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M B Settler: A More Economical Alternative to Conventional Settler

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The conventional water treatment units are not suitable for use in rural areas and small communities due to their high capital and maintenance cost. The multibottom settling tank (MBST) as proposed is economical both in capital and maintenance cost and practically requires no electricity and skilled labour for maintenance. The experimental study on pilot plant of about 3m³ capacity was carried out by varying different design parameters. With the depth of flow as 50 cm and above, angle of inclination 45°, horizontal velocity 12 cm/min, the surface loading as 6.66 l/m² -min and detention time 15 min, the performance of the MBST was observed to be as good as that of conventional units. The settling tank in combination with solid media flocculator (SMF) also gives good bacterial removal efficiency. The cost of the MBST plus SMF works out to be 11% to 33% of the clariflocculator.

INTRODUCTION

Water for drinking and food preparation must be free from organisms capable of causing disease and from the mineral and organic substances producing physiological effects. Moreover, the water should be free from apparent turbidity, colour, odour and any objectionable taste. The raw water available from many sources contain impurties making it unfit for human consumption. Hence it becomes necessary to treat the water before feeding it into public distribution system. Similarly, the treatment of liquid wastes comprising of spent water from bath rooms and lavatory basins of residences, process water from industry, semi-liquid wastes like the human and animal excreta, make them more amenable to its safe and satisfactory disposal either on land or in large bodies of water.

TUBE SETTLER

Sedimentation, for treating water and waste water among many methods, is the most important and widely used operation. This method/unit removes turbidity to a great extent at much less cost compared to any other units of the treatment plant but the cost has now gone up particularly due to the increasing cost of the mechanical parts. To reduce the cost of the settling unit and also to attain higher degree of performance, tube settlers were developed.

Tube settlers were developed by Culp, *et al*[1] by using very small diametre tubes. Their design is based on the principle that the removal of settlable solids is primarily a function of overflow rate and is independent of basin depth. The tube settlers have large surface area, small depth, no mechanical parts and require a detention time of about 3 min only. Thus, cost and space both are saved substantially. The two basic shallow depth settling systems now available are illustrated in Fig 1. These have, however, certain disadvantages : (i) the settled particles move in a direction opposite to the direction of flow and hence the sludge obtained is not concentrated, (ii) about 2 to 5% of water is wasted, and (iii) the cost of the material used in the tube settler is quite high.

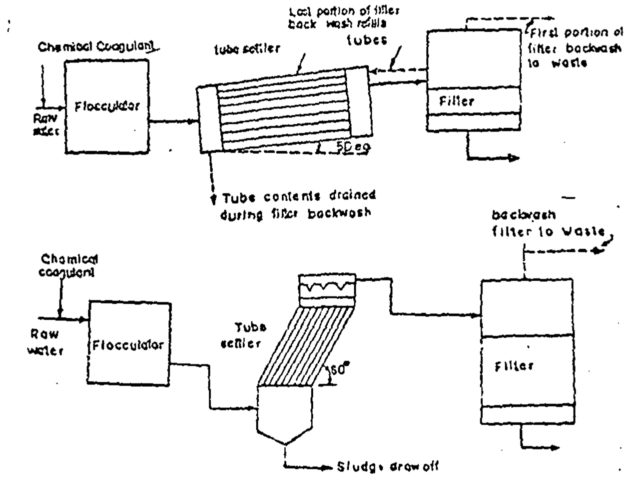

Fig 1 (a) Essentially horizontal (top) and steeply inclined (bottom) tube settlers

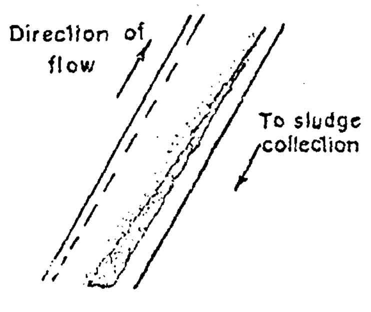

Fig 1 (b) Counter-Current flow pattern in steeply inclined tubes due to flow of liquid and sludge

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MULTIBOTTOM (MB) SETTLERS

To overcome the above disadvantages, MB settler (Fig 2) has been developed at the University of Roorkee[2]. This settler has all the advantages of the tube settler like large surface area, small depth, no mechanical parts and requires less space. In addition, due to the provision of vertical sludge zone with minimum horizontal flow, the settled solids moves normal to the direction of the flow. This results in more effective settling and the sludge obtained is more concentrated.

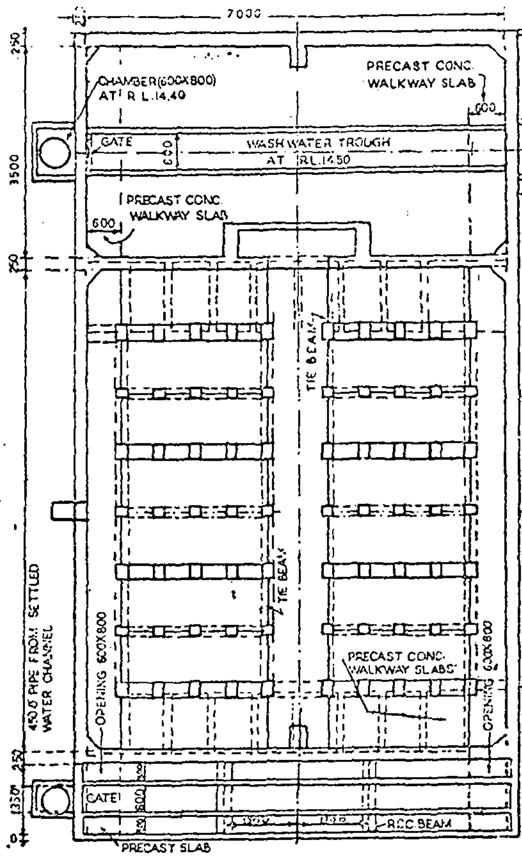


Fig 2 Plan of flash flocculator and MB settler

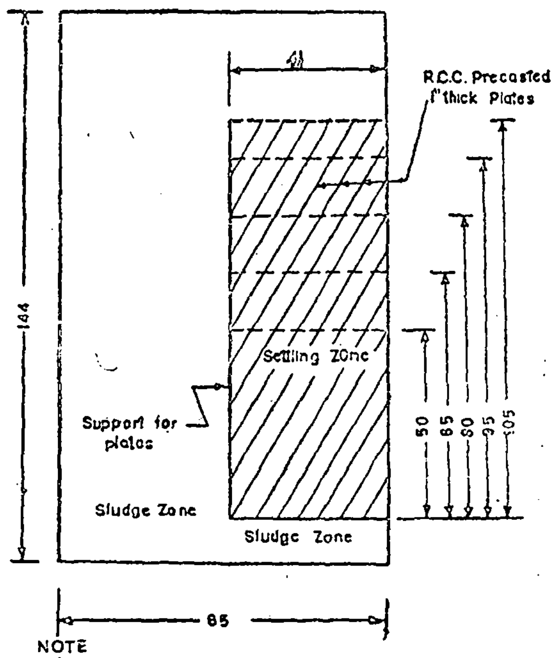
Kohli[2] conducted experiments on a laboratory scale model of the MB settler using only coagulated water and established the feasibility of this settler. Kelkar[3] conducted experiments on this using raw sewage and observed that about 80-82% of settled solids and 50% of BOD are removed. A 16.2 million l/d unconventional water treatment plant constructed at Roha (Maharashtra) incorporates MB settler. The study carried out by Parmar[4] at this plant indicates that raw water turbidity of 85 mg/l is reduced to 2.0-2.8 mg/l.

This paper deals with the study of depth of flow, angle of inclination plates, horizontal velocity and surface loading on the performance of the MB settler using coagulated and flocculated water. In addition, the effect of shock loading, bacterial removal efficiency of MB settler in combination with solid media flocculator, another conventional unit developed at the University of Roorkee[5] and the quantity of the sludge accumulating as the percentage of the total suspended solids were studied.

EXPERIMENTAL SET-UP

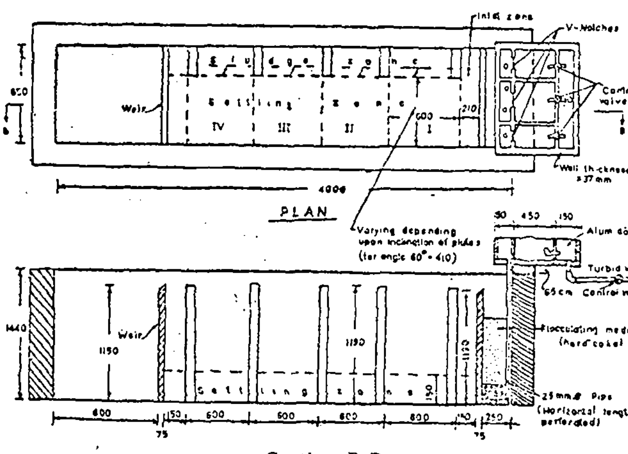
MB SETTLER

The multibottom settling tank, on pilot plant scale, was constructed by utilizing an existing masonry chamber of dimensions 4 m × 0.85 m × 1.05 m (Fig 3). The model consisted of four clearly divided zones—inlet zone, the settling zone, the outlet zone and the sludge zone. The settling zone was constructed in four units, each 60 cm long. It was possible to use any number of units at any time since any one or more units could be taken out of the chamber. Each unit consisted of 15 inclined 1 cm thick RCC precast plates, temporarily held in position with the help of wooden frames. The vertical spacing between the plates was kept 10 cm centre to centre and could be increased by taking out certain number of plates. The inclination of plates to the horizontal was kept as 45° which could be varied by shifting the position of the wooden frame. The depth of flow was varied by increasing or decreasing the height of the weir wall at the downstream end of the outlet zone.



NOTE
(i) Plates inclined at 60° to horizon
(ii) All dimensions in cms.

Fig 3(a) Sectional elevation at 'AA'



Section B B

Fig 3 (b) Multibottom settler and solid media flocculator

FLOCCULATION TANK

The flocculation tank consisted of two chambers 25 cm × 20 cm each and one 25 cm × 40 cm in cross-section. In these chambers hard coke of about 1.5 mm size was filled to a height of about 50 cm from the bottom.

All these chambers when operated together were capable of allowing a discharge of 100 lpm at a flow rate of 40 cm³/cm²-min, which was sufficient to keep the flocs suspended[5].

EXPERIMENTATION

The experimental work was carried out in four different sets.

Set 1

To study the performance of MB settling tanks with regard to depth of flow in settling zone.

Set 2

To study the effect of change of angle of bottom on residual turbidity and the sludge deposited on plates per unit area of plate.

Set 3

To study the effect of horizontal velocity, surface loading and detention time on residual turbidity.

Set 4

To study (i) the bacterial removal efficiency of MBST in combination with solid media flocculator (SMF), (ii) the effect of shock loading and (iii) the total sludge deposited on plates as the percentage of total suspended solids removed in the settling zone during 24 hours run.

RESULTS

1. The total depth of flow has no appreciable effect on turbidity removal efficiency on the MBST.

2. The residual turbidity decreases with the decrease in angle of inclination with the horizontal but the sludge accumulated per m² on bottom also increases. The angle of inclination of 45° seems to be the most suitable considering both the aspects, Figs 4(a) and (b).

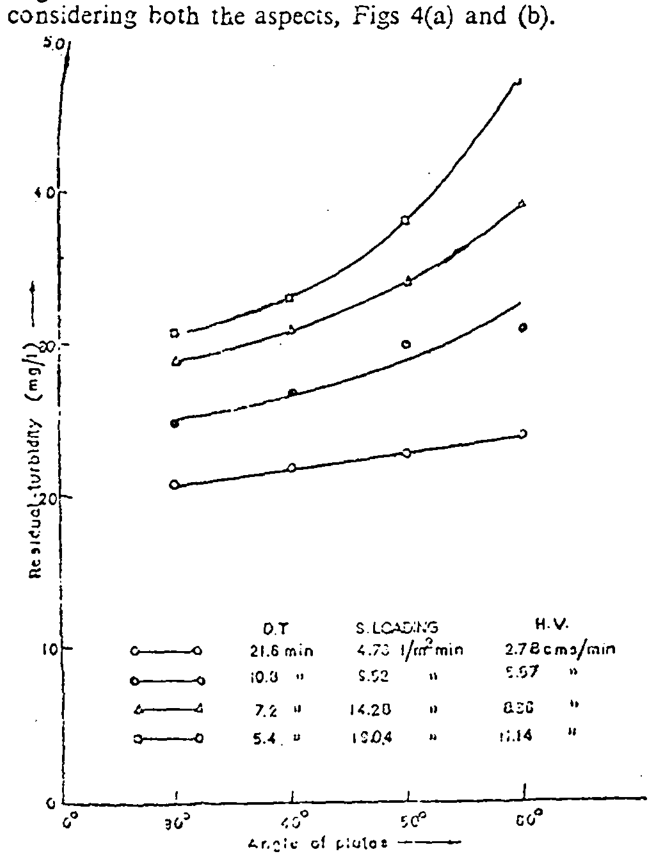


Fig 4(a) Residual turbidity—angle of plates characteristics

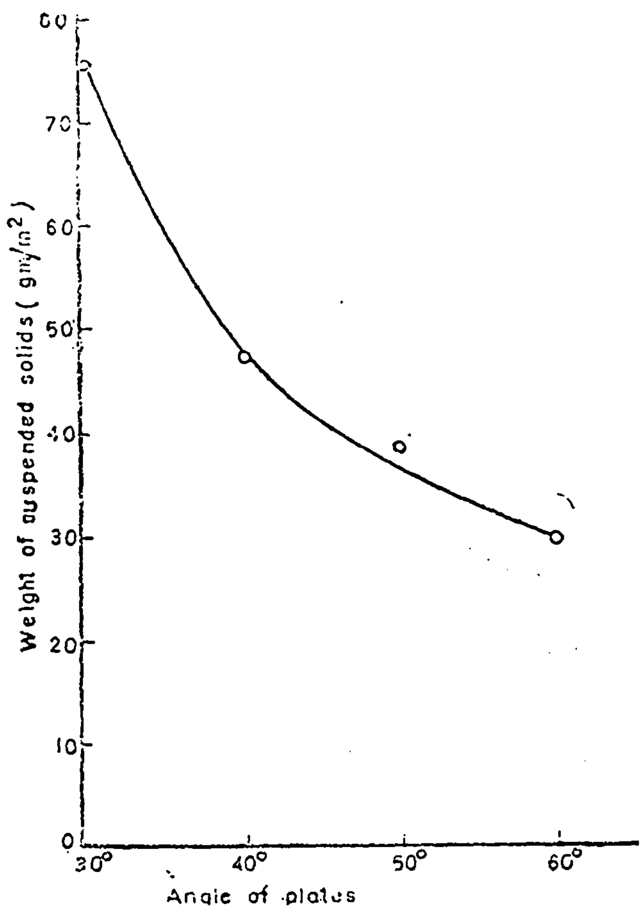


Fig 4 (b) Weight of suspended solids deposited on plates per m²—angle of plates characteristics

3. The efficiency of MBST is not much affected for horizontal velocities less than 10 cm/min. But beyond this, effect is appreciable. The rate of increase of residual turbidity is still faster for higher surface loadings, Fig 5.

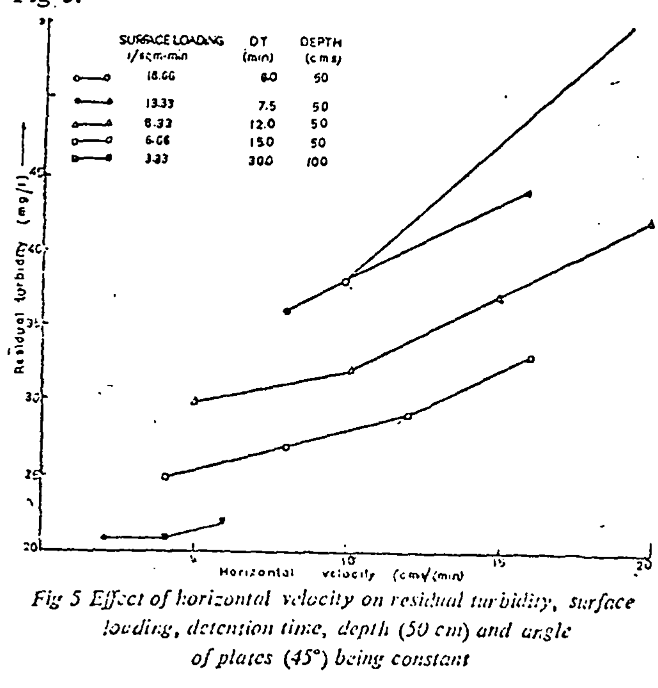


Fig 5 Effect of horizontal velocity on residual turbidity, surface loading, detention time, depth (50 cm) and angle of plates (45°) being constant

4. The efficiency of the MBST decreases with the increase in surface loading. The residual turbidity considerably decreases to about 20 mg/l for surface loadings less than 4 l/m²-min, Fig 6.

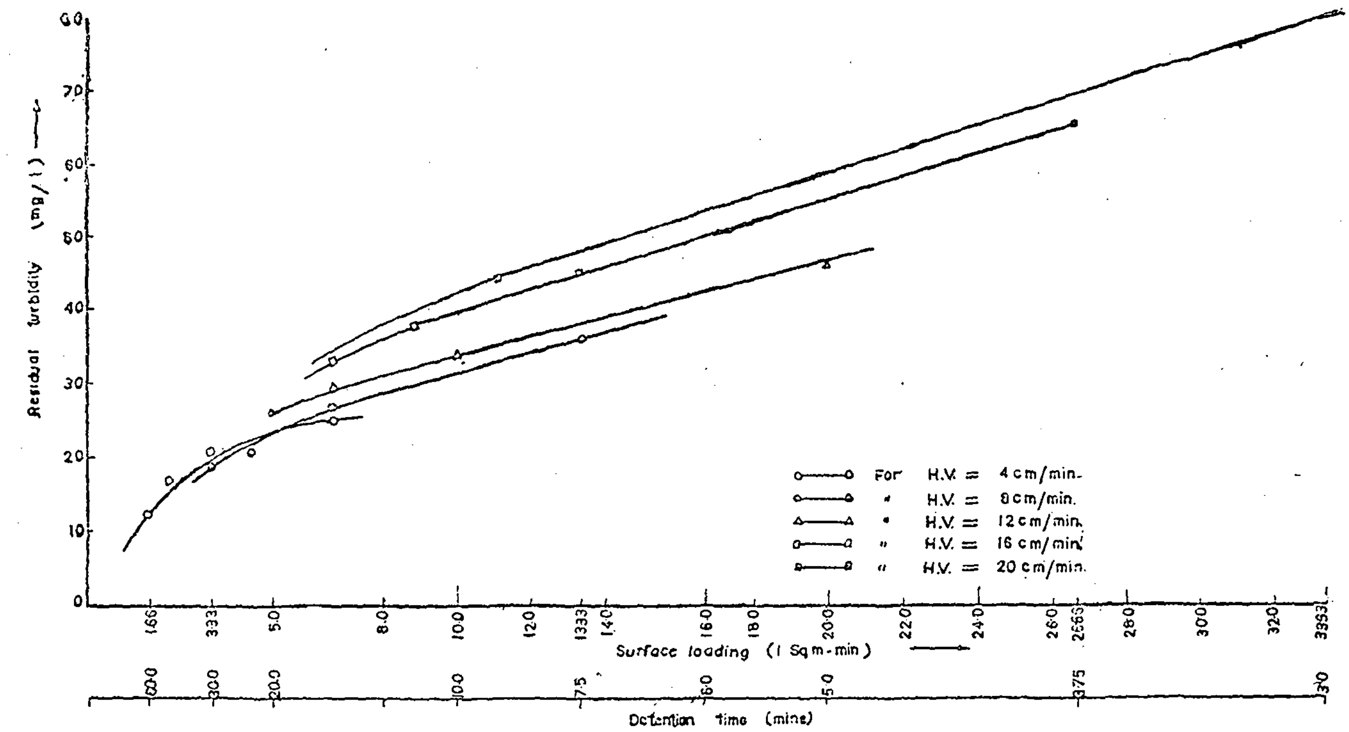


Fig 6 Effect of surface loading on residual turbidity, horizontal velocity being constant

5. The efficiency of the MBST is not affected either due to continuous long runs or shock loading (Tables 1 and 2).

TABLE 1 PERFORMANCE OF MB SETTLER DURING FIRST 20 hr OF RUN

(Raw Water Turbidity 300-400 mg/l)
Dates April 28-29, 1977

Time, hr	Residual Turbidity	Time, hr	Residual Turbidity
18.00	Run started	4.00	29
19.30	29	5 00	35
20.00	29	6.00	31
21.00	31	7.00	27
22.00	31	8.00	29
23.00	27	9.00	31
24.00	33	10.00	31
1.00	27	11.00	30
2.00	33	12.00	29
3.00	31	13.00	27
		14.00	31

TABLE 2 EFFECT OF SHOCK LOADING ON RESIDUAL TURBIDITY

Date April 29, 1977

Time, hr	Raw Water Turbidity, mg/l	Residual Turbidity in settled water. mg/l
14.30	4.80	31
15.30	6.40	35
15.30	700	29
16.00	660	35
16.30	800	33
17.00	920	31
18.00	1100	35

6. The MBST in combination with SMF gives good bacterial removal efficiency, Table 3.

TABLE 3 BACTERIAL EFFICIENCY

Samples	Bacterial Removal Efficiency, %	
	Total Count Test	MPN Test
1	94.88	96.0
2	68.26	89.0
3	70.2	83.0

7. The suspended solids deposited on plates in four settling units after 24 hr of continuous run were found to be 1.3 percent of the total suspended solids removed.

FINANCIAL ASPECTS

Since the cost of any treatment unit is one of the important parameters for its adoptation, a comparison was made between conventional (Clariflocculator) and unconventional (MBST in combination with SMF). For this purpose two types of units having the same performance were designed for capacities 5.0 mld and 0.5 mld. The abstract of comparison is given in the Appendix. The comparison between conventional and unconventional units of the Roha Plant is given there.

It is seen that the cost is reduced by 67 to 89 percent. The reduction is more in case of smaller units. Even in comparison to bottom hoppers, used for smaller plants, the reduction in cost is about 66 percent. Further power requirement is also nil and there is also a saving of 70 to 80 percent in the land requirement.

CONCLUSION

The MBST gives better performance, requires lesser space and no electric power and is economical in capital and maintenance cost. Therefore its use in the field is of great significance in effectively solving the problems of rural areas and small communities.

It is recommended that the MBST should be designed with the following design criteria :

(i)	Surface loading	5.0 to 8.0 l/m²-min.
(ii)	Detention	15 to 20 min.
(iii)	Horizontal velocity	10 to 20 cm/min
(iv)	Angle of inclination with the horizontal	45°
(v)	Spacing between plates	7.5 to 15 cm centre to centre.

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Appendix

COMPARISON OF THE CLARIFLOCCULATOR AND THE NEW UNITS, FOR THE SAME PERFORMANCE

	Capacity 0.5 mld		Capacity 5.0 mld		Roha Plant, Capacity 16.2 mld	
	Clarifloccu-lator	Solid Media Floccu-lator/MBST	Clarifloccu-lator	Solid Media Floccu-lator/MBST	Clarifloccu-lator	Gravel Floccu-lator/MBST
Flocculator						
Detention Time, min	30.0	10.0	30.0	6.5	30	about 11
Volumetric Contents, m³	10.4	3.50	104.0	35.0	495	126.25
Plan Area, m²	3.5	0.78	35.0	7.6	119	24.50
Flocculating Media	Paddles	Gravel	Paddles	Gravel	Paddles	Gravel
Mechanical Equipment	Drive, gears, paddles, etc	Nil	Drive, gears, paddles, etc	Nil	Drive, gears, paddles, etc	Nil
Length of inlet pipe, under inside struture, m	6.0	Almost nil	12.0	Almost nil	20	Almost nil
Clarifier						
Detention time, min	180.0	20.00	180	20.00	150	23.5 Over all effective 18.6
Volumetric Contents, m³	62.4	12.90	624	127.00	2 490	288.4
Plan Area, m²	20.8	4.30	208	28.25	590	56.0
Surface loading, l/m²-min	16.65	6.66	16.66	6.56	27.5	14.4
Mechanical Equipment	Drive, gears, Bridge, Scraper, etc	Nil	Drive, gears, Bridge, Scraper, etc	Nil	Drive, gears, Bridge, Scraper, etc	Nil
Volume of Concrete in the structure (Flocculator and Clarifier, m³)	15.0	10.00	103.0	56.0		
Costs (Flocculator and Clarifier)						
Civil Works (Rs lakh)	0.11	0.06	0.80	0.45	2.30	1.10
Mechanical Works (Rs lakh)	0.44		1.40		1.10	Nil
Total (Rs lakh)	0.55	0.06	2.20	0.45	3.40	1.10
Cost of Clariflocculator and Clarification in Rs/m³/hr	2 644	288.0	1 057.00	216.0	504.0	163.0
Percentage saving on SMF/MBST		89%		80%		67.5%
In case of Bottom Hoppers Total Cost	18 000	6 000				
Percentage saving on SMF/MBST		66%				