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Building Capacity for Egypt to Respond to UNFCCC Communication Obligations

Climate Change and Waste Management Workshop

Mitigation Potential (Domestic Liquid Waste)

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Presentation Outline

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Annex 1:

Extracted from : Workbook for Waste
Prepared by : National Greenhouse Gas inventory Committee, Australia, 1996

Annex 2:

U.S. EPA
Methane Outreach Program
(On the INTERNET)

1. Emissions of Green House Gases from Domestic Wastewater Treatment Systems:

Wastewater and sludge, its residual solids by-product, produce methane emissions if they are stored or treated under anaerobic conditions (in the absence of oxygen). In some cases this methane is collected and used or flared, but in most circumstances the methane produced is released to the atmosphere. Although data are very limited, current global estimates of methane emissions from the management of residential, commercial, and industrial liquid and water-carried wastes are about 20 to 25 Tg per year (based on calculations of the organic content of wastewater in different regions). These estimates are no better than ± 50%.

The amount of methane emitted depends on the organic loading in the wastewater (measured as biochemical oxygen demand, or BOD) and the extent to which the organic material degrades under anaerobic conditions. The majority of the methane emissions from wastewater are believed to originate in developing countries where domestic sewage and industrial waste streams are often unmanaged or maintained under anaerobic conditions without control of the methane (USEPA, 1993b). However, much uncertainly remain regarding the emissions rates from wastewater treatment conditions found in many developing countries. Consequently, the emissions reduction that could potentially be achieved is not well quantified.

Sources: UNDP Manual

2. Methane as a green house gas, some interesting findings:

- The global-warming potential of methane is 21 times that of CO_2 (per unit mass).

- The estimation of methane concentration increase in the period 1965-1991 is 25% compared by 11% for CO_2.

- The contribution of methane to global warming represented by the methane stock in the atmosphere in 1991 amounted to only 10% of that of CO_2.

- It has been speculated that it may be more significant is the methane presently not in the atmosphere but is held locked in ice lattices in tundra and permafrost and in shallow coastal- marine sediments. Concerns have been voiced that this large amount of methane has the potential of being released by global warming.

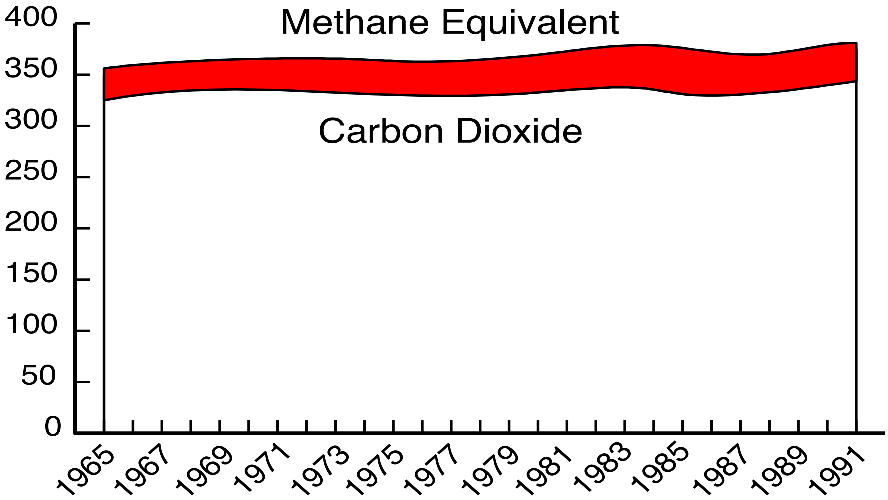
Although intrinsically slow, once begun this release process would reinforce itself because of methane's strong warming potential.

Note: Ice lattice structures with methane locked into them, known as clathrates, are estimated to contain some 12,000 billion tons of trapped carbon. Just 750 billion tons of carbon dioxide are present in the global atmosphere today. Cathrates carbon also exceeds the world supply of coal.

While carbon dioxide now vastly outweighs other gases . methane - with twenty - one times the potential for global warming - bears watching

Atmospheric concentrations of the major greenhouse gases , 1965 - 91

(Parts per million)



The figure shows the cumulative atmospheric concentrations of methane and CO_2 since 1965. Methane is measured in terms of its CO_2 equivalence based on its global-warming potential.

3. Methane, Chemistry of Synthesis

The principal by-product of the anaerobic decomposition of the organic matter in wastewater is methane gas. Methane is colorless, odorless, combustible hydrocarbon of high fuel value.

Normally, large quantities of methane are not encountered in untreated wastewater because even small amounts of oxygen tend to be toxic to the organism responsible for the production of methane. However, as a result of anaerobic decay in accumulated bottom deposits, methane is produced in sewer system or in treatment plants.

4. Methane Emission Factor (EF*m*)

The methane emission factory varies with the type of waste. Most organic wastes are made up of a mixture of carbohydrate, fat and protein (Meynell 1982). Below are Ef*m* values, derived from theory and as measured. Table contains theoretical Ef*m* as derived by Meynell (1982). Table contains measured values of Ef*m*.

Theoretical Methane Emission Factors (Ef*m*) as derived by Meynell (1982)

Methane Emission Factor	Volume CH4 (m_3/kg dry material)	Mass CH4 (kg CH4/kg BOD)
Ef*mc* (for carbonhydrates)	0.36	0.21
Ef*mf* (for fats)	1.04	0.58
Ef*mp* (for proteins)	0.49	0.39

Source: Meynell (1982)

Measured Methane Emission Factors (Ef*m*)

Methane Emission Factor	Volume CH4 (m_3/kg volatile suspended solids (VSS) added)	Mass CH4 (kg CH4/kg BOD)
Ef*md* (for domestic waste)	0.5-0.75	0.18-0.271
Ef*ma* (for animal waste)	0.24	0.132
Ef*mv* (for fruit and vegetable)	0.31	0.172

Notes:
1. Vesilind (1980).
2. Price and Cheremisinop (1981)

The default methane emission factor, Ef*m*, is 0.22 (IPCC Vol. 3 1995, p. 6.21). This value is consistent with observed methane emission factors (see above) and is used in this methodology for both domestic and commercial wastewater and industrial wastewater.

5. Fraction of Domestic and Commercial BOD Load Removed as Sludge

Default values of F*sl* for various treatment processes are shown in Table 6. Information on the treatment processes employed by individual plants can be obtained from water authorities. Alternatively, a national default value of 0.32 may be applied when dealing with total BOD*d*, based on National Greenhouse Gas Inventory Committee (1995, p. 47). At the state and regional level, specific data should be used if available.

Fraction of BOD*d* Load Removed as Sludge

Treatment Process	**Fraction of BOD*d* load removed as sludge (F*sl*)1**
Screening	0.05-0.15
Primary with anaerobic digestion	0.15
Secondary with anaerobic digestion	0.3
Aerobic	0.5
Facultative lagoons (including anaerobic facultative lagoons)	0.2
High rate anaerobic treatment	0.03

Note: 1. BOD load into wastewater treatment plant.
Source: NGGIC 1995.

Fraction of Methane Yield from Sludge Decomposition

Default values of F*msl* for various sludge disposal practices can be found in Table 7. Information on sludge disposal methods can be obtained from water authorities. Alternatively, a national default value of 0.12 may be applied when dealing with total BODd (National Greenhouse Gas Inventory Committee 1995, p. 47).

Methane Yield from Sludge Disposal

Sludge disposal method	Fraction of methane yielded from sludge decomposition (F*msl*)
Incineration1	0
Landfill	0.22
Land spreading	0.05
Ocean disposal	0.1
Lagoon storage	0.15

Note: 1. Assumes complete combustion of methane. Incomplete combustion with some incinerator types can emit unburnt methane . F msl can vary between 0 - 0.05 (Baldwin & Scott 1991)

Source : NGGIC 1995.

6. Mitigation Potential- General

Four scenarios have been suggested by RIVM for the calculation of the development of the greenhouse problem . These scenarios are not based on prognoses; they only illustrate the consequences of the tendencies and the changes therein. The scope of the four scenarios in terms of policy is as follows.

A. Continuing tendencies

In this scenarios the line of present development is continued, based on the following conditions :

- **A population increase to more than 10 milliard in 2100. This is also applied in the other scenarios.**
- **Global economic growth of 2% per year.**
- **Economic development of the entire world population to the. western level**
- **Development by means of fossil energy sources, particularly greater use of coal.**
- **Development of intensive agriculture.**

B. Adjusted tendencies

It is assumed that the tendencies according to scenario A will be adapted to lower emissions through spontaneous or governmental action.
Scenario B is considered to be more plausible than A.

C. Changing tendencies

The scenario assumes a drastic restructuring of the present tendencies, possibly the effect of a world wide environmental policy. To realize this, it would be necessary to aim economic development at the longer term rather than at the short time. This scenario appears to reflect a realistic minimum of emission.

D. Enforced reductions

This scenario is an approximation of long - lasting developments, required to overcome the threat of the greenhouse effect.
This scenario is not very realistic. On the one hand it might be applicable if a very great economic development would make very strict environmental measures possible. On the other hand, such a scenario might apply to depressed world economy.

7. Mitigation Measures - Basic Idea

It should be noted that both Aerobic and Anaerobic methods of wastewater treatment are derived from Processes Occurring in Nature. The aerobic and anaerobic cycles shown in the next two figures are typical examples. By controlling the environment of the microorganisms, the decomposition of wastes is speeded up. regardless of the type of waste, the biological treatment process consists of controlling the environment required for optimum growth of the microorganisms involved.

8. Mitigation options- Practical Solutions

Although the factors affecting methane emissions from wastewater treatment remain very uncertain, it is generally believed that providing effective aerobic wastewater treatment will help reduce emissions. If anaerobic treatment is preferred to aerobic treatment, capturing and using the methane produced during treatment would also reduce emissions. These two approaches are summarized as follows (additional description is provided in USEPA, 1993a):

- ☐ Aerobic Treatment. Aerobic treatment includes aerobic primary and secondary treatment and land treatment. Aerobic primary wastewater treatment is achieved by sustaining sufficient oxygen levels during the primary phase of wastewater treatment (i.e., in oxidation ponds), using controlled organic loading techniques or providing oxygen to the wastes through mechanical aeration. Aerobic secondary treatment consists of stabilizing wastewater by prolonging its exposure to aerobic microorganisms which are either suspended (due to mechanical aeration) or attached to a fixed bed or a rotating cylinder. Finally, land treatment involves applying wastewater to the upper layer or the surface of soil, which acts as a natural filter and breaks down the organic constituents in the wastewater.

- ☐ Recovery and Utilization of Methane from Anaerobic digestion of wastewater or Sludge. If the wastes are treated (digested) under controlled anaerobic conditions, the resulting methane and other gases can be recovered and utilized as an energy source to heat the wastewater or sludge-digestion tank, produce power in other parts of the plant, or sell to nearby homes, industrial plants, or utilities. Flares are frequently used as part of these operations to dispose of excess methane.

Sources: UNDP Manual

9. Examples of Recent Developments in Aerobic Wastewater System

Reciprocating Jet Reactor.

Fixed Bed Aerobic Reactor.

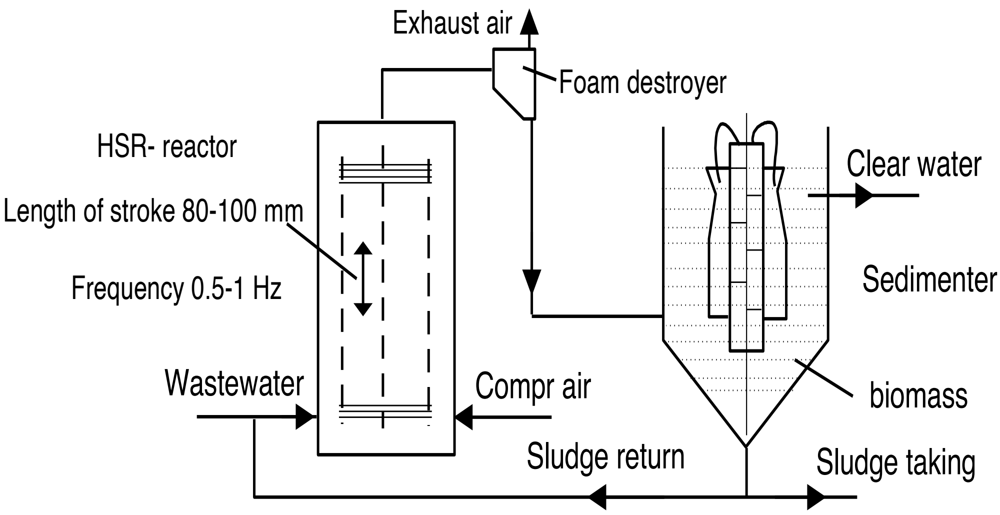
Stahlermatic Aerobic Reactor.

Sequencing Batch Reactor, (with application)

Fixed Film Bioreactor .

Trickling Filters with Polyethylene Strip Media.

Reciprocating Jet Reactor.



Reciprocating. Jet Reactor (cont.)

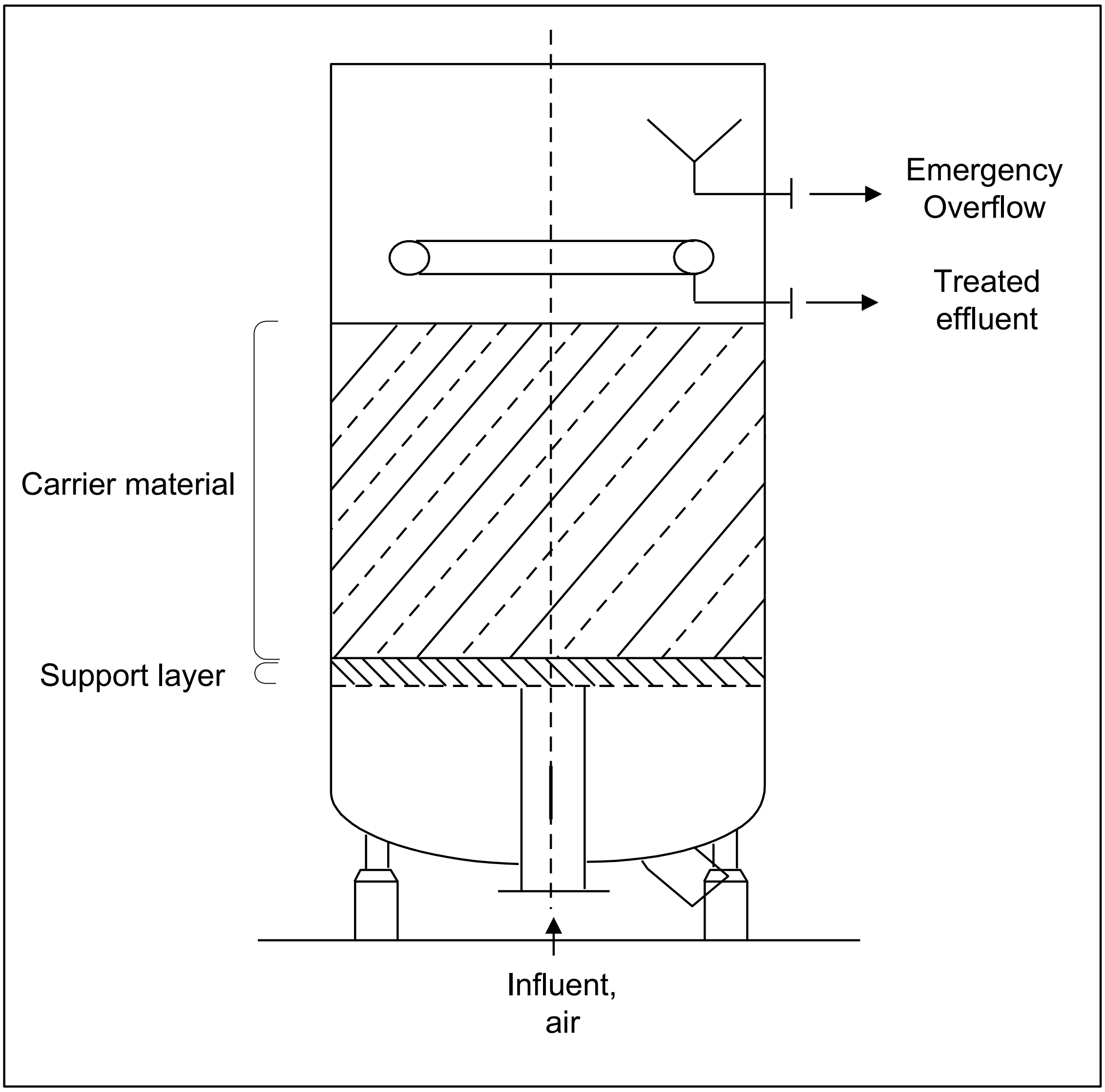
Description and Advantages

The reciprocating jet reactor (HSR) allows a hitherto unknown "first-class biological performance" to be realized within a very small area. The advantages of this reactor, which fulfills the requirement for modern wastewater technology , can be described as follows:

– small constructional volume
– small surface area
– closed system of the reactor and therefore no emission of odours
– high concentration of active aerobic biomass
– convenient integration into existing technical plants
– wastewater treatment is possible directly at the place of origin
– high oxygen efficiency in the completely agitated reaction space
– good sedimentation of the biomass produced

The reactor itself consists of a vertical cylindrical vessel which is fitted out completely with plate units. Perforated discs, the total number of which accords with the size of the reactor, are installed at intervals of 50 min. Each perforated disc is provided with 12 mm holes spaced at 30 mm intervals over its entire surface. The plate units are kept in constant motion at a frequency of 0.8-1 Hz and a length of stroke of 100 mm. The lifting motion of the perforated disc units generates a whirl cell around each hole, which itself acts as blast nozzle, and this cell is designated as an elementary cell of the HSR reactor. The reaction chamber comprises a very large quantity of these elementary cells, depending on size ofthe reciprocatmg jet reactor. The suitability for large-scale technical projects of an HSR system with an 8.5 m3 reaction chamber was verified within a research project sponsored by the German Federal Ministry for Research and Technoloey and under the charge of the responsible body for water technology projects at the Karisruhe Nuclear Research Centre. The functional diagram shows that HSR plants involve conventional aerobic activated sludge systems which, however, compared with the systems previously used, are equipped vath a high-performance biological process operating a very small area.

Fixed Bed Aerobic Reactor



Fixed Bed Aerobic Reactor (cont.)

Fixed Bed Reactors in Biological Wastewater Treatment:
Depending on the application, fixed bed reactors may present an economic alternative to activated carbon processes.

As generally known,the elimination of wastewater constituents which are difficult to biodegrade as well as nitrification and denitrification require special micro-organisms which have an extremely slow growth rate.One solution to overcome this drawback is to inunobilize these micro-organisms and fix them on carrier materials.

Compared to suspended systems, fixed bed reactors feature the following advantages:

- independence from microbial growth rate
- independence from excess sludge discharge rate
- elimination of suspended solids
- independence from the operating mode of the final sedimentation stage

Depending, on the process. fixed bed reactors are classified into two broad categories as shown in table1

Static	dynamic
- Tricking filters	- Rotating disk contractors
- Backwash-type, immersed reactors contractors	- Rotating immersed
- Wet filters	- Moving bed reactors
- Dry filters	- Fluidized bed reactors
	- Floating contractors

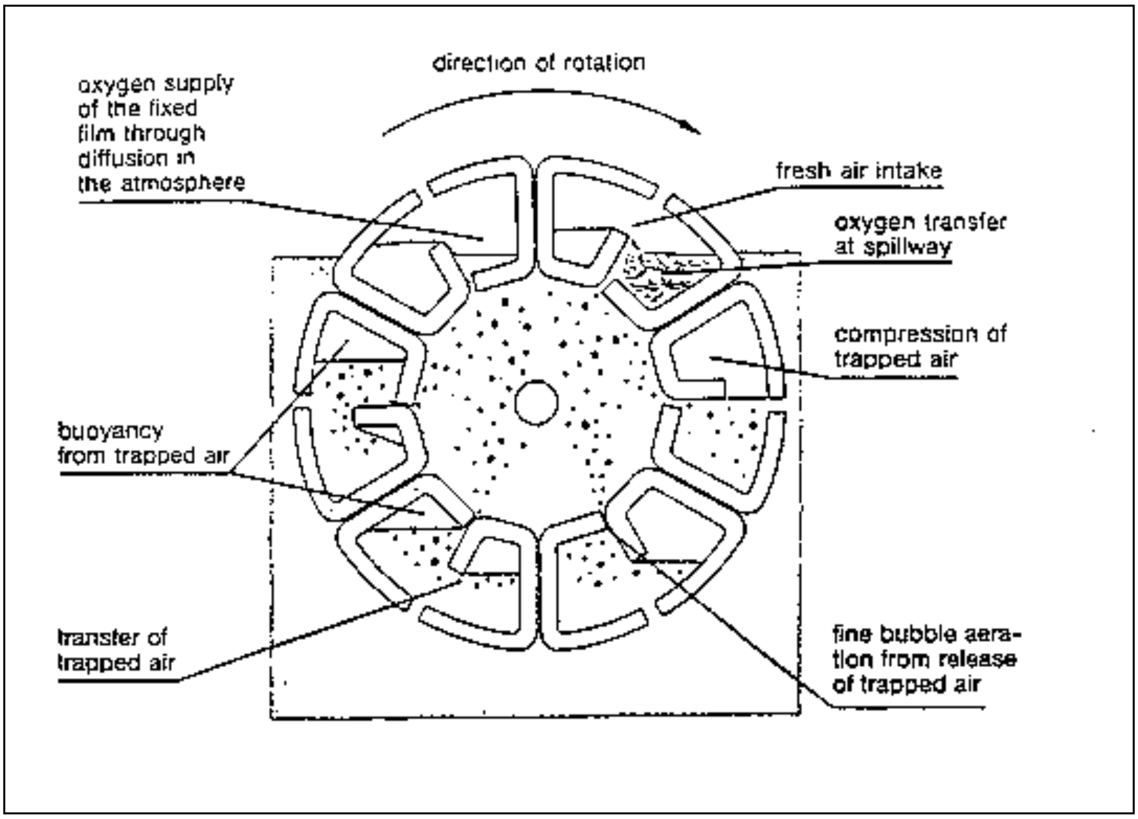
Modes of Reactor Operatior,-

- wastewater and air or pure oxygen are passed through the reactor from bottom to top in co-current flow
- reactors operating in a counter-current mode

Of the great variety of fixed bed reactors listed in Table 1, a reactor with a completely immersed packing is normally selected for the removal of substances which are difficult to biodegrade. because of its high bio-conversion efficiency. The wastewater and the air are passed through the reactor from bottom to top in co-current flow.

At comparable elimination efficiencies, fixed bed reactors are normally superior to adsorption systems as regards operating cost. While biological processes produce only small sludge volumes to be disposed of, activated carbon systems require expensive regeneration routes.

Stahlermatic Aerobic Reactor.



Stahlermatic Aerobic Reactor (cont.)

Description and Advantages

Wastewater treatment represents an important link in the recycling of water resources. The demands on performance and effluent quality of wastewater treatment facilities have increased considerably in order to comply with higher standards to protect human health, to clean up rivers and lakes to make them fishable and swimable, and to provide needed resources for drinking water and industrial uses. In addition to the removal of oxygen consuming compounds of carbon and nitrogen, it will become increasingly important to remove inorganic nutrients such as nitrate and phosphorus. Growing investment costs for added treatment capacity is a direct result. Therefore, tile challenge to minimize the costs of increasing demands lies at hand. Most biological wastewater treatment systems use either fixed film or activated sludge processes. Plants using the fixed film process offer greater process stability and simplicity of operation, and may cost less to construct, while activated sludge plants offer greater flexibility in adjusting process efficiency by altering the type and/or quantity of micro-organisms. To combine the most advantageous characteristics of both of these two well-known treatment processes in a meaningful and least costly way, the **STAHLERMATIC** system has been developed.

System Description

The **STAHLERMATIC** system is a biological wastewater treatment system. In general the following processing steps are involved:

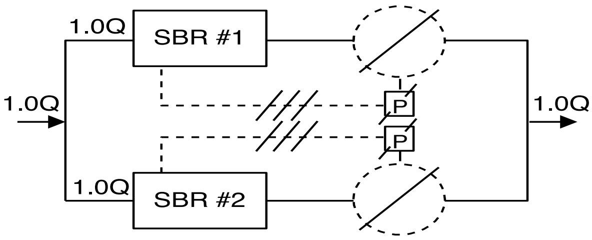
- Mechanical pre-clarification with bar screen and grit chamber.
- **STAHLERMATIC** bio-stage, consisting of
  - STAHLERMATIC bio-tank, and
  - clarifier with sludge recycling to the bio-tank and wasting of excess
  - sludge.

The heart of this wastewater treatment process is the **STAHLERMATIC** bio-tank in which the biological treatment occurs.

The bio-tank is equipped with the **STAHLERMATIC** submerged contact aerator wheel. A gear motor above the water level rotates the submerged contact aerator about its axle. The submerged contact aerator may be built in different designs, either as a cell-wheel or as a pipe-wheel. Both designs provide a system of hollow pockets in the outer portion of the wheel which in turn incorporate a large number of specially profiled polypropylene plates or discs to give generous surface area.

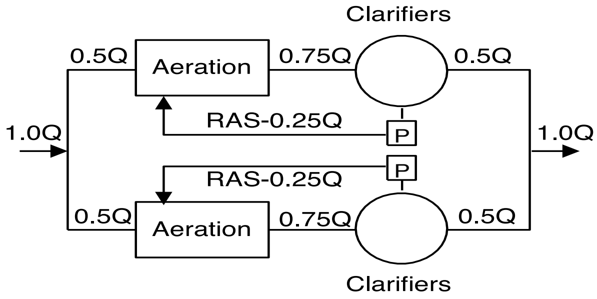
Sequencing Batch Reactor.

Sequencing Batch Reactor
Typical 1.0 MGD Plant



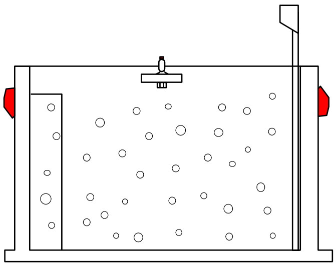
Flow: 1.0Q to each half of the Treatment System, 50% of Time. Secondary clarifiers, return sludge pumping and piping not required in SBR system.

Conventional Activated Sludge System
Typical 1.0 MGD Plant

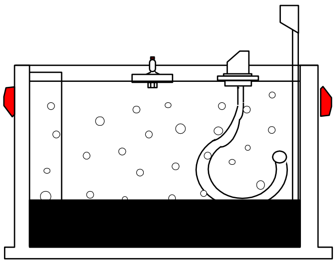


Flow: 0.5Q to each half of the Treatment System, 100% of time.

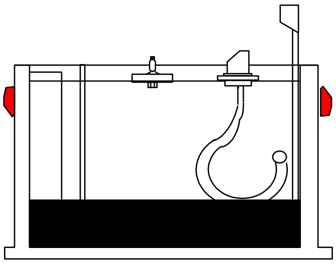
Sequencing Batch Reactor.



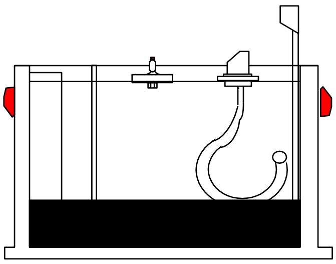
React - Influent flow is terminated, while mixing and aeration continue. Intermittent operation of the aeration system may continue to complete the nitrification/ denitrification process, or to conserve energy.



Settle - Mixing and aeration cease. Solids/ liquid separation takes place under perfectly quiescent conditions.



Decant/ Sludge Waste - The mixer and aeration system remain off and, at this time, up to approximately 1/3 of the reactor volume is decanted by means of subsurface withdrawal. The reactor is immediately ready to receive the next batch of raw influent. A small amount of sludge is wasted each cycle.

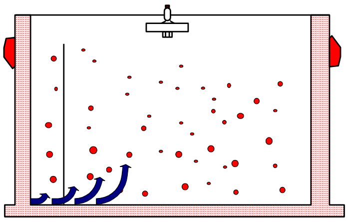


Idle - Occurs in multiple- basin systems anytime that flow conditions are less than peak design flow. Idle time varies depending on actual flow conditions.

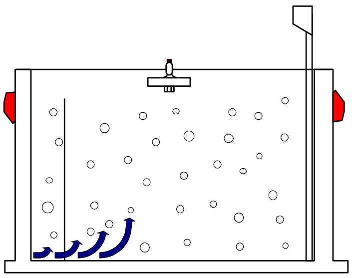
Sequencing Batch Reactor (cont.)

Operation

The use of microprocessor controlled phases enables the operator or engineer to vary the operation strategy of the SBR to suit the treatment requirements. Normally , the process follows the basic steps of Fill, React, Settle and Decant. The ability to create aerobic or anoxic conditions within the reactor results in flexible operation, better treatment of the waste, and optimum effluent quality.

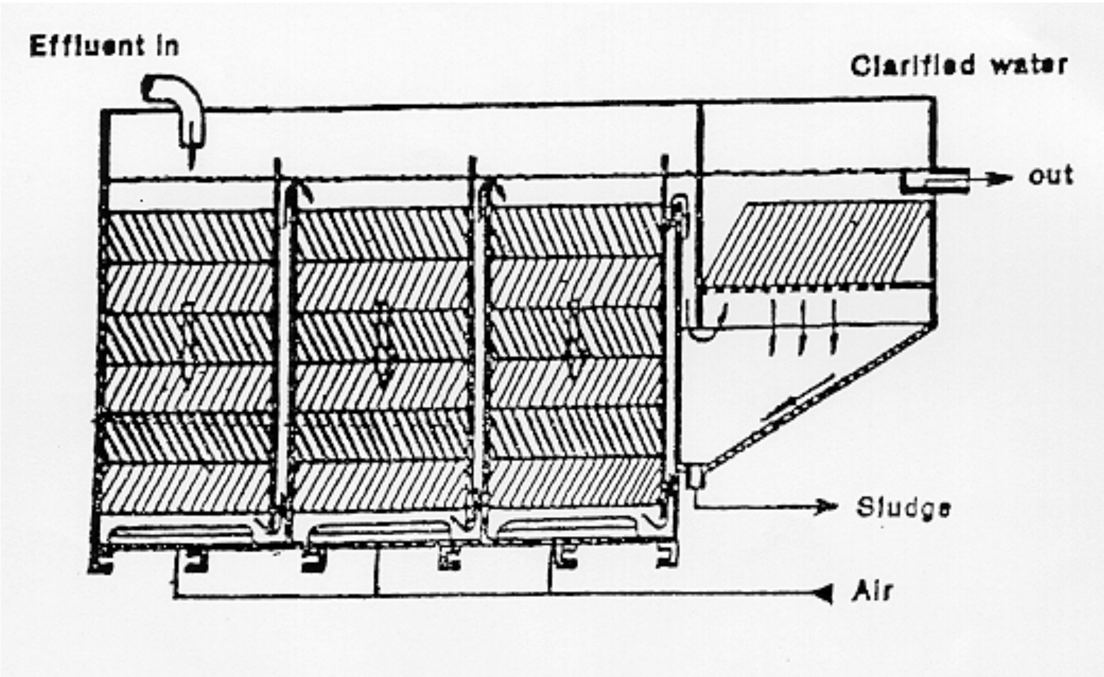


Mixed Fill - Influent enters the SBR reactor. Complete mix of the reactor contents is achieved without the use of aeration. An anoxic or anaerobic condition exists. This phase assists in control of filamentous organisms; and is essential for those systems which require nutrient removal.



React Fill - Influent flow continues under mixed and aerated conditions. Aeration may be intermittent to promote aerobic or anoxic conditions. Nitrification and denitrification can be achieved. The aeration source may also be operated intermittently during low flow and low organic loading conditions to conserve energy

Fixed Film Bioreactor

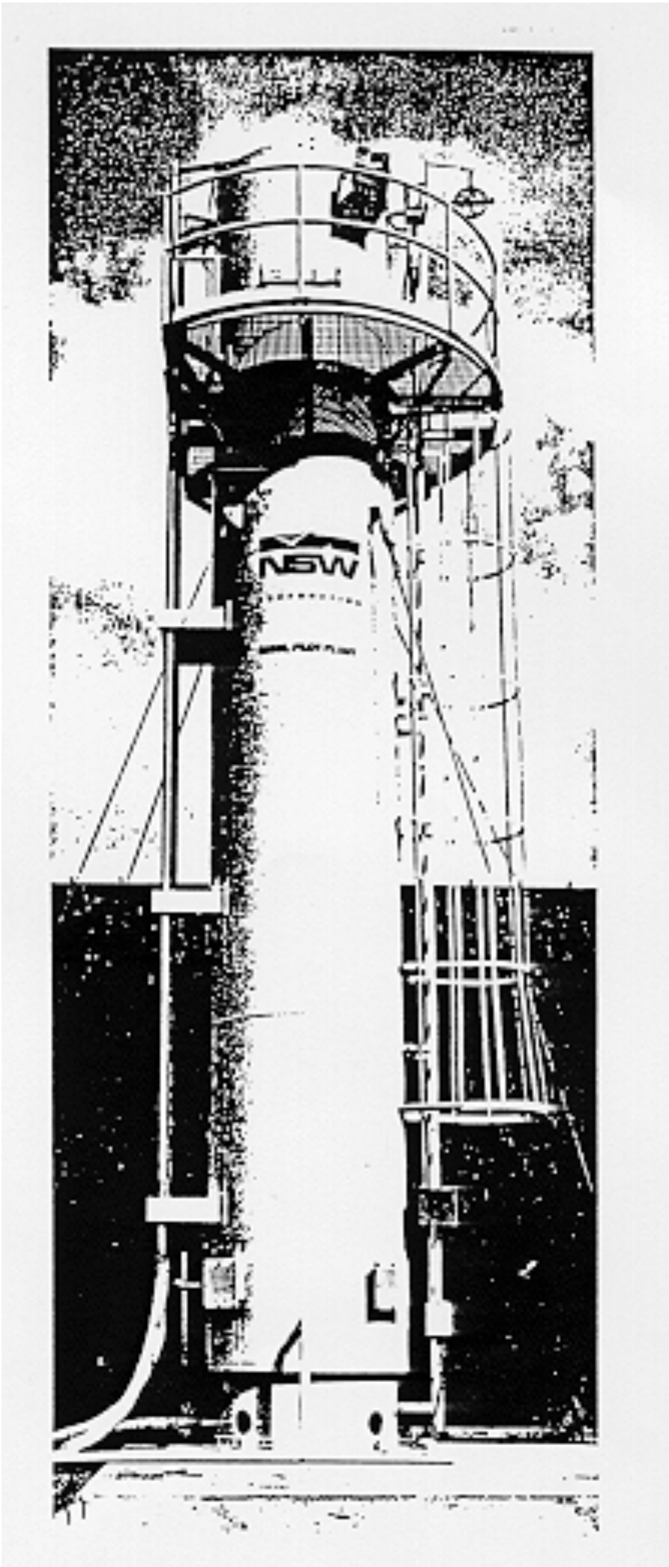


Fixed Film Bioreactor (cont.)

Advantages

- High Rate Submerged Fixed Film Bioreactor
- Very high BOD removal: 3-7 kg/m^3 day
- Low sludge production
- Low power requirement Small footprint: low land requirement
- Simple operation: mostly automated
- Low capital cost: minimum civil work
- Designed for industrial high strength waste

Trickling- Filters with Polyethylene Strip Media.



Trickling Filters with Polyethylene Strip Media (cont.)

Description

The NSW Sessil Pilot Plant is a 4.5 ft diameter x 32 ft. high tower with 20 ft Sessil media depth. Supplied with the tower are two skid mounted pumps for wastewater feed and recycle pumping with interconnecting hoses. Some site piping is usually required. Power must be run to control panel on the pump skid and to tower base for the rotary distributor drive. The pumps are I.5 hp. The motors are 220 volts/1 phase/60 hertz.

The pilot plant is shipped in one piece by truck with Sessil in the tower. A 35 ton crane with a 80 ft minimum Boom is required to unload and erect the tower. Nylon strings must be used to protect the outside coating of the pilot plant. The lessee is responsible for coordinating the tower unloading and erection and upon completion of the pilot study, the lessee is responsible for dismantling, loading and shipping the tower back to NSW in Roanoke, Virginia.

All freight charges associated with the tower are the responsibility of the lessee along with unloading, erection, dismantling and loading charges incurred. If required, NSW will have a representative on-site to supervise erecting and start-up of the tower.

Operation

Feed and recycle flow rates are dependent upon the strength of the wastewater and degree of treatment required. The combined flow rate typically ranges between 6 to 24 gpm. NSW process engineers will assist in the development of pilot plant program since each study must be tailored to study, objectives and nature of the wastewater.

Annex 1

Extracted from : Workbook for Waste
Prepared by : National Greenhouse Gas inventory Committee, Australia, 1996

Annex 2

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