



## UNCONVENTIONAL LOW COST SIMPLIFIED SEWAGE TREATMENT BY ROTATING BIOLOGICAL CONTACTOR AND ANAEROBIC (UPFLOW) FILTER SYSTEM

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## ABSTRACT

Rotating biological contactors or biological discs and septic tank systems followed by anaerobic (upflow) filter or composite anaerobic (upflow) filter are some of the simple treatment devices relevant to semi-urban and urban fringe areas, rural areas and institutions where localised collection and treatment of sewage could be expedient. Laboratory, pilot plant and field scale studies carried out at National Environmental Engineering Research Institute, Nagpur have clearly established the feasibility of these systems and brought out the process design criteria and operational aspects. The paper brings forth briefly the salient features of the studies.

## INTRODUCTION

Considering the various constraints that stand in the way of providing conventional sewerage and sewage treatment systems, the alternative is to go in for low cost simplified sewage treatment or sanitation systems, which are also hygienic and appropriate to local conditions. Low cost pour flush sanitary water seal latrine systems for individual houses is one alternative. In water logged and flooded areas, rocky areas, fissured rocks and chalk formations, these may become unsuitable from construction and underground pollution travel point of view. Adoption of alternative systems need to be given consideration. Rotating biological contactor (or biological disc), septic tanks followed by anaerobic (upflow) filter or composite anaerobic filter system followed by polishing by grass plots, are some of the unconventional simple treatment devices applicable to treat domestic sewage from small communities, institutions and urban fringe areas. The aspects regarding the feasibility of these systems, operational data and the process design criteria based on laboratory and pilot plant studies are presented briefly.

## ROTATING BIOLOGICAL CONTACTOR (RBC) OR BIOLOGICAL DISC.

Experiments were conducted at NEERI, Nagpur on a prototype rotating biological contactor or biological disc followed by a secondary settling tank for treating domestic sewage. The disc chamber consists of mild steel hemispherical drum with 40 PVC circular discs of one meter diameter centrally fixed to a revolving horizontal cylindrical shaft, rotating at 5 rpm and with a clear spacing between the discs of 2.5 centimeters. The discs are half immersed in sewage and the shaft is driven by a 1.5 KW geared motor and pulley drive (Fig. 1). The treatment process is basically aerobic.

Observations (Ref. 1,2) were made with pumped screened raw sewage, and settled municipal sewage during the period 1977-1980. Flow rate was controlled at 0.45 to 0.55 cubic meter per hour, which provided detention time of 1.25 to 1.3 hours in the disc chamber and 1 to 1.2 hours in the settling tank. The experiments were conducted with the disc chamber closed with a mild steel hemispherical cover with small perforations. Summary of the results are presented in Table-1 for RBC system treating raw sewage, without presettling.

Reduction of BOD<sub>5</sub> and suspended solids to the extent of 77 to 90 per cent and 65 to 94 per cent respectively was observed at organic loading rate of 16.0 to 22.3 grams of BOD<sub>5</sub> per square meter of disc area per day for treating screened raw sewage of BOD<sub>5</sub> varying from 200 to 250 mg/l, and the power consumption was found to be 1.0 to 1.2 kilowatt hours per kilogram of BOD<sub>5</sub> removed. The dissolved oxygen in disc chamber was around 1 mg/l. The systems efficiency was not significantly affected due to intermittent sewage flows especially when there was no flow in the night time.

The efficiency of biological disc (Ref. 3) with reference to BOD<sub>5</sub> for treating settled sewage improved

**Table -1 : Performance Data of Pilot RBC\* system for treating raw sewage.**

Raw sewage Temp.: 25° to 33°C.  
( Average values )

Parameters	Period	
	1979	1980
Hydraulic Loading, m <sup>3</sup> /m <sup>2</sup> /day	0.078	0.09
Organic Loading, BOD <sub>5</sub> gm/m <sup>2</sup> /day	20.7	16.7
BOD <sub>5</sub> , mg/l	Inf.	255
Eff.**	45	31
COD, mg/l	Inf.	662
Eff.**	72	105
SS, mg/l	Inf.	466
Eff.**	54	22

\* enclosed with perforated cover.

\*\* after settling.

to an extent of 10 percent compared to that of treating raw sewage. It was also observed that a reduction of 5 to 10 per cent in the overall BOD<sub>5</sub> removal efficiency of closed disc system compared to that of the disc chamber kept open or exposed.

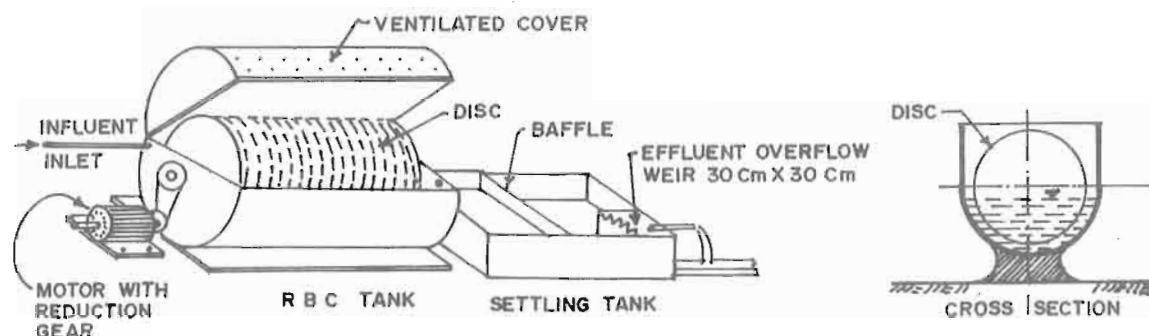
The cost of the prototype biological disc system ( including motor drive, settling tank ) comes to Rupees 16,000/- ( ₹ 1 = Rupees 18/- ) based on rates as in 1977. Such a unit is capable of treating 0.5 cumeter per hour of domestic sewage, equivalent to a contributory population of 80 to 100 persons. The major portion of the cost is consumed by the PVC discs to the extent of Rs. 5,000/-. If the PVC discs are replaced by netted plastic or natural cane webbed over circular steel or wooden rib with spokes, the cost of the discs comes down to about Rupees 1,500/-.

Two of such modified discs were installed in the chamber and were found to function well. Further experiments are under way using inexpensive discs consisting of web or mesh with plastic or wooden cane, netted in a circular steel or wooden rib with some spokes.

#### ANAEROBIC ( UPFLOW FILTER )

The anaerobic filter is an upflow submerged contact filter where the wastewater is introduced from the bottom, unlike the conventional trickling filter. The microbial growth is retained on the stone media making possible higher loading rates and efficient digestion anaerobically. The anaerobic (upflow) filter was successfully tried for low strength settled and raw domestic sewage. This was also used as secondary treatment device for treating septic tank effluent ( Ref. 3,4 ) in areas where dense soil conditions, high water table and limited availability of land preclude conventional soil absorption or leaching system for effluent disposal. The effluent from the anaerobic filter could be further 'polished' by passing through a grass plot, where the effluent could pick up some dissolved oxygen, resulting also in further reduction of BOD. The observations on the performance of field filter treating raw sewage, and the grass plot for polishing the filter effluent are briefly discussed.

A masonry filter box rectangular in plan of dimensions 1.6m x 1.6m x 1.4m deep ( Fig. 2 ) was constructed in the NEERI campus, Nagpur. The filter was filled with stones of 2.0 to 2.5 cms diameter sizes to a depth of 1.2 meters supported over 15 cms thick of stone media of size 7.25 cms. The media rested on wire



**FIG. 1. RBC PILOT PLANT WITH COVER, WITH SETTLING TANK**

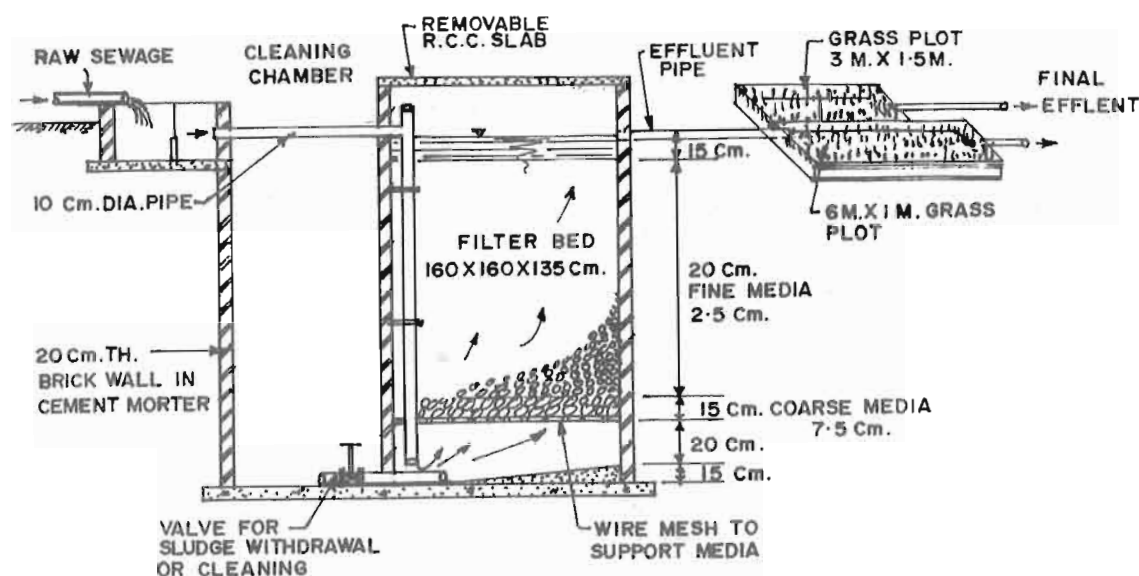


FIG. 2. UPFLOW ANAEROBIC FILTER

mesh. Municipal domestic sewage pumped from a municipal sewer was discharged over a V-notch and passed through the filter from the bottom. The pilot field filter can treat sewage from a small community of 40 to 60 persons. The flow was maintained at a rate of  $0.42 \text{ m}^3/\text{hr}$  for a period of 8 to 10 hours daily while during the rest of the period in a day there was no flow. The detention time works out to 6 to 8 hours. The results are summarised in Table 2. Reduction of  $\text{BOD}_5$  to the extent of 70 to 85 per cent was obtained depending on influent  $\text{BOD}_5$  concentration while suspended solids removal was of the order of 80 to 89% and turbidity reduction of 70 to 75 per cent. Increase in ammonia concentration in the effluent was noted. The effluent was relatively clear and did not emanate any noticeable odour. The filter could work continuously for a year to  $1\frac{1}{2}$  years before clogging sets in. By flushing water from top and desludging from bottom, the filter can work continuously.

#### GRASS PLOT

Overland flow through grass plots was used for 'polishing' of the anaerobic filter effluent. Dub-grass (*Cynodon* sp.) was grown in small plots of size  $3 \text{ m} \times 1.5 \text{ m}$  and  $6 \text{ m} \times 1 \text{ m}$  (Fig. 2). The filter effluent was allowed to flow over these grass plots every alternate day. There was build up of dissolved oxygen (1 to  $2 \text{ mg/l}$ ) and further reduction in BOD as the effluent flowed out of the grass plot (vide Table 3).

Table-2: Performance Data of Anaerobic Contact Upflow Field Filter Treating Raw Sewage (Average Values)

Hydraulic Loading:  $0.42 \text{ m}^3/\text{hour}$   
 Average Temp. of Sewage:  $29^\circ\text{C}$  to  $30^\circ\text{C}$   
 Detention Time: 6 hrs.  
 Period: 1979.

Parameters	Influent	Effluent	Efficiency %
$\text{BOD}_5, \text{mg/l}$	210 (112-310)	43 (12-82)	79.5
S.S	272 (54-336)	22 (10-44)	88.5
$\text{NH}_3\text{-N}$	41	52	-
pH	7.3	7.4	-

Table-3 : Overland Flow Grass Filtration of Anaerobic Filter Effluent.

Period: 1980.

Parameter	Influent Raw sewage	Anaerobic filter Effluent	Final Effluent after grass plot
$\text{BOD}_5 \text{ mg/l.}$	230 (120-310)	74 (35-132)	49 (14-105)
S.S	212 (98-350)	92 (35-132)	55 (14-87)
D.O.	nil	nil	1.0 (0.2-2.0)

## CONCLUSIONS.

Rotating Biological Contactor (RBC) and Anaerobic filter systems are simple to construct, and operate at low head loss and are relatively free from odour nuisance. RBC system is compact, has simple mechanical gadgets and power consumption is moderate, while the anaerobic filter does not have any mechanical gadgets. Both can function satisfactorily when the flow of sewage is intermittent.

RBC can be operated with raw sewage instead of settled sewage, thereby eliminating presettling tank. Even though the efficiency is lower with raw sewage compared to settled sewage, the performance can be improved by increasing the detention time of disc and settling chamber of pilot plant and decreasing the organic loading rate to get an efficiency more than 90 per cent.

The anaerobic filter can function as a composite secondary treatment device in which case the sewage should be free from grit and preferably partly homogenised. The filter can also be used as a secondary treatment device for treating effluent from septic tanks. Overland grass filtration treatment of filter effluent will be an useful adjunct for further 'polishing' the effluent from filter or RBC. The RBC system, septic tank followed by anaerobic upflow filter and grass plot, or composite anaerobic upflow filter followed by grass plot are suitable for treating sanitary sewage from institutions, small communities and individual houses. Based on the studies so far, the process design criteria can be briefly stated as follows:

### RBC for treating raw sewage.

Organic Loading rate to disc chamber:  
16 to 20 gms BOD<sub>5</sub>/m<sup>2</sup>/of disc area/day.

Overall BOD removal efficiency: 90%

Detention time in  
disc chamber : 1.5 hrs.

RPM of disc : 5

Temp. of sewage : 23 to 32°C.

Influent BOD concentration : 200 to 300 mg/l

### Anaerobic Filter

Media ( Gravel, broken stone )

Size of media : 1.9 cms to 2.5 cms.

Depth of media : 115 cms to 125 cms.

Hydraulic Loading rate: 3.4 m<sup>3</sup>/m<sup>2</sup>/day.

Temp. of sewage : 23°C to 33°C.

BOD removal efficiency: 70 to 80% for  
influent BOD  
concentration  
of 110 mg/l  
to 300 mg/l.

### Grass Plot: Hydraulic Loading

0.8 to 1.5 m<sup>3</sup>/day/sq. meter of area  
minimum 2 plots.

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## REFERENCES

1. RAMAN, V. and KHAN A.N. Development in Sewage Treatment for Small Communities, Indian Association for Water Pollution Control, Technical Annual IV, Nagpur, 1977.
2. KHAN A.N. and RAMAN V. Rotating Biological Contactors for the Treatment of Wastewater in India Proc. First National Symposium on Rotating Biological Contactor Technology, Champion, Pennsylvania, sponsored by University of Pittsburgh, USEPA, 1980.
3. RAMAN V. and CHAKLADAR N. Upflow Filter for Septic Tank Effluent. J. Water Pollution Control Federation, 44, 1552-1560, 1972.
4. RAMAN V and KHAN A.N. Upflow Anaerobic Filter: A Simple Sewage Treatment Device. Proc. Int. Conference on Water Pollution Control in Developing Countries, Asian Institute of Technology, Bangkok, 1978.