverse population -- competition based on food availability and environment e.g., as BOD decreases adequately nitrification can occur. d. Note that bio-decomposition of protein can yield ammonia. 2. Discuss diversity of organism population in fixed-film systems. a. Bacteria b. Filamentous-favored by type of food availability, low DO conditions c. Note conditions necessary for slow growing nitrifiers to develop d. Protozoans are present in active bio-systems e. Rotifers are indicators of stable systems with low organic levels

Module No:	Module Title:
II3JWW	Intermediate Rotating Biological Surface Operation
	Submodule Title:
Approx. Time:	Topic:
2.0 Hours	RBS System: Purpose; functions; components

Objectives: Upon completion of this topic, the participant will be able to

1. Fully describe a typical RBS system and cite its process performance characteristics in organic removal and nitrification applications.
2. Discuss the nature of the bio-mass and the component parts of the system.

Instructional Aids:

Slides & Transparencies: RBS System. RBS Components. Existing plants. Handouts

Instructional Approach:

Discussion

References:

1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976
2. Autotrol Corporation, Bio-surf Design Manual, 1972
3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process

Class Assignments:

Read assigned materials in references.
Study handout materials.

Module No: II3JWW	Topic: RBS System: Purpose; functions; components

Instructor Notes:	Instructor Outline:
TRANS ID-11 Rotating Biological Surface Reactor TRANS ID-12 Typical RBS Configuration TRANS ID-13 Process Unit Components TRANS ID-14 Process Description	1. Describe the RBS system and note typical process performance re-BOD reduction and nitrification. 2. Note the various components e.g. a. Nature of disk material and area b. Rotational mechanism and function c. Nature of bio-mass-growth, appearance, shearing with rotation
SLIDES DS-1 through DS-17	3. Observe typical installations via the slides.
Note: The bio-mass is described in MOP #11	

Module No:	Module Title:
II3JWW	Intermediate Rotating Biological Surface Operation
	Submodule Title:
Approx. Time: 3.0 Hours	Topic: RBS System: Factors Affecting Performance

Objectives: Upon completion of this topic, the participant will be able to

1. Discuss the significance of proper pre-treatment to maintain RBS unit performance. The effect of carry over solids, slug loads, flow variation, toxic substances would be included.
2. Discuss the effect of pH, temperature, alkalinity on the process.

Instructional Aids:

Transparencies: Cause and Remedy Situations
Handouts

Instructional Approach:

Discussion

References:

1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976
2. Autotrol Corporation, Bio-surf Design Manual, 1972
3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process

Class Assignments:

Read assigned references.
Study handout materials.

Module No: II3JWW	Topic: RBS System: Factors Affecting Performance
Instructor Notes:	**Instructor Outline:**
TRANS ID-15 Variations in Flow and Strength Note: MOP #11 is thorough in this area.	1. Discuss the importance of pre-treatment a. Potential for grit or other solids to settle in RBS channels or units if not removed earlier. b. Cite the impact of increases in BOD loads to the system e.g., from industrial wastes. Bio-mass response and oxygen availability. Also consider items like grease. c. Note flow increase affects on RBS units (contact time and performance) and on the final clarifier performance. d. Toxic interference with bio-activity e.g., metal inhibition of enzymes. 2. Comment on effect of varying parameters in the system. a. Note sensitivity of nitrifiers to pH - (not as critical for organic removal). b. Note decrease in performance with temperature drops. Imp. of covers or heated air in buildings. c. Note alkalinity buffering aspect. d. Sunlight impact could affect algal growth if disks are exposed. e. Changes in DO with stages.

Module No:	Module Title:
II3JWW	Intermediate Rotating Biological Surface Operation
	Submodule Title:
Approx. Time: 1.0 Hours	Topic: RBS System: Typical design criteria

Objectives: Upon completion of this topic, the participant will be able to

1. List and briefly discuss the typical design criteria for an RBS unit including hydraulic loading, rotational speed, BOD considerations, temperature effects, NH_3 considerations, etc.

Instructional Aids:

Transparency: Typical design criteria

Handout

Instructional Approach:

Discussion

References:

1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976
2. Autotrol Corporation, Bio-surf Design Manual, 1972
3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process

Class Assignments:

Study handout material.

Module No: II3JWW	Topic: RBS System: Typical design criteria
Instructor Notes:	**Instructor Outline:**
TRANS ID-16 through 19 Typical Design Criteria	1. Discuss typical design factors for RBS Units a. Hydraulic loading vs. removal b. Effect of increasing the number of stages c. Rotational speed d. Tank volume e. Temperature-note that if you can lower the hydraulic loading you can compensate for lower temperature conditions. f. Note that nitrification occurs with low BOD/NH_3 ratios. g. Note effect of nitrification on BOD analysis.

Module No: II3JWW	Module Title: Intermediate Rotating Biological Surface Operation
	Submodule Title:
Approx. Time: 1.0 Hour	Topic: Final settling tank and sludge disposal

Objectives: Upon completion of this topic, the participant will be able to

1. Discuss the settling properties of RBS unit solids and the typical performance of a final clarifier.
2. Discuss the quantity and nature of final settling tank sludge and its disposal alternatives.

Instructional Aids:

Transparency: Typical final clarifier and its process control factors
Typical sludge treatment and disposal alternatives

Handouts

Instructional Approach:

Discussion

References:

1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976
2. Autotrol Corporation, Bio-surf Design Manual, 1972
3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process

Class Assignments:

Study handout materials.

Module No: II3JWW	Topic: Final settling tank and sludge disposal

Instructor Notes:	Instructor Outline:
TRANS ID-20 Sludge Treatment & Disposal	1. Note the settling properties of RBS bio-solids. Review settling tank performance criteria e.g. a. Overflow rate b. Detention time 2. Discuss sludge removal, treatment and disposal. a. Typical quantities and quality of sludge. b. Combining with primary sludge. c. Note alternative processes. d. Comment on rising sludge possibilities vs. pumping rates. Denitrification vs. thick sludges. e. Comment on storage of sludge.

Module No: II3JWW	Module Title: Intermediate Rotating Biological Surface Operation
	Submodule Title:
Approx. Time: 1.0 Hour	Topic: Maintenance

Objectives: Upon completion of this topic, the participant will be able to

1. Discuss the maintenance requirements of an RBS unit and the related process units.

Instructional Aids:

Transparencies: Maintenance Schedule
Typical Maintenance Manual Instructions

Instructional Approach:

Discussion

References:

1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976
2. Autotrol Corporation, Bio-surf Design Manual, 1972
3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process

Class Assignments:

Study handouts.
Read assigned readings.

Module No: II3JWW	Topic: Maintenance

Instructor Notes:	Instructor Outline:
TRANS ID-21 Bio-module Units TRANS ID-22 Preventive Maintenance TRANS ID-23 Lubrication & Maintenance	1. Discuss maintenance requirements and operation of mechanical units. 2. Have student participants share their practices with RBS units with the class.

Module No:	Module Title:
II3JWW	Intermediate Rotating Biological Surface Operation
	Submodule Title:
Approx. Time: 3.0 Hours	Topic: Reports and calculations

Objectives: Upon completion of this topic, the participant will be able to

1. Complete appropriate IDEQ reports regarding process performance of an RBS wastewater treatment plant.
2. Complete appropriate calculations including detention time, hydraulic loading, per cent removal, lbs/day to concentration conversions for flow rates, chemical feed requirements.
3. Understand and describe terms, units, loadings, conversions, etc.

Instructional Aids:

Transparencies: IDEQ Report Forms
Typical Calculations

Handouts
Problem Assignments

Instructional Approach:
Discussion

References:

1. Water Pollution Control Federation, Operation of Wastewater Treatment Plants, Manual of Practice No. 11, 1976
2. Autotrol Corporation, Bio-surf Design Manual, 1972
3. Autotrol Corporation, Operating & Maintenance Manual for the Bio-surf Waste Treatment Process

Class Assignments:

Study handouts.
Complete sample problem calculations.

Module No: II3JWW	Topic: Reports and calculations.

Instructor Notes:	Instructor Outline:
TRANS ID-24 IDEQ Monthly Report TRANS ID-25 IDEQ Effluent Monitoring TRANS ID-26 Typical Calculations-I TRANS ID-27 Typical Calculations - II	1. Review and discuss typical IDEQ reporting requirements. Use Emmetsburg example or other if familiar with them. 2. Ask for class discussion on reporting and monitoring experiences. 3. Discuss typical calculations using sample problem. Expand as desired. 4. Review various terms and units typically associated with reports and performance calculations.

Module No: II2FWW, II3JWW, II4OWW	Topic: References Utilized in Developing Training Module Material

Instructor Notes:	Instructor Outline:

Water Pollution Control Federation, Operation Wastewater Treatment Plants, MOP No.11, 1976

Autotrol Corporation, Bio-surf Design Manual, 1972

Autotrol Corporation, Operating and Maintenance Manual for the Bio-surf Waste Treatment Process

Autotrol Corp., "Bio-surf Process Package Plants for Secondary Wastewater Treatment", 975-1.1.2, 1975

Autotrol Corp., "The Bio-surf Process", (G-3-876), 1976

U.S.E.P.A., "Process Design Manual for Nitrogen Control", October 1975

Metcalf & Eddy, Inc. Wastewater Engineering, McGraw-Hill, 1972

Clark, J.W., Viessman, W. Jr and Hammer, M., Water Supply and Pollution Control, IEP, 1977

Sawyer, C.N. & McCarty, P.L., Chemistry for Sanitary Engineers, McGraw-Hill 1967

APHA, Standard Methods for the Examination of Water and Wastewater, 14th Edit. 1975

WPCF, Simplified Laboratory Procedures for Wastewater Examination, MOP No. 18, 1970

U.S.E.P.A., Methods for Chemical Analysis of Water and Wastes, 1974

Mather, Stanley E.J. "Plant Upgraded With Rotating Biological Surface System", Public Works, Jan. 1977

Congram, G.E., "Biodisk Improves Effluent-Water-Treating Operation", Oil & Gas Journal, Feb. 1976

Module No: II2FWW, II3JWW, II4OWW	Topic: References Utilized in Developing Training Module Material

Instructor Notes:	Instructor Outline:
	Wexler, H.M., "Value Engineering: Make Sure The Costs Are Right", Water & Wastes Engr, June 1976 Antonie, R.L. "BOD Removal and Nitrification with the Rotating Biological Contactor," Great Plains Design Conference, March 1977 Malhotra, S.K., Williams, T.C. & Morley, W.L., "Performance of a Bio-disk Plant in a Northern Michigan Community", WPCF Conf., 1975

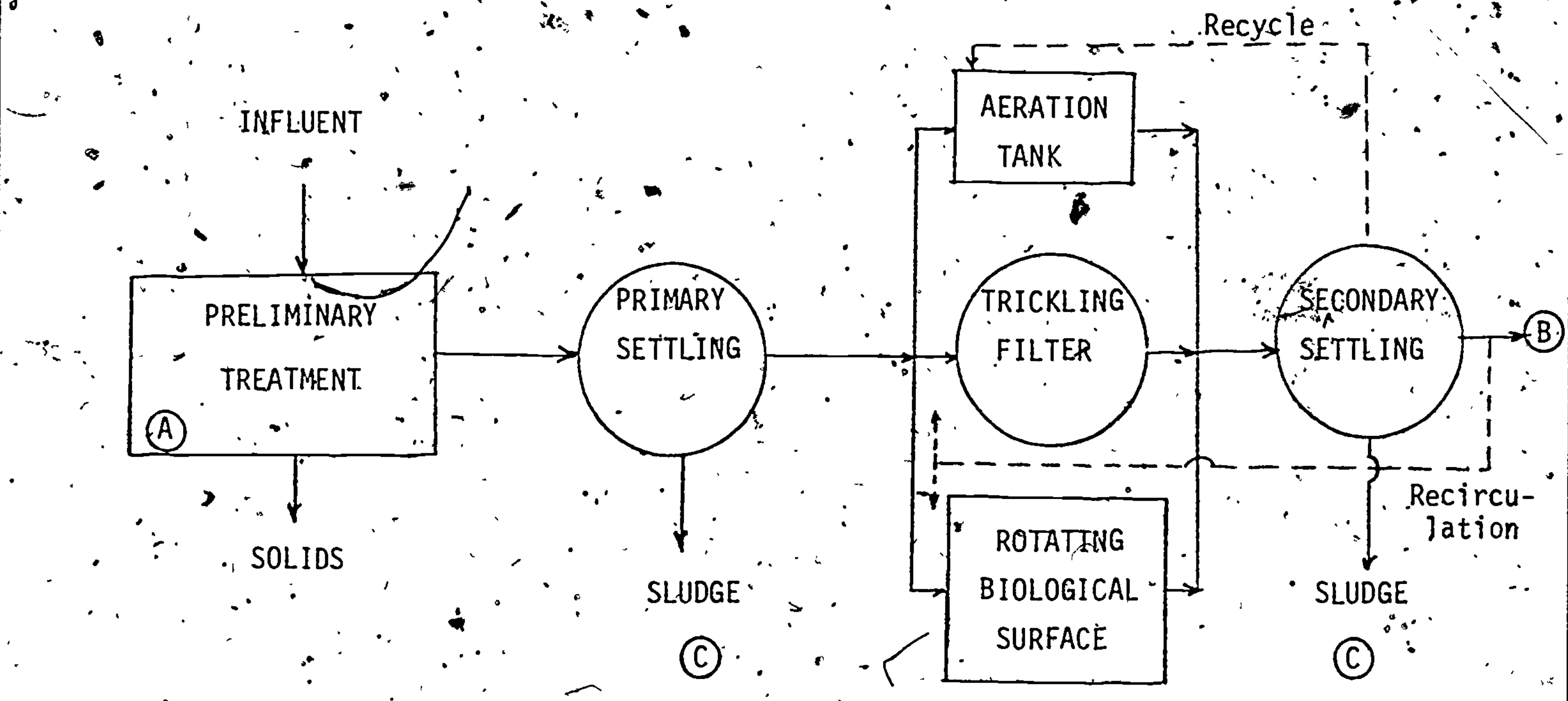
TRANSPARENCIES

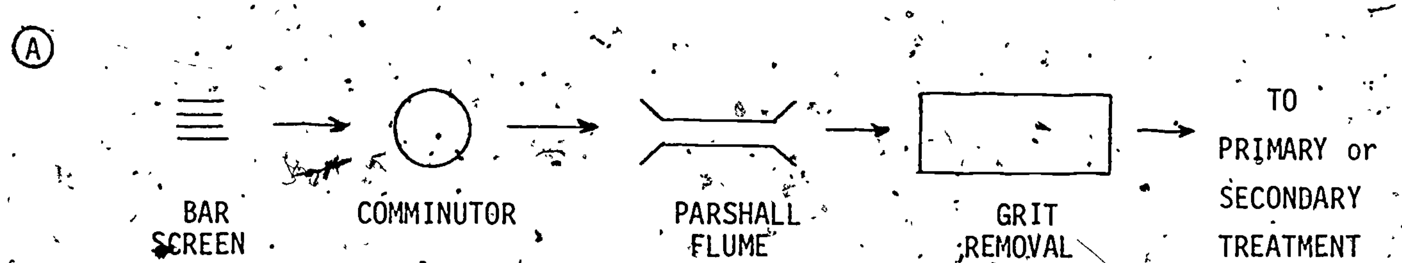
for

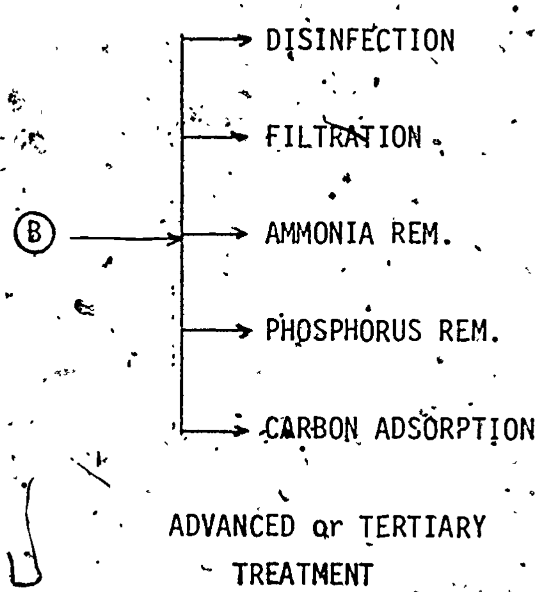
Training Module II3JWW

Intermediate Rotating Biological Surface

WASTEWATER TREATMENT SYSTEMS







ROLE of RBS UNITS

SECONDARY TREATMENT

- Reduction of BOD by aerobic biological treatment
- Used in place of a rock trickling filter or an activated sludge process
- Applied to municipal and to industrial wastewater
- Oxidize some organics in industrial wastes

TERTIARY TREATMENT

- Decrease ammonia nitrogen (NH_3-N) concentration by biological oxidation
- Used alone or in combination with other biological processes

WATER QUALITY PARAMETERS

pH. - A measure of the hydrogen ion concentration

$pH = \log \frac{1}{[H^+]}$ · $pH + pOH = 14$

TEMPERATURE - $^{o}F = 9/5\ ^{o}C + 32$

ALKALINITY - Due to presence of hydroxides, carbonates and bicarbonates of calcium, magnesium, sodium, potassium and ammonia

NITROGEN - Typical in domestic wastewater:

Total Nitrogen	20 to 85 mg/l
Organic Nitrogen	8 to 35
Ammonia Nitrogen, NH_3	12 to 50
Nitrite & Nitrate (NO_2) (NO_3)	Generally zero

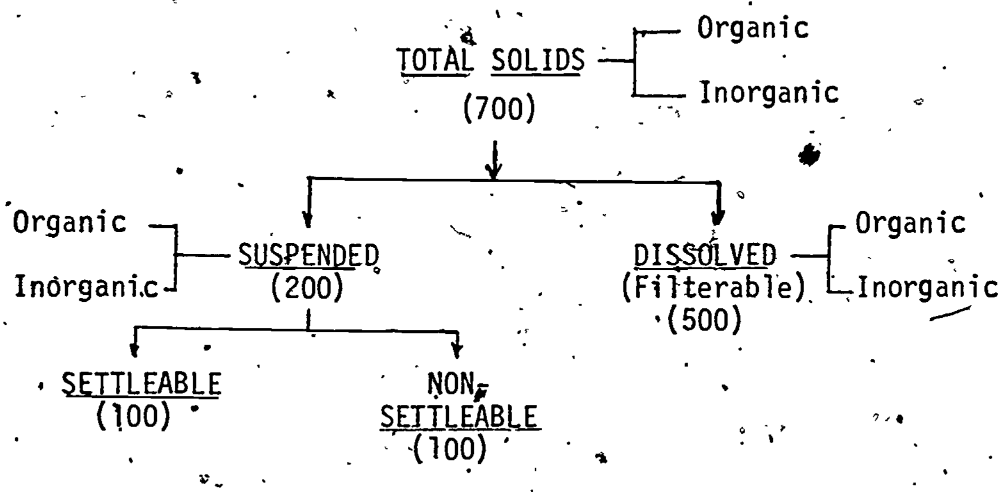
PHOSPHORUS - Essential nutrient in biological treatment

GREASE - Cause clogging; interfere with biological life

TOXICS e.g. Heavy metals, cyanide. Interfere with bio-activity

DISSOLVED OXYGEN - Oxygen in solution. Winkler titration. DO Probes. Needed for aerobic bio-activity.

SOLIDS SPECTRUM



VOLATILE — Essentially organic fraction - $600^{o}C$

FIXED — Essentially inroganic fraction

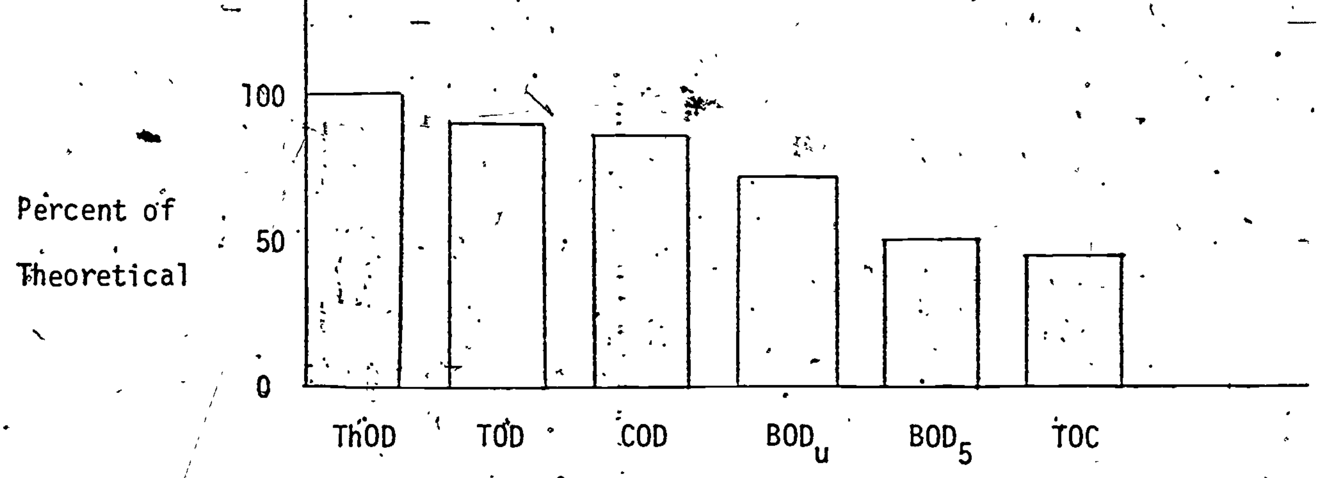
SETTLEABLE — One hour - Imhoff cone

GRIT — Inorganics. Higher settling rate

CARRIAGE WATER SOLIDS — Dissolved solids in water supply

PARTICLE SIZE — Settleable - greater than 10 microns
Colloidal - 10^{-3} to 1 micron
1 micron approx. equals 1/25000 "
Bacterial Diameter ~ 1 micron

ORGANIC CONTENT of WASTE WATER



ThOD - If chemical formula of organics is known ThOD may be computed. (Theoretical Oxygen Demand).

TOD - Convert organics to stable end products in a platinum-catalyzed combustion chamber (Total Oxygen Demand)

COD - Oxidize organics chemically in an acidic medium. (Chemical Oxygen Demand)

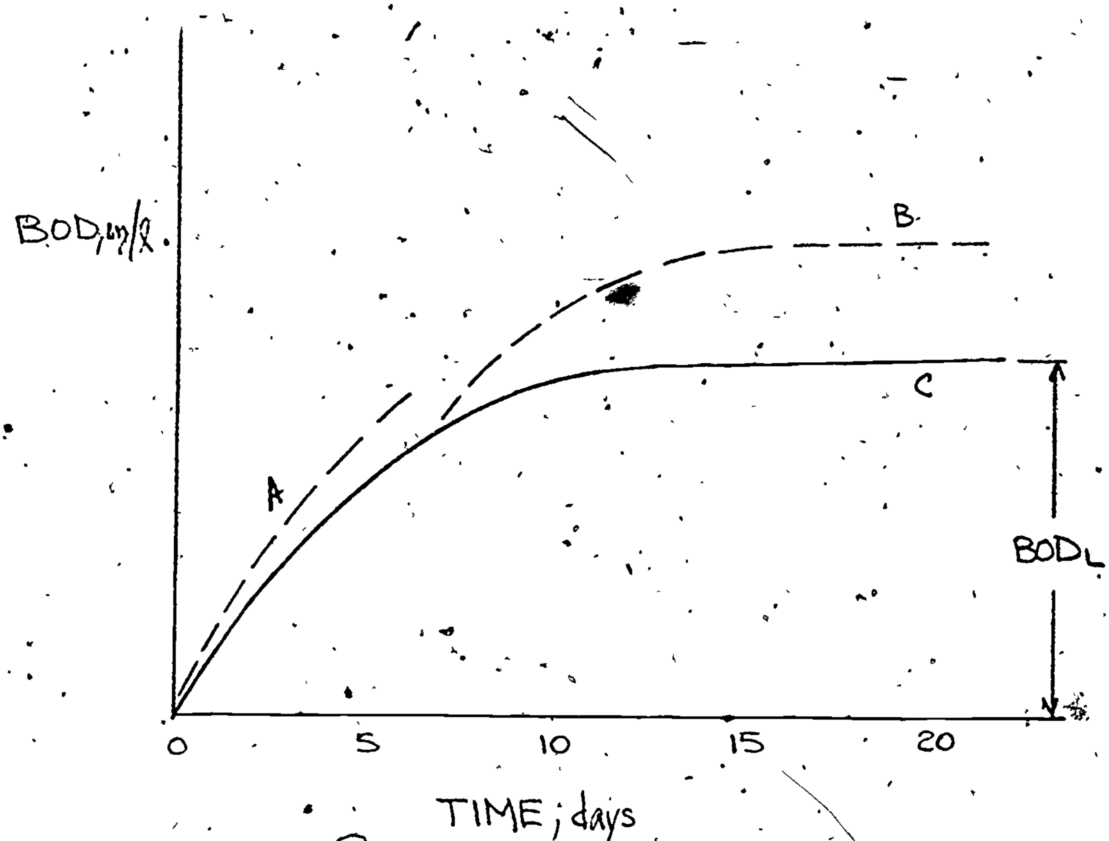
BODu - The organics are oxidized biologically in the presence of oxygen and adequate nutrients at 20^{o}C. (The Ultimate (20 day) Biochemical Oxygen Demand)

BOD$_5$ - The 5 day Biochemical Oxygen Demand

TOC - Organic carbon is oxidized to carbon dioxide in a high temperature furnace in the presence of a catalyst. (Total Organic Carbon)

Typical Domestic Wastewater: BOD/COD 0.4 to 0.8
BOD/TOC 0.8 to 1.0

BIOCHEMICAL OXYGEN DEMAND



Curve C represents the carbonaceous oxygen demand

$Y_5 = L\ (1-10^{-5k})$ — Y_5 - BOD at 5 days

L - BOD_L

k - Deoxygenation rate

Curve B illustrates normal progression of nitrification (At 20^{0}C, it takes from 6 to 10 days to develop a nitrifying population)

Curve A illustrates nitrification initially due to an adequate population of nitrifiers in the sample e.g. RBC effluent

<u>Note</u>: Nitrification effects can be separated out by pretreating the sample e.g. pasteurization or by the use of chemical inhibitory agents e.g. thiourea

BIOLOGICAL TERMINOLOGY

FOOD or SUBSTRATE, F (BOD, COD, TOC) → SYNTHESIS or GROWTH NEW CELLS, M (Volatile Solids)

→ ENERGY & END PRODUCTS*

F/M - Food to Microorganism Ratio

* ORGANIC - HETEROTROPHS

AEROBIC (Presence of D.O.) -- $CO_2 + H_2O$

ANAEROBIC (Absence of D.O.) -- $CH_4 + CO_2$

FACULTATIVE -- Can adjust to presence or absence of D.O.

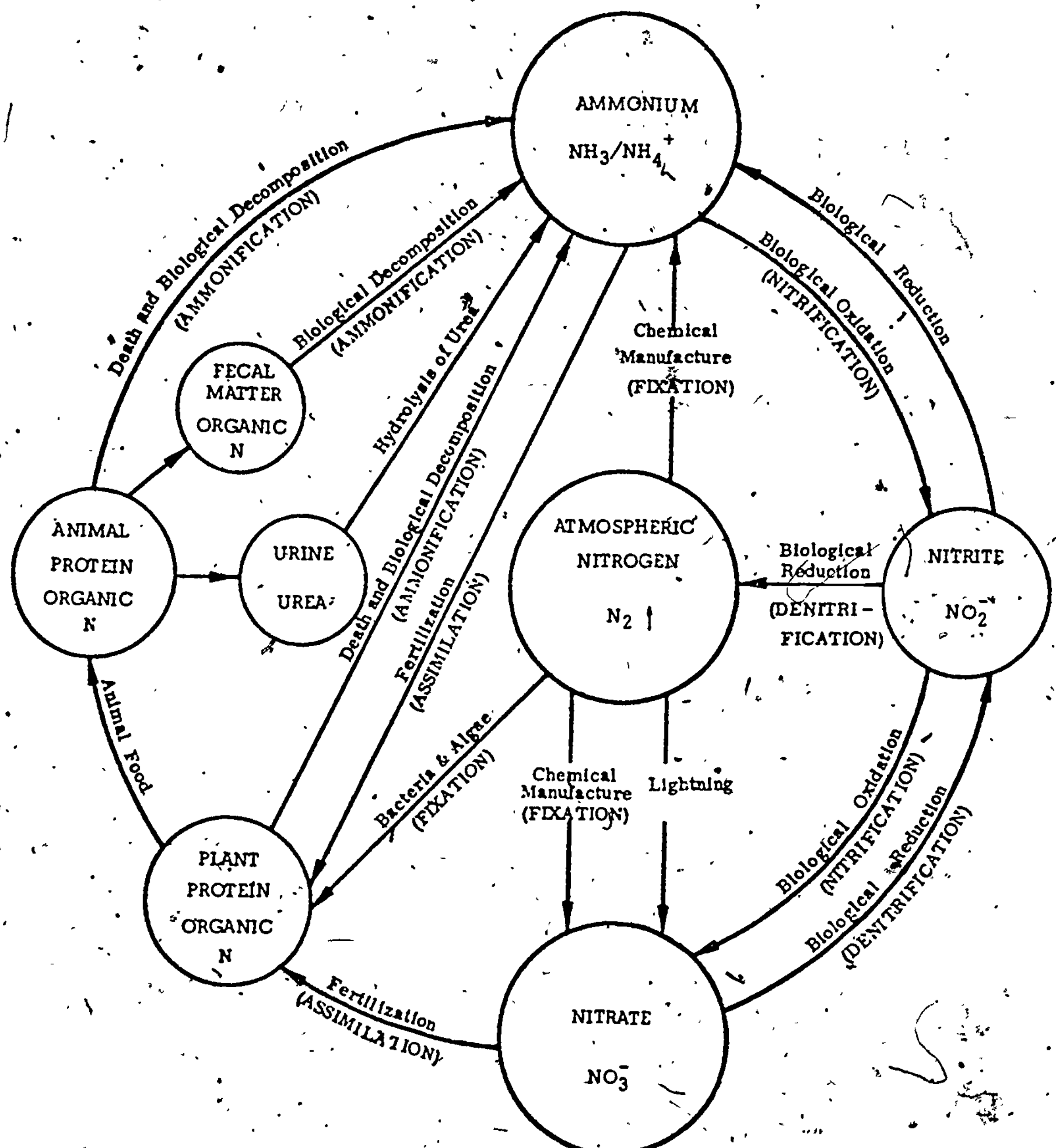
* INORGANIC - AUTOTROPHS

NITRIFICATION -- $NH_3 \rightarrow NO_2 \rightarrow NO_3$

(Aerobic) (Uses CO_2 as carbon source)

PHOTOSYNTHESIS -- Uses CO_2 as carbon source
Yields oxygen in presence of light
e.g. algae

NITROGEN CYCLE



NITRIFICATION

THE BIOLOGICAL OXIDATION OF AMMONIUM, FIRST TO NITRITE THEN TO THE NITRATE FORM

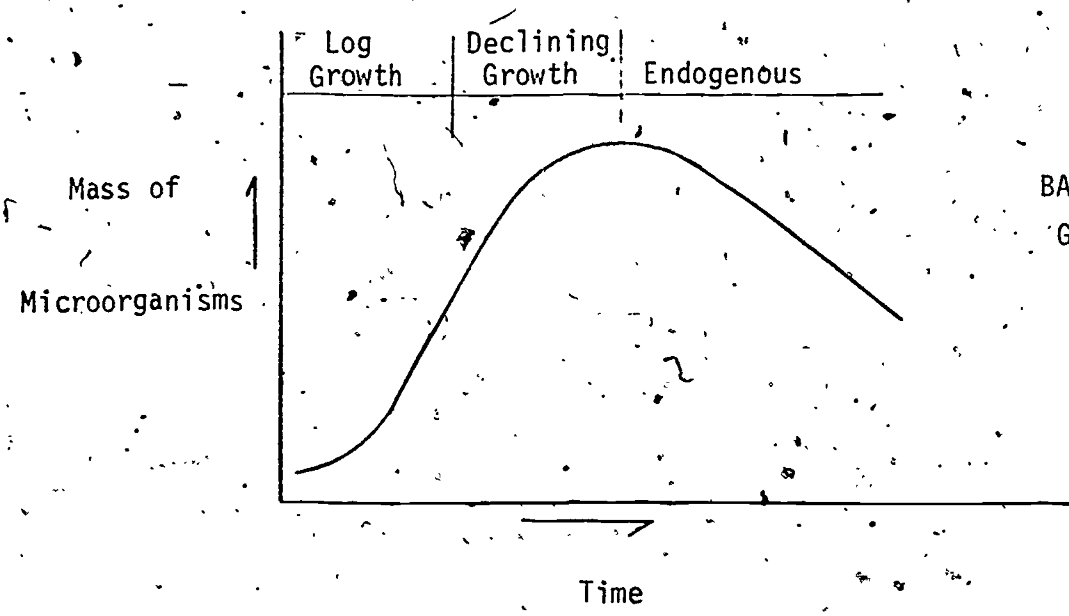
$$2\ NH_4^+ + 3\ O_2 \xrightarrow[\text{Nitrosomonas}]{\text{bacteria}} 2\ NO_2^- + 4\ H^+ + 2H_2O$$

$$2\ NO_2^- + O_2 \xrightarrow[\text{Nitrobacter}]{\text{bacteria}} NO_3^- + 2N^+ + H_2O$$

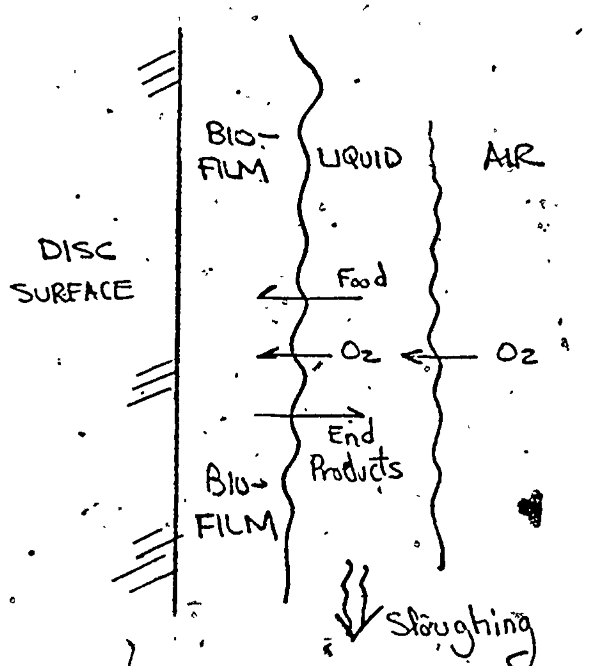
OVERALL REACTION:

$$NH_4^+ + 2\ O_2 \longrightarrow NO_3^- + 2N^+ + H_2O$$

4.6 mg/l of oxygen is required to oxidize 1 mg/l of ammonia-nitrogen when synthesis of nitrifiers is neglected.



BACTERIAL GROWTH CURVE



FIXED FILM BIO-ACTIVITY (Attached Growth)

ROTATING BIOLOGICAL SURFACE REACTOR

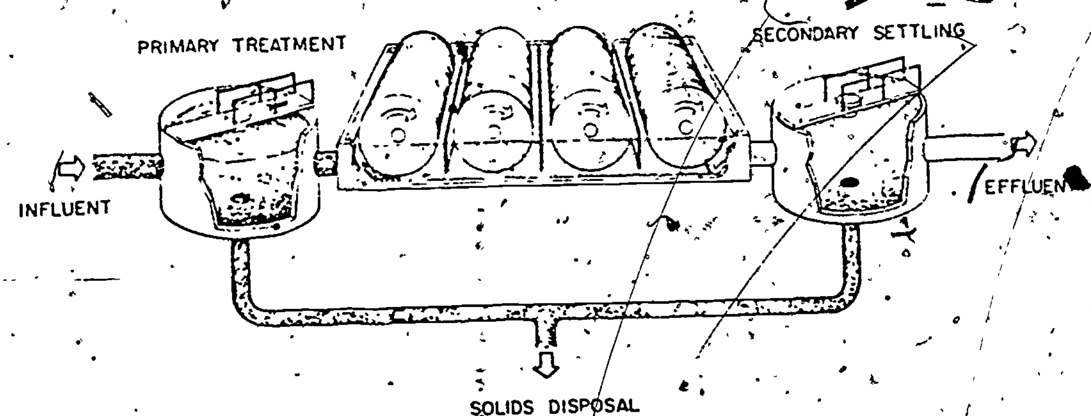


FIGURE 10-5. Rotating biological reactors should be preceded by pretreatment and followed by secondary sedimentation.

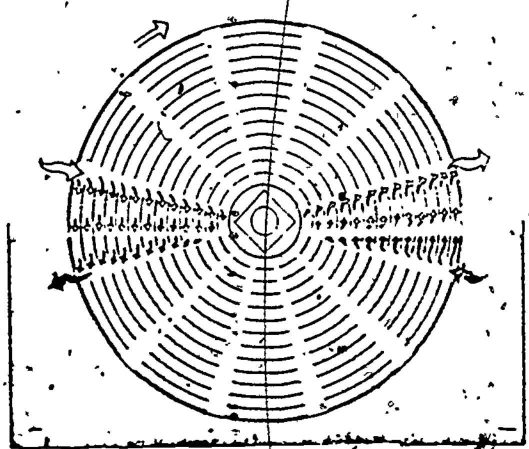
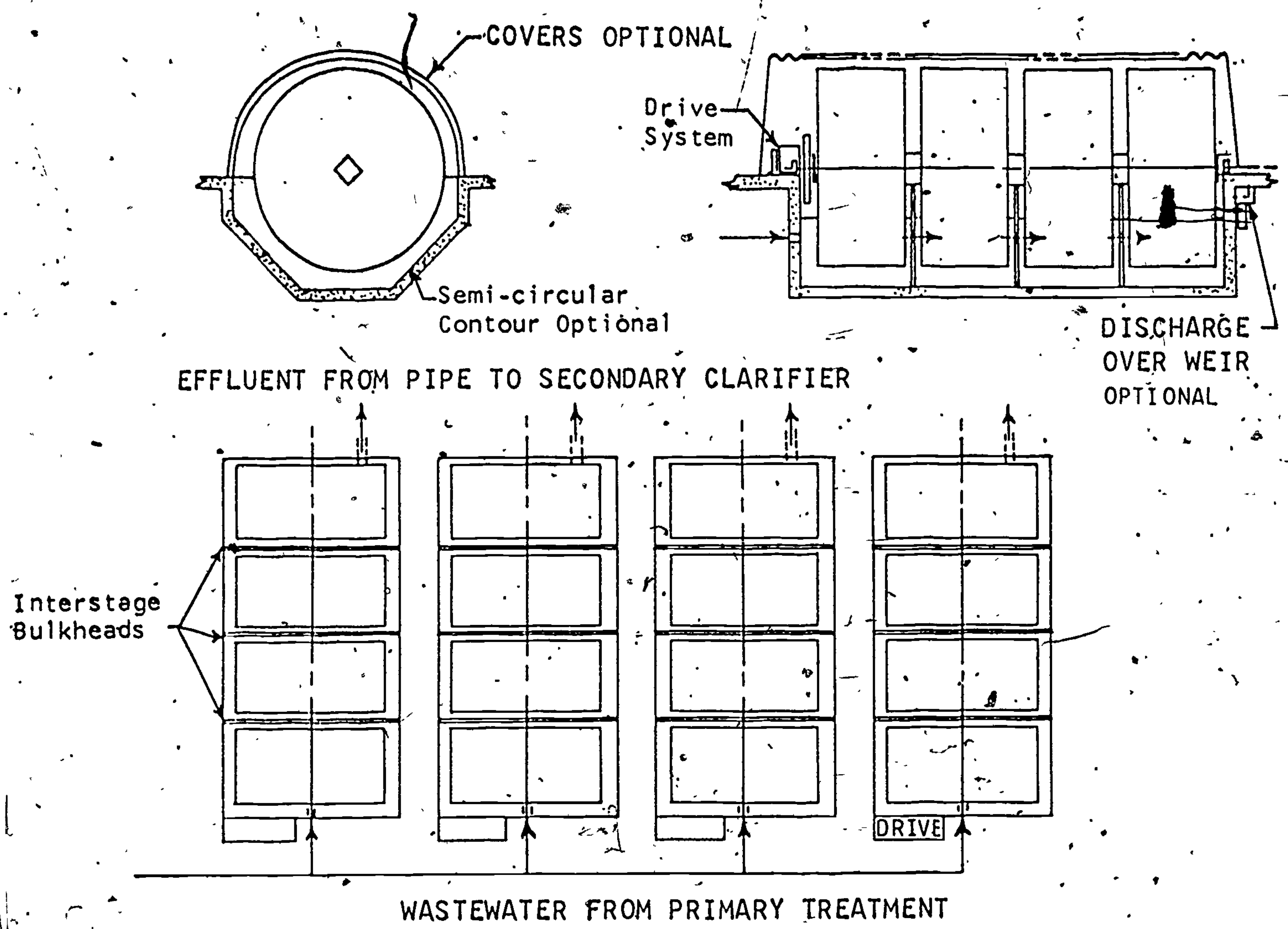


FIGURE 10-4. Reactor carries film of wastewater into the air. Wastewater trickles down the surface and absorbs oxygen from the air.

TYPICAL RBS CONFIGURATION



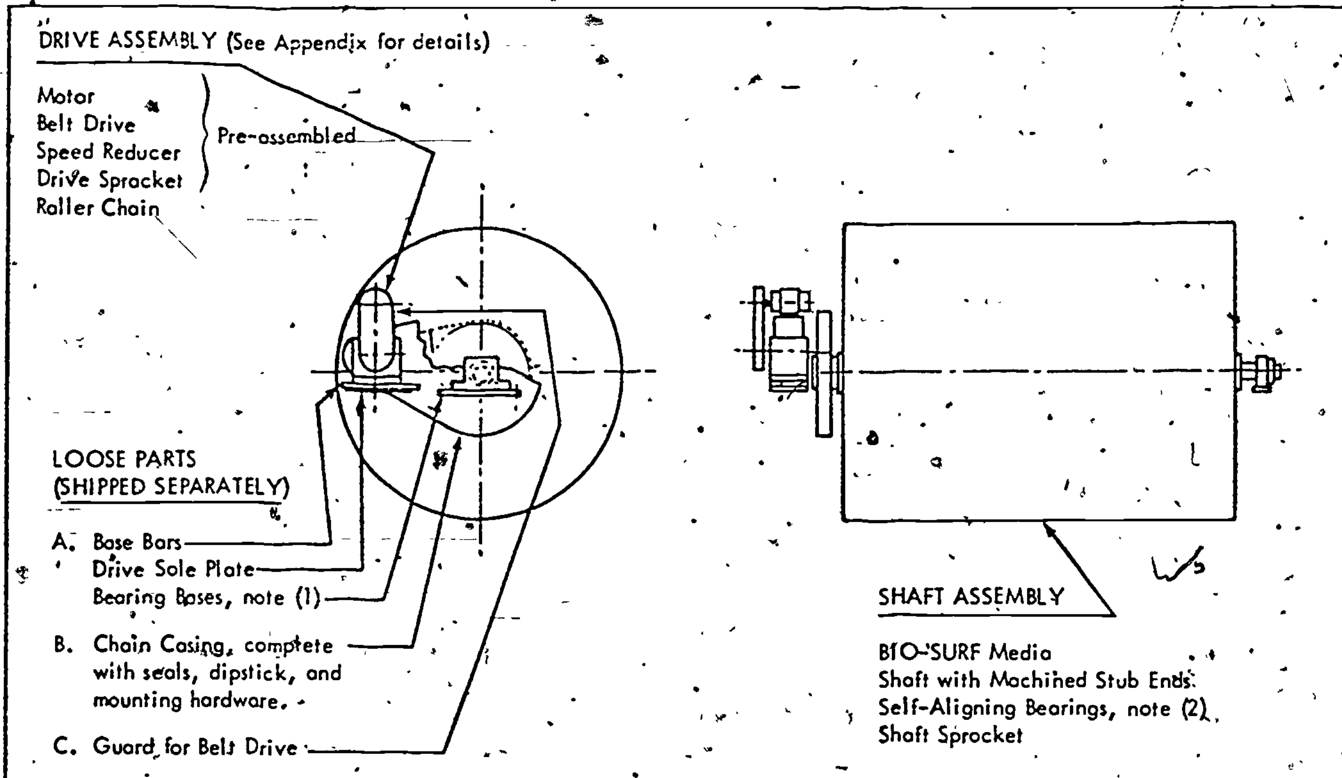
AUTOTROL CORPORATION
BIO-SYSTEMS DIVISION

Figure E-1

CONFIGURATION NO. 1
FOUR-STAGE BIO-SURF SHAFTS IN PARALLEL

Drg. No. A-0025

TRANS ID - 12

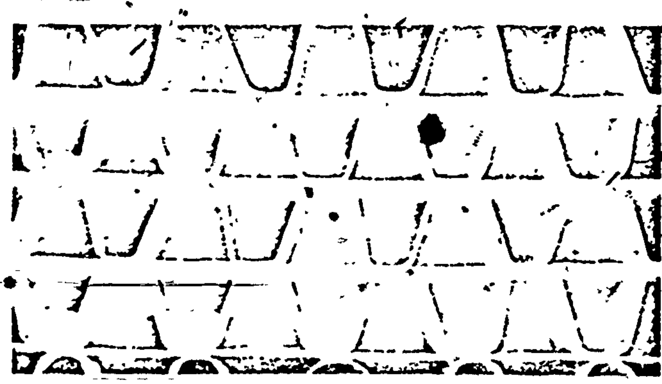


(1) Bearing base for drive end differs from base for idle end.

(2) Drive side bearing is non-expansion type. Idle end bearing is expansion.

BIO-SURF Media

The photo shows a cross-section of the BIO-SURF media. It consists of alternating flat and corrugated sheets of polyethylene which are thermally bonded for strength and long service life. The corrugated sheets are vacuum-formed with integral radial passages. The radial passages allow a free flow of wastewater, air and stripped biomass in and out of the media as it rotates.



PROCESS DESCRIPTION*

The BIO-SURF process is a secondary biological treatment system. It consists of from 2 meter to 12-foot diameter corrugated polyethylene media, which is mounted on a horizontal shaft up to 20 feet long and placed in a steel or concrete tank. The media is rotated at 1.5-3 rpm while about 40% of the surface area is immersed in wastewater.

Shortly after start-up, microorganisms begin to grow on the surface of the media. One to two weeks later, the entire surface area is covered with a 2-4 mm thickness of biomass.

Rotation of the media alternately contacts the biomass with the wastewater for removal of organic materials and exposes it to the air for absorption of oxygen. The amount of attached biomass is relatively large compared to the amount of wastewater under treatment -- the equivalent of 10,000 to 20,000 mg/l of mixed liquor volatile solids. This allows high degrees of treatment to be achieved for relatively short retention times -- usually about one hour for most treatment requirements.

Rotation of the media at a peripheral velocity of 1.0 foot per second exerts shearing forces on the biomass which strips excess biological growth and prevents clogging. The mixing action of the media keeps stripped biological solids in suspension until the flow of treated wastewater carries them to a clarifier for separation and disposal.

Excerpts from Autotrol Publications

Power Requirements	-	0.3 hp-hr per pound BOD removed
Effluent Quality	-	Some applications can achieve effluents of less than 10 mg/l BOD and suspended solids and less than 1 mg/l of ammonia nitrogen
Settling	-	Solids settling rate 10 to 15 ft/hour. Low solids loadings. Can achieve 3 to 4% sludge solids
Modules	-	Can be of modular construction to aid expansion

*From Autotrol Corporation publications

VARIATION IN FLOW AND STRENGTH

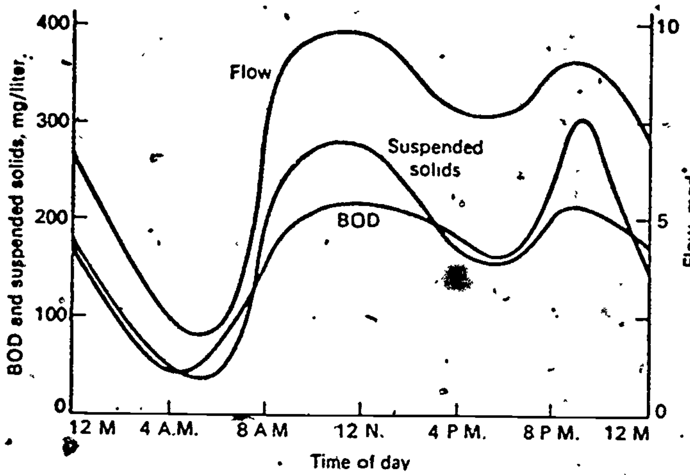


FIG. 7-1 Typical hourly variation in flow and strength of domestic sewage.

BIO-SURF Process Design Criteria

HYDRAULIC LOADING

BIO-SURF process design criteria have been established through extensive pilot plant testing in the United States since 1965, and from more than ten years of operating experience in Europe.

A list of technical publications from the U.S. and Europe which form the basis for conclusions reached regarding design criteria, is contained in the Appendix of this manual, Chapter H.

The BIO-SURF process has been found to demonstrate first order kinetics for the removal of carbonaceous BOD, oxidation of ammonia nitrogen, and removal of ultimate oxygen demand. This means that at a specific hydraulic loading, a specific percentage removal of BOD will occur regardless of BOD concentration. This has been demonstrated on domestic wastewater over a BOD concentration range of 80 to 600 mg/1. Because of this, the primary design criterion is hydraulic loading. To simplify design calculations, hydraulic loading is expressed as flow per unit time, per unit of surface area covered by biological growth, or gallons per day/square foot (GPD/Ft^2). It would seem that retention time would be the means of determining hydraulic loading. However, since actual retention time can be calculated only by estimating the void volume of biomass covered media, and cannot be directly translated into a requirement for a specific amount of rotating equipment, hydraulic loading on the biomass covered surface is used for determining equipment requirements (See Figure B-3a). Therefore, the main effort associated with design and selection of BIO-SURF equipment for any wastewater treatment application is to determine the requirement for growth covered surface area. Chapters C and D contain a detailed discussion of design procedures for domestic and industrial wastewaters.

Other processes for biological wastewater treatment use organic loading as lb BOD/day/1000 Ft^3, or a food to microorganism ratio as lb BOD/day/lb MLVSS as the primary design criterion. Because of first order behavior, hydraulic rather than organic loading is the primary factor in BIO-SURF process performance. Although the food to microorganism ratio is an important factor in the BIO-SURF process, it is self-regulating because the attached biomass in each stage will develop to a thickness in proportion to the concentration of organic matter present. Therefore, food to microorganism ratio is not used as a criterion of process design.

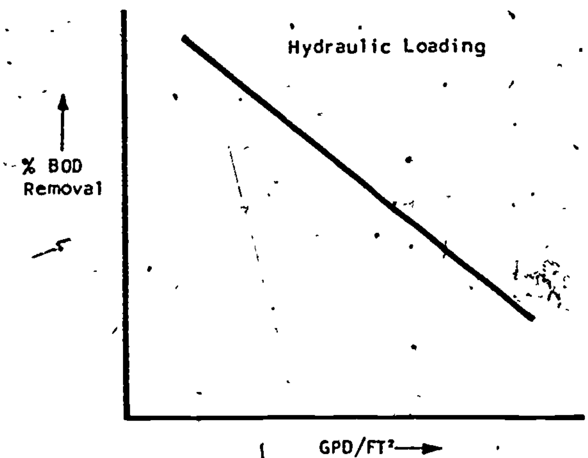


Figure B-3a

STAGING AND PLANT ARRANGEMENT

The arrangement of media in a series of stages has been shown to significantly increase treatment efficiency (Figure B-3b). This occurs for two reasons. First, the development of specific microbial cultures in the successive stages of media which are adapted to the wastewater characteristics in each stage. With domestic wastewater, the latter stages of media develop nitrifying organisms which oxidize ammonia nitrogen. Secondly, because the BIO-SURF process exhibits first order kinetics, the improved residence time distribution (i.e., more closely approaching "plug flow") obtained with staging increases the BOD removal rate. In "plug flow" operation, organisms in the first stage of media are exposed to a high BOD concentration and respond by removing BOD at a high rate. As the BOD concentration decreases from stage to stage, the rate at which the organisms remove BOD, also decreases. The average BOD removal rate is greater than if all the media were in a single completely mixed stage where all organisms are exposed to a relatively low BOD concentration.

Thus, it has been found necessary to construct BIO-SURF plants in at least four stages to

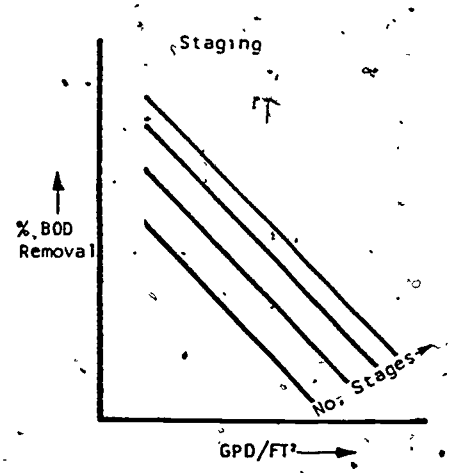


Figure B-3b

most effectively utilize the surface area. For treatment plants requiring many shafts of media, convenient plant layout often calls for more than four stages in series. This can be done without fear of overloading the first stage on domestic wastewater and will result in a slight increase in treatment efficiency.

Treatment plants, requiring four or more BIO-SURF process shafts are arranged so that each shaft is an individual stage of treatment. The shafts are arranged in series and the wastewater flow is perpendicular to the shafts. For plants where fewer than four shafts are required, they can be arranged in parallel. Each tank containing a shaft is divided into stages with crosstank bulkheads along its length, and wastewater flow is parallel to the shaft. Each bulkhead has a submerged orifice, and each section of media between bulkheads acts as a separate stage of treatment. Tests have shown that each stage is completely mixed, and that there is no difference in treatment capacity using either shaft arrangement. Plant layout options are shown in Chapter E.

EFFLUENT BOD CHARACTERISTICS

Effluent from a BIO-SURF unit providing nitrification contains nitrifying organisms. Because of this, significant nitrification occurs during a 5-day BOD test on the effluent. In BOD tests where allylthiourea was added to dilution water to suppress nitrification, it has been shown that a BIO-SURF process effluent of 30-40 mg/l total BOD_5 or less is approximately 50% carbonaceous and 50% nitrogenous BOD. This relationship is valid for effluents as low as 8-10 mg/l total BOD_5. Below this BOD level, nitrification is essentially complete and the proportion of carbonaceous BOD increases. This is shown graphically in Figure B-3c. Total BOD_5 removals of 85% and 90% then correspond to carbonaceous BOD_5 removals of approximately 90% and 95% respectively.

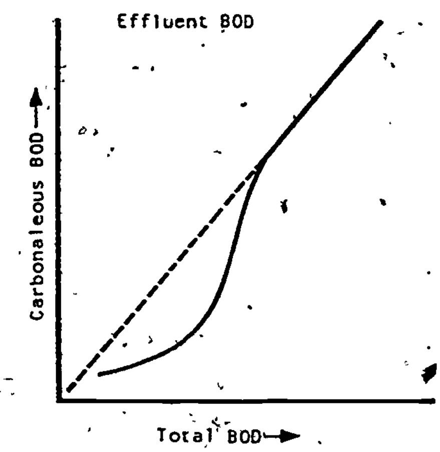


Figure B-3c

MEDIA ROTATION

Rotational velocity of the media is also an important design criterion. Testing of various diameter media indicates that peripheral velocity can be used to select the required rotational velocity for any diameter.

Rotational velocity affects wastewater treatment in several ways: it provides contact between the biomass and the wastewater, it aerates the wastewater, and it provides energy to thoroughly mix the wastewater in each stage. Increases in rotational velocity increase the effect of each of these factors. However, there is an optimum rotational velocity above which further increases in these factors no longer increase treatment levels. This optimum velocity will vary with wastewater BOD concentration, i.e., the optimum velocity is higher for concentrated industrial wastes and lower for domestic waste, (See Figure B-4a). Also, the optimum rotational velocity will decrease from stage to stage in a BIO-SURF treatment plant as the BOD

TYPICAL DESIGN CRITERIA - III

concentration decreases from stage to stage. It has been found that when all stages of discs in the plant rotate at the same velocity, the optimum peripheral velocity for domestic wastewater is 60 ft/min. This is true for BOD removal and nitrification.

Since power requiremments increase exponentially with increases in media velocity, there is a practical upper limit of rotational velocity used for industrial waste treatment. The ability to maintain a large attached culture is not a factor in selecting rotational velocity. Pilot plant testing at velocities well above practical limits on the basis of power consumption (400 to 500 ft/min.) have shown no loss in the amount of biomass.

The direction of media rotation has no effect on treatment efficiency and is not a factor in selecting rotational velocity. In a multi-shaft installation, the immersed portion of the media is rotated in the same direction as the wastewater flow to minimize the hydraulic head loss through the plant and minimize backmixing between adjacent stages.

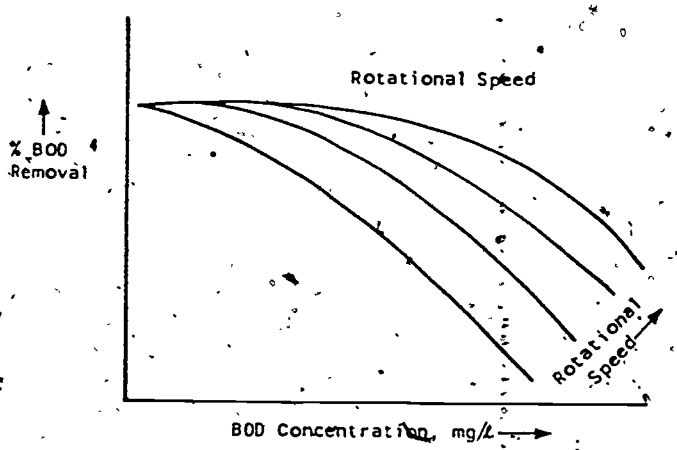


Figure B-4a

TANK VOLUME

An important factor affecting performance of the BIO-SURF process is the retention time of the wastewater within the tanks containing the discs. At a given hydraulic loading, as GPD/Ft², the wastewater will have a given retention time depending upon the void fraction of the media, and the size of the tank containing the media. Increasing void fraction of the media or increasing the tank size will all increase the amount of wastewater held within the tank.

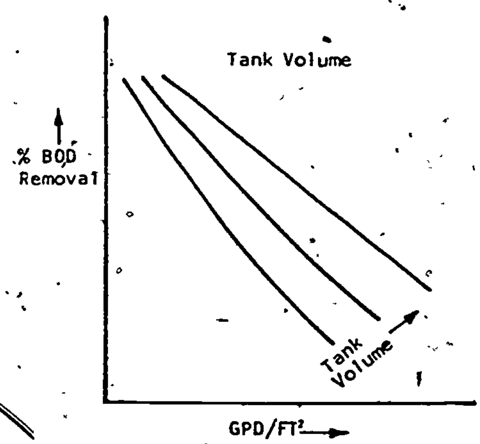


Figure B-4b

This will increase the retention time at a given hydraulic loading and will, therefore, increase performance. Extensive testing using various void fractions and tank sizes has led to the conclusion that there is an optimum tank volume which maximizes the treatment capacity of the growth covered surface, (See Figure B-4b). For purposes of plant design, this tank volume is measured as wastewater volume held within a tank containing a shaft of media per unit of growth covered surface on the shaft, or gallons per square foot (Gal/Ft²). The optimum tank volume determined for domestic wastewater treatment is 0.12 Gal/Ft² taking into account displacement by the growth covered media. Therefore, all large scale BIO-SURF process layouts described in subsequent sections of this manual use this tank volume. The use of tank volumes in excess of 0.12 Gal/Ft² does not yield corresponding increases in treatment capacity when treating domestic wastewater. Where low wastewater temperatures are encountered, improved wastewater treatment will be achieved by providing tank volumes in excess of 0.12 Gal/Ft². Details on this technique will be discussed in more detail in the design Chapters C and D of this manual.

WASTEWATER TEMPERATURE

Wastewater temperature affects BIO-SURF process performance just as it does all biological wastewater treatment processes. Wastewater temperatures between 55 and 85° F have no affect on BIO-SURF process performance. When wastewater temperatures decrease below 55°F, the treatment efficiency will also decrease. (See Figure B-4c).

If wastewater flows are sufficiently lower during periods of low wastewater temperatures, then treatment efficiency will be maintained. In cases where low wastewater temperature is due to sewer infiltration or run-off from rainfall, the conditions of lower temperature will not coincide with lower flows. Then, treatment efficiency will not be maintained. (Infiltration, however, will generally dilute the raw wastewater so that while percentage removal may decrease, the effluent concentration may not be materially affected. Also, discharge standards for a receiving body may not be as stringent under cold weather conditions). If it is required that a given percentage treatment or maximum effluent quality be maintained under all conditions, then it will be necessary to design the BIO-SURF plant to offset the effect of the low wastewater temperature.

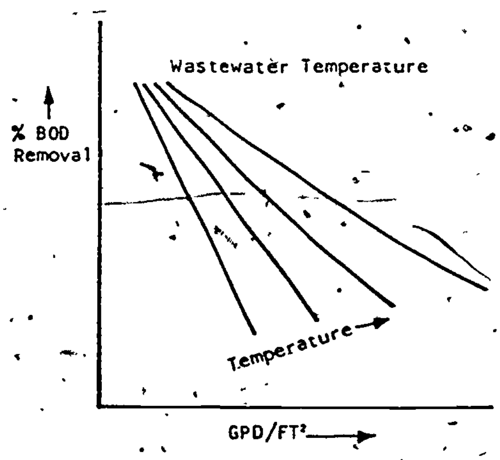


Figure B-4c

ENCLOSURES

Year round operation in northern climates requires that BIO-SURF plants be covered to protect the biological growth from freezing temperatures. Some industrial wastes have inherent odor problems. The enclosure for the BIO-SURF process plant will facilitate odor control measures.

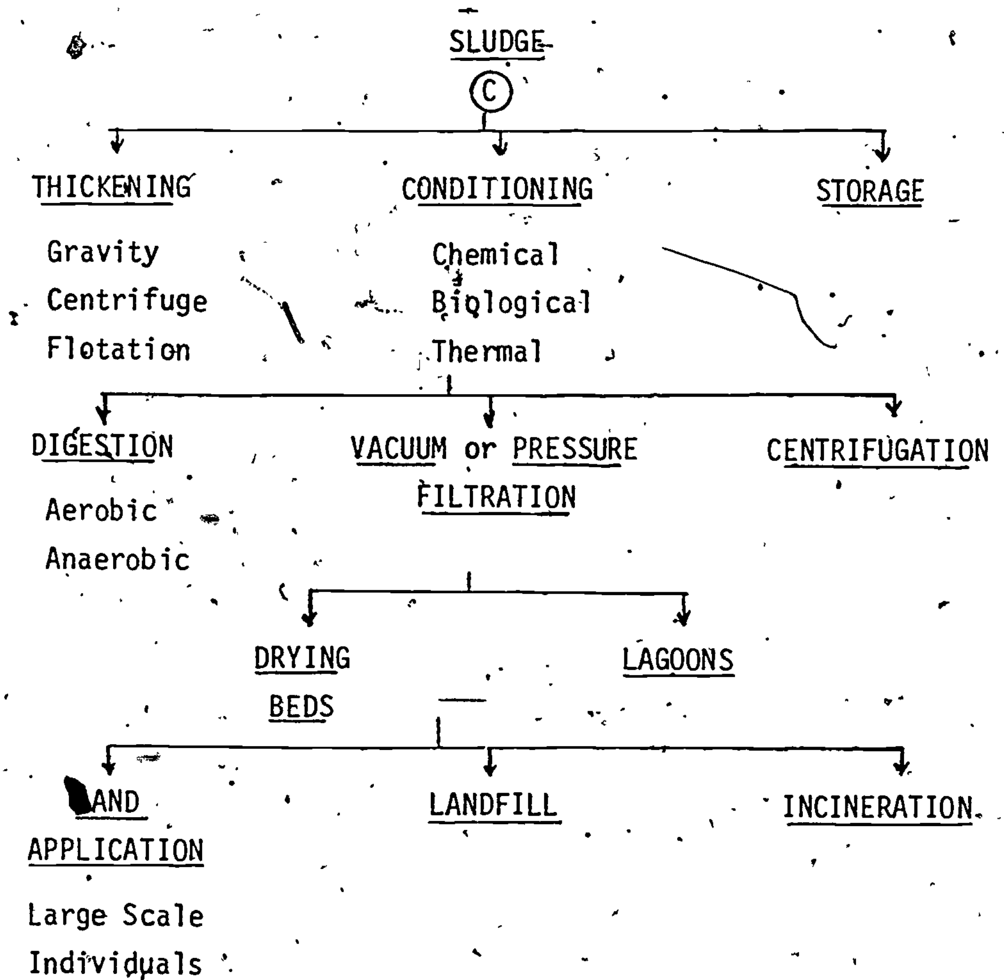
Installations in southern climates, or installations in northern climates which operate during the warmer seasons only (such as recreational areas), need not be covered except for aesthetic reasons.

Wind cannot damage the media and precipitation cannot remove the biomass from the corrugated media.

Enclosures can be constructed of any suitable corrosion resistant material. Heating or forced ventilation are not necessary. Windows or simple louvered mechanisms which are opened in the summer and closed during the winter, provide adequate ventilation. Air within the enclosure is at a temperature approximately equal to that of the wastewater. At very low ambient air temperatures, the high humidity within the enclosure will result in condensation on the walls and ceiling. To minimize corrosion within the enclosure and increase operator comfort, the condensation can be eliminated by insulating the enclosure or heating the air within the enclosure. Because condensation will occur only during cold weather, heating will generally be more economical.

To reduce the cost of enclosing a BIO-SURF plant, Autotrol has developed a molded plastic cover with thermal insulation which can be supplied as an integral part of a BIO-SURF shaft assembly. This enclosure minimizes the area to be covered and eliminates the need for the operator to enter the enclosure. This also eliminates the need for heating. Ventilation is provided by louvered openings in the ends. More details on the design of this cover are presented in Chapters E and F.

SLUDGE TREATMENT & DISPOSAL



BIO-MODULE UNITS

Description

A BIO-MODULE unit is a packaged wastewater treatment plant designed to treat domestic or industrial sewage through a process where fixed aerobic cultures of microorganisms remove both dissolved and suspended organic matter from the wastewater. A BIO-MODULE unit consists of a wet well, rotating bucket feed mechanism, and multi-stage BIO-SURF media incorporated into a semi-circular steel tank. The BIO-MODULE unit is intended to operate in conjunction with primary treatment, secondary clarifier and sludge disposal facilities.

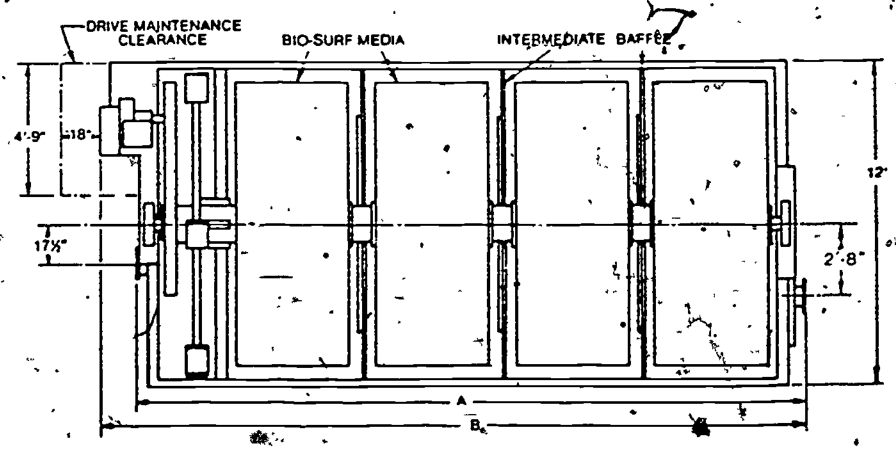
Operation

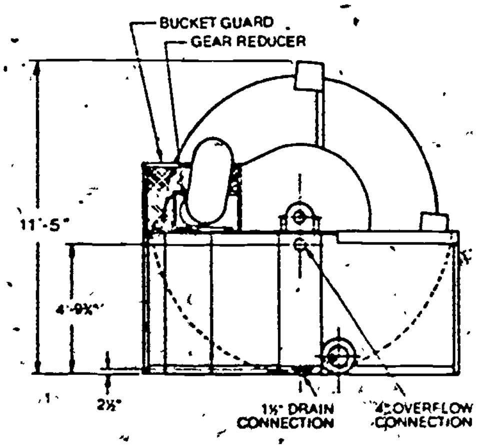
After pretreatment, wastewater enters the BIO-MODULE wet well where it is picked up by the rotating buckets. The buckets are attached to the main shaft by hollow arms. As the bucket is raised to the same elevation as the shaft, the wastewater flows down the hollow arm and is discharged parallel to the shaft over a bulkhead into the first stage of the BIO-SURF process treatment.

After entering the first stage of the BIO-SURF process, wastewater passes through a submerged orifice in the center of each bulkhead separating individual stages of treatment. Mixed liquor from the last stage of media passes over a weir and flows to a secondary clarifier.

BIO-MODULE	3.2m		
MODEL NO.	621-104	621-154	621-204
Effective media area (ft²)	23 000	39 500	56 000
Operating wt (lb)	53 000	73 000	94 000
Shipping wt (lb)	16 000	20 000	24 000
Motor horsepower*	1½	2	3
A	15'-3½"	20'-3½"	25'-3½"
B	16'-6½"	21'-6½"	26'-6½"
Bucket pump capacities with 1, 2, 3 or 4 buckets (GPD)	22,500 45 000 67 500 90,000		

*230/460V three phase open drip-proof enclosure. Other options available





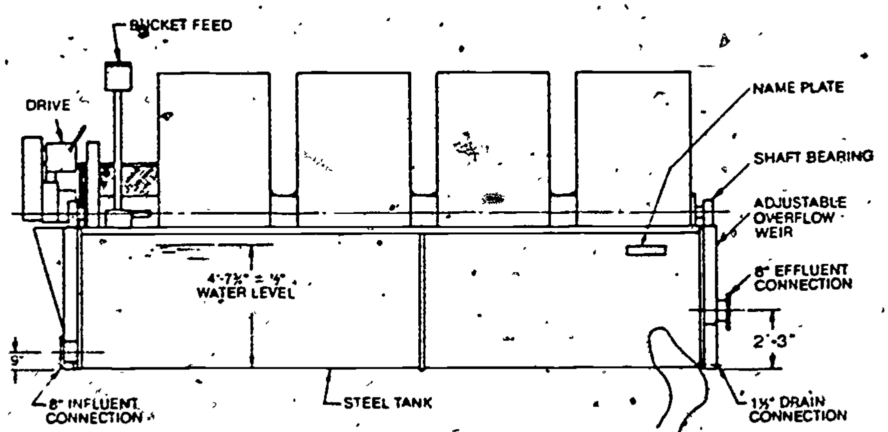


TABLE 10-I. Preventive Maintenance Guide

Procedure	Interval				
	Weekly	Monthly	Quarterly	Semiannually	Annually
Check contactor shaft bearings. Feel to see if they are running hot. Listen for unusual noises. This includes any pillow block on output of speed reducer.	X				
Feel motors to see if they are running hotter than design temperature. Check area around the drive train and shaft bearings for oil spills.	X				
Check oil levels in speed reducer and chain drive system.	X				
Lubricate contactor shaft bearings. Consult manufacturer's instructions.		X			
Check chain drives for alignment and tightness.			X		
Check belt drives (if any) for alignment and tightness.			X		
Coat machined ends of contactor shaft with grease in case these ends do not have permanent coating.			X		
Adjust contactor shaft bearings. This includes any pillow block on the reducer output.			X		
Change lubricant for chain drive system.				X	
Change oil in speed reducer. Clean magnetic drain plug, if any.					X
Replace the grease in the seals (if any) in the speed reducer. Consult manufacturer's instructions.					X
Grease bearings in the electric motor (if applicable). Consult manufacturer's instructions.					X

LUBRICATION AND PREVENTATIVE MAINTENANCE CHART

PROCEDURE	INTERVAL Daily	Weekly	4 wk.	3 mo.	6 mo.	12 mo.
1. Check for hot mainshaft and drive package output bearing (3 HP drive only). If too hot for hand, use pyrometer. Replace bearings if temperature exceeds 200°F.	X					
2. Check for unusual noises in mainshaft and reducer output bearings.	X					
3. Grease the mainshaft bearings and drive package output bearing (3 HP drive only). See Table 3, Recommended Lubricants, for proper lubricants. Add grease slowly while shaft rotates. When grease begins to come out of seals, the bearings contain the correct amount of grease. Add six full strokes where bearings cannot be seen.		X				
4. Inspect all chain drives, see MAINTENANCE INSTRUCTIONS.			X			
5. Inspect mainshaft bearings and drive package output bearing (3 HP drive only). See MAINTENANCE INSTRUCTIONS.			X			
6. Apply a generous coating of general purpose grease to mainshaft stub ends, mainshaft bearings and end collars.			X			
7. Change oil in chain casing. See Table 3, Recommended Lubricants. Be sure oil level is at or above the mark on the dipstick.				X		
8. Inspect belt drive (drive package), see MAINTENANCE INSTRUCTIONS.				X		
9. Change oil in speed reducer. See Table 3, Recommended Lubricants for correct oil.					X	
10. Clean magnetic drain plug in speed reducer.					X	
11. Purge the grease in the double-sealed shaft seals of the speed reducer by removing the plug located 180 degrees from the grease fitting on both the input and output seal cages, pump grease into the seal cages and replace plug. See Table 3, Recommended Lubricants for proper grease.					X	
12. Grease motor bearings, see Table 3, Recommended Lubricants, and OPERATING INSTRUCTIONS, U.S. ELECTRICAL MOTORS (in appendix). To grease motor bearings, stop motor and remove drain plugs. Inject new grease with pressure gun until all old grease has been forced out of the bearing through the grease drain. Run motor for approximately five minutes to relieve bearing of excess grease. Replace drain plugs.						X

STATE OF IOWA
DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY MANAGEMENT DIVISION

OPERATION PERMIT SYSTEM
MONTHLY MONITORING REPORT

FACILITY NAME ______ EMMETSBU
FACILITY NUMBER ______
DISCHARGE SERIAL NUMBER ______

______ MONTH ______ YEAR

DATE		PRECIPITATION INCHES/DAY	GENERAL				RAW SLUDGE			BOD (5 DAY 20° C)						SUSPENDED SOLIDS						SETTLEABLE SOLIDS ML/L				AMMONIA NITROGEN				pH		EFFLUENT DISSOLVED OXYGEN MG/L	EFFLUENT FECAL COLIFORM NO./100 ML	EFFLUENT RESIDUAL CHLORINE MG/L	RECEIVING STREAM FLOW-CFS
			RAW SEWAGE TEMPERATURE	TOTAL FLOW 1,000'S GPD	BY-PASSED 1,000'S GPD	RECIRCULATION 1,000'S GPD	GALLONS PUMPED 100'S GPD	TOTAL SOLIDS	VOLATILE SOLIDS	INFLUENT MG/L	INFLUENT LBS/DAY	PRIMARY EFFLUENT MG/L	R.B.S. EFFLUENT MG/L	FINAL EFFLUENT MG/L	FINAL EFFLUENT LBS/DAY	INFLUENT MG/L	INFLUENT LBS/DAY	PRIMARY EFFLUENT MG/L	R.B.S. EFFLUENT MG/L	FINAL EFFLUENT MG/L	FINAL EFFLUENT LBS/DAY	INFLUENT	PRIMARY EFFLUENT	R.B.S. EFFLUENT	FINAL EFFLUENT	INFLUENT MG/L	INFLUENT LBS/DAY	FINAL EFFLUENT MG/L	FINAL EFFLUENT LBS/DAY	INFLUENT	FINAL EFFLUENT				
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TOTAL																																			
AVG																																			
MAX																																			
MIN																																			

TRANS ID - 24

INFLUENT 24 HOUR SAMPLE COLLECTION (000)

BOD_5 ______ MG/L ______ LBS/DAY(5)(76024)
SUSPENDED SOLIDS ______ MG/L ______ LBS/DAY(5)(74024)
AMMONIA NITROGEN ______ MG/L ______ LBS/DAY(5)(70424)
FLOW ______ MILLION GALLONS/DAY(74324)

EFFLUENT 24 HOUR SAMPLE COLLECTION (001)

BOD_5 ______ MG/L ______ LBS/DAY(5)(76024)
SUSPENDED SOLIDS ______ MG/L ______ LBS/DAY(5)(74024)
AMMONIA NITROGEN ______ MG/L ______ LBS/DAY(5)(70424)
FECAL COLIFORM ______ ORGANISMS/100 ML (76324)

SIGNATURE OF EXECUTIVE ______

TITLE ______

ROTATING BIOLOG

3. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

(a) During the period beginning on the date of issuance and lasting through June 30, 1981 the permittee is authorized to discharge from outfall serial number 001.

Such discharge shall be limited and monitored by the permittee as specified:

Wastewater Parameter	Effluent Limitations kg/day (lbs/day) Daily Avg	Max	Other Units (Specify) Daily Avg	Max	Monitoring Requirements Measurement Frequency	Sample Type	Sample Location*
Flow m³/day (MGD)	-	-	2082(0.55)	3123(.825)	Daily	-	1 or 2
BOD (5-day)**	21(46)	31(69)	10 mg/l	15 mg/l	1/month	24-hr. Composite	1,2
Suspended Solids**	42(92)	62(138)	20 mg/l	30 mg/l	1/month	24-hr. Composite	1,2
Ammonia Nitrogen (as N)**	4(9)	10(23)	2 mg/l	5 mg/l	1/month	24-hr. Composite	1,2
Fecal Coliform**	-	-	-	-	1/3 months	Grab	2
BOD (5-day)	-	-	-	-	2/week	6-hr. Composite	1,2,3
Ammonia Nitrogen (as N)	-	-	-	-	2/week	6-hr. Composite	1,2,3
Settleable Solids	-	-	-	-	3/week	Grab	1,2,3
pH	From 6.5 to 9.0				3/week	Grab	1,2
Dissolved Oxygen	-	-	-	-	3/week	Grab	2
Temperature	-	-	-	-	3/week	Grab	1,3
Residual Chlorine @	-	-	-	-	3/week	Grab	2
EQAP***	-	-	-	-	Monthly	Grab	2

TRANS ID - 25

@Disinfection shall be practiced from April 1 through October 31 and the monitoring performed as specified.

There shall be no discharge of floating or settleable substances in other than trace amounts.

*Samples collected as specified in the monitoring requirements shall be taken at the following location(s):

1 - raw wastewater influent to the treatment facility
2 - final effluent from the treatment facility
3 - effluent from final clarifier.

**These analytical values shall be recorded in the special spaces provided on the Records of Operation report form.

***Sample submitted for the Effluent Quality Analysis Program (EQAP) conducted in accordance with Chapter 18 of the Rules of the Iowa Department of Environmental Quality (1975 Iowa Administrative Code).

45

TRANS ID - 26

TYPICAL CALCULATIONS - I

PLANT DATA   Flow: 2.0 mgd

Suspended Solids: Inf. - 240 mg/l

Pri. Eff. - 100

Final - 20

BOD: Final Effluent - 20 mg/l

Final Clarifier - 65 ft. in diameter
8 ft. depth

I. DETERMINE THE PER CENT REMOVAL OF SUSPENDED SOLIDS

A. Primary Settling:

$$\% \text{ Rem.} = \frac{240 - 100\ (100)}{240} = 58\%$$

B. Total Plant:

$$\% \text{ Rem.} = \frac{240 - 20\ (100)}{240} = 92\%$$

TRANS ID - 27

TYPICAL CALCULATIONS - II

II. IF THE HYDRAULIC LOADING IS 2.0 gpd/ft^2, WHAT MEDIA IS REQUIRED?

$$\text{Area} = \frac{(2{,}000{,}000)}{2} = 1{,}000{,}000 \text{ ft.}^2$$

III. WHAT IS THE OVERFLOW RATE ON THE FINAL CLARIFIER?

$$\text{Area} = 3.14 \frac{(65)}{2} \frac{(65)}{2} = 3317 \text{ ft.}^2$$

$$\text{Overflow Rate} = \frac{2{,}000{,}000}{3317} = 603 \text{ gpd/ft.}^2$$

IV. WHAT IS THE DETENTION TIME IN THE CLARIFIER?

$$\text{Time} = \frac{\text{volume}}{\text{flow rate}} \qquad V = (3317)\ (8)\ (7.48)$$

$$V = 198{,}490 \text{ gallons}$$

$$T = \frac{198{,}490}{2{,}000{,}000/24} = 2.4 \text{ hours}$$

V. HOW MANY POUNDS PER DAY OF BOD ARE DISCHARGED?

lbs. = (flow rate) (conc) (8.34) = (2.0) (20) (8.34) = 334 lbs/day
mgd ppm

STUDENT-PARTICIPANT GUIDE

for

Training Module II3JWW

Intermediate Rotating Biological Surface

II3JWW INTERMEDIATE ROTATING BIOLOGICAL SURFACE OPERATION

STUDENT OUTLINE

Note: Participants will receive a copy of each transparency used in the presentations. Participants should own or receive WPCF Manual of Practice No. 11 Operation of Wastewater Treatment Plants. Appropriate chapters in the Manual should be studied for each topic.

Autotrol and other manufacturers will be contacted to obtain technical brochures and process description supplements for the participants.

I. Review of Wastewater Treatment Systems and Process Performance Parameters

A. Review typical wastewater treatment systems (Trans ID-1).

B. Note the purpose of individual treatment processes and their performance-water quality change.

1. Especially review the performance of pre-treatment processes that are utilized ahead of fixed-film biological processes.

2. Observe the performance and factors that affect sedimentation processes e.g., final settling tanks.

C. Compare the role of RBS Units to that of trickling filters and activated sludge units (Trans ID-1, ID-2)

D. Review the common water parameters in wastewater treatment. (Trans ID-3, ID-4, ID-5, ID-6)

1. Note the meaning and significance of the parameter.

2. Review appropriate analytical techniques.

3. Especially note the nitrification effects in BOD analysis.

II. Basic Biology and Biological Systems (Trans ID-7, ID-8, ID-9, ID-10)

A. Study the various types of bacterial activity and growth rates.

B. Note the significance of food to microorganism ratios and the source of carbon for the bio-activity in a RBS system.

C. Note nitrification (aerobic) and denitrification (anaerobic). Also note the biological release of NH_3 from protein and the use of nitrogen in cell synthesis.

D. Relate cell synthesis to sloughing or loss of bio-solids.

E. Review and study the different types of organisms and what they indicate about the system e.g.

1. Conditions favoring filamentous organisms.

2. Conditions favoring rotifers.

III. RBS System: Purpose; functions; components (Trans ID-11, ID-12, ID-13, ID-14)

A. Study the RBS system layout, configuration and component parts.

B. Note how the process functions and the typical performance of the system regarding BOD, Suspended Solids and Ammonia reduction.

C. Study the nature of the bio-mass; its formation appearance and removal from the disk.

D. Observe typical systems (Slides DS-1 thru DS-17).

IV. RBS System: Factors Affecting Performance (Trans ID-15)

A. Study the pre-treatment factors that affect performance

1. Solids carryover from primary - flow interference and odor production.

2. Increased organic loads - bio-growth and effluent quality.

3. Flow variation - affect on hydraulic loading of disks and settling tanks.

4. Toxics - interference with biological activity.

B. Note the effects of certain water quality parameters

1. BOD reduction is not as sensitive to pH as is nitrification (pH in the 8.0 to 8.6 range desired).

2. Low temperatures decrease rate of BOD reduction and nitrification - housing units and lower hydraulic loadings.

3. Alkalinity is reduced due to CO_2 utilization in nitrification.

4. Note DO and nitrogen form changes in the stages.

V. RBS System: Typical Design Criteria (Trans ID-16, ID-17, ID-18, ID-19)

A. Note the various criteria that affect the design of RBS units and what they are.

B. Note how changes in the various design factors affect BOD reduction <u>and</u> nitrification.

C. Especially note the significance of the hydraulic loading and how it could be adjusted to compensate for changes in wastewater quality parameters e.g., temperature and BOD.

VI. Final settling tank and sludge disposal (Trans ID-14, ID-20)

A. Note the settling properties of RBS solids.

B. Review the primary factors that affect clarifier performance e.g..

1. Overflow rate
2. Detention time

C. Note the quantities and quality of final settling tank sludge and its disposal alternatives.

1. Sludge pumping vs. thickness.
2. Rising sludge and denitrification
3. Sludge storage and/or recycle to primary tanks

VII. Maintenance (Trans ID-21, ID-22, ID-23)

A. Review the components of the system.

B. Review typical maintenance guides.

C. Note appropriate manufacturer's operational and maintenance instructions.

VIII. Reports and Calculations

A. Review typical IDEQ report form and effluent monitoring requirements (Trans ID-24, ID-25).

1. Note type of sampling.

2. Note parameters, units, terminology, etc.

B. Study typical calculations including detention time, hydraulic loading, per cent removal, lbs/day-concentration conversions (Trans ID-26, ID-27).

EXAMINATION QUESTIONS

II3JWW Intermediate
II4OWW Advanced

Note: 1. The questions for the Basic Level Module should be used as desired by the instructor and evaluating group.

2. The topical coverage for the intermediate and advanced modules is generally quite similar. The following questions are provided for use in either module. The instructor and evaluating group can make the appropriate selections.

1. RBS unit performance decreases with very low wastewater temperatures, in the 40's and low 50's (°F). This can be corrected by housing the units in a building (Emmetsburg) and heating the air or by providing ______________________________ initially in the construction of the units.

2. One of the primary advantages cited for the RBS process is its ______________________________

3. What are two pre-treatment requirements for RBS units? ______

(a) ______________________________

(b) ______________________________

T F 4. For a given RBS system-fixed media area-, you could increase the % BOD removal by decreasing the hydraulic loading that is lowering the flow rate to the disks.

5. A procedure that could be utilized to increase BOD removal in the RBS system is

a. Increase the hydraulic loading on the disks
b. Hold the pH between 6.5 to 6.8
c. Increase the number of stages
d. Increase the hydraulic loading on the final clarifier

T F 6. Wastewater temperatures between 55 and 85°F have little or no effect on BIO-SURF (RBS) process performance.

T F 7. The alkalinity of the wastewater can be reduced in RBS systems practicing nitrification.

T F 8. The optimum pH range for nitrification appears to be in the 8.0 to 9.0 range.

9. The rate of nitrification decreases with

a. decreasing DO concentration below 3.0
b. increasing BOD/NH_3 ratio in the wastewater
c. decreases in the wastewater temperature
d. All of the above

T F 10. For a given influent BOD concentration, as you increase the hydraulic loading you decrease the percent ammonia removal.

11. A white filamentous growth on the contactor midea is indicative of

a. High $CaCO_3$ levels
b. Septic wastewater and high H_2S
c. High rotation speed and lime addition

T F 12. pH control is not as critical when BOD removal is the goal. A range of 6.5 to 8.5 will not affect process efficiency.

13. What operating equipment is checked more frequently for maintenance requirements?

Answer the questions following the plant data.

Data: Flow 3.0 mgd - Maximum Flow 4.8 mgd

BODs: Influent 220
Primary Effluent 155
Final Effluent 20

Final Clarifier: 70 ft. in diameter
8 ft. depth

14. Determine the per cent removal of BOD in the primary unit and the whole plant.

15. How many pounds per day of BOD is discharged to the stream?

16. Assume the total bio-disk area is 1,800,000 square feet, calculate the hydraulic loading for average flow and maximum flow conditions?

17. What would happen to plant performance if the maximum flow lasted for several days?

18. Determine the overflow rate and detention time for the final clarifier.

19. If the maximum flow rate was of short duration and occurred frequently, what could be done to modify plant operation without increasing the disk area?