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## **Filling characteristics of latrine pits**



### 1. INTRODUCTION

The fullfledged piped water supply and sewerage system being just a dream in the vast rural areas of the country, the leaching pit type latrines are still amongst a few answers to the problem of excreta disposal in vast majority of the rural India and will continue to be the practical solution through a good many years to come. Successful excreta disposal programme will obviously call for, among others, a knowledge of filling characteristics of such leaching pits in various conditions.

Unfortunately field data on filling characteristics of latrine pits are too scanty, particularly in Indian conditions. Because of certain complex inter-relationship between the leaching rate of the pit and the fluctuation of water table and also the change of soil condition of the pit due to mechanical clogging of the soil pores and or formation of zooglear film, it would possibly be more prudent to rely on field data. A complete study was, therefore, under taken in typical rural condition in the rural practice field of All India Institute of Hygiene & Public Health, Calcutta in order to throw some light on the filling characteristics based on field observations. The referred practice field is located at "Singur" block in the District of Hooghly of the State of West Bengal and falls on the Gangetic belt. The present paper high lights some of the findings of the above study.

### 2. OBJECTIVE

The principal objective of this study was to find out the rate of filling of such pits and to predict the optimum cubic capacity/capita and minimum depth required for a leaching pit to last for a minimum period of 4-5 years.

Incidentally the study would throw some lights on the nature of filling, effect of water table, rate of sludge accumulation, extent of consolidation of sludge, which would all influence the life of a pit.

### 3. MATERIALS AND METHODOLOGY

The study was designed within the facilities available at the Rural Health Unit & Training Centre, Singur. Twelve latrines scattered in 7 villages were constructed in different periods of time. The past experiences were not indicative of a great deal of variations in soil composition or the water table conditions in major parts of the operational area of Singur and so the 12 latrines constructed were not considered insufficient to reveal the filling characteristics in the area. No statistical parameters were used in the selection of sites for location of pits and the sites were picked up on the basis of participants' co-operation.

#### 3.1. General and constructional features

In 11 cases the latrines were "R.C.A." type where the pit and the seat are separated, whereas in one case the pit was below the seat and referred as "dugwell" type. Except in one, all the pits were provided with protective linings of earthen rings because of vulnerability of the pits to collapse due to high water table condition usually prevalent throughout the area. The leaching of the pit was ensured by keeping the rings open jointed or dry jointed. One pit was kept unlined to see whether there was any marked effect of non-lining on filling characteristics. The pit was covered with R.C.C. cover. A small 2" (51 cm) square opening with removable concrete lid was kept in the cover slab for measurement of liquid and solid depths of accumulation in the pit. In case of dugwell latrine the concrete squatting plate, 3'-0" (91 cm) dia and concrete pan with in-built water-seal was used. Two observation holes, 1 $\frac{1}{2}$ " (3.8 cm) square were kept in the squatting slab on either side of the pan with removable cement concrete lids fitting to the grooves provided on the top edges of the holes.

As a prerequisite of the study soil analysis as per wet method was carried out in 5 places. The above analysis was carried out in order to have a rough idea of the clay; silt; sand content in the area. The M.I.T. standards viz. clays smaller than .005 mm., silt greater than .005 mm., and sand greater than 0.05 mm. were used.

Percolation tests, based on "Ludwig's" method were conducted at about all the Sites. The test was conducted for 0'-2' (0.06m), 2'-4' (0.6m-1.2m) and in some cases 4'-6' (1.2m-1.8m). The latrine pits were located exactly on the same place where percolation tests had been conducted.

For each latrine pit an observation pit 4" (10.16 cm) dia, lined with dry jointed perforated clay pipe and provided constructed for measuring unaffected water table.

### 3.2. Measurement techniques adopted

In view of prolonged observations to be taken by field workers comparatively simple device were adopted in taking various measurements. Measuring wooden telescopic graduated sticks consisting of two 6'-0" (1.83 m) ones, the narrower one sliding on the outer larger ones were used. The stick would be inserted through the observation hole made on the cover slab of the pit and gently and slowly pushed down through the liquid and solids till it refused to sink by the gentle pressure of the hand. At this point of refusal to sink, it was presumed that the bottom of the consolidated sludge <sup>was reached</sup>. The stick would then be gently and quickly withdrawn so as not to scour the sludge sticking on to its surface. As the graduated stick would come out, reading against the top of the wetted portion would be taken and the reading on the top of the black sludge, sticking on to surface would then be taken quickly before the slimy sludge starts falling back and clear the surface of the yardstick. The reading on top of the wetted portion gives the depth of the total liquid, the reading to the top of the brownish portion gives the depth of sludge. The depth of the pit would also be noted against ~~the~~ fixed reference mark on the cover slab and thus the depth of the consolidated mass could also be computed by subtracting this depth from the original depth recorded prior to using of the pit. In each of the cases the mean of the three reading were recorded.

### 3.3. Determination of use-position

This was possibly the most difficult determinants because of its complete dependence users' co-operation. For this purpose a small board was hung on the wall/door of each latrine and a simple record-sheet was fixed on it. The record-sheet had well-marked 31 rows, each row is placed against a date of the month. Each row would represent each date and would contain the records of that date. Each person using the latrine would have to simply put a stroke mark just before or after using the latrine. Thus the first user would put the first stroke against a particular

date, the next user would put another stroke beside the first one and so on. For facilitating the ticking a lead pencil was already tied with a string fixed on to the recording board.

Thus a complete record of the use position during one month would be available. The filled record-sheet would be replaced with a fresh one at the end of the month. Weekly (towards the beginning) and fortnightly (later on) checking on the users ticking accompanied with health education in negative cases were maintained through out the period of study.

## 4. OBSERVATION AND DISCUSSIONS

The particulars of the latrines viz. type, volume, actual duration, percolation rate, soil characteristics and the rate of filling are presented through table 1. The actual no. of users, as presented in table 1 have been computed by taking average of all the figures obtained from monthly charts showing number of daily users. The pit was reckoned to be filled up when combined liquid and solid level in the pit reached the top of the pit and the pit was no more usable and was taken as the actual duration of the pit. The average rate of filling is then calculated for each pit, as presented in the table 1. The rate of fill varied from a minimum of 0.00258 (0.073 litres) cft/capita/day in latrine pit no. 1 to a maximum of 0.00721 (0.204 litres) cft/capita/day in pit no. 8 with an average of 0.00453 (0.128 litres) cft/capita/day from all the pits whose data were complete. The interesting observation was that the rate at which the pit gets filled up has been found to vary with actual duration, the rate of fill being inversely proportional to the actual duration. This is probably because the longer digestion period gives greater opportunity for the sludge to undergo more complete digestion thereby effecting reduction of volume to a tangible extent. The authors therefore suggest that the rate of filling for a range of actual durations would be a more scientific parameter to be used. The relationship between the rate of filling and actual duration is elucidated in greater detail under "Conclusion".

The percolation rate does not seem to have a tangible effect on the rate of filling probably because of the modified condition of the pit after repeated use for a considerable time.

Table - 1.

Table showing actual conditions of the experimental pits and their duration characteristics.

	pit 1	pit 2	pit 3	pit 4	pit 5	pit 6	pit 7	pit 8	pit 9	pit 10	pit 11	pit 12
Soil (C:Si:S)	1:2.26 :0.73	1:8: 1.15	1:2.2 :1.14	1:8 :1.15	-	-	-	n o t	k n o w n	-	-	-
P. Rate (Min/Inch)	7.65	43.1	5.18	x	28	---	5.7	56.1	8.2	---	9.0	---
Type of latrine	RCA	RCA	D. WELL	RCA	RCA	RCA	RCA	RCA	RCA	RCA	RCA	RCA
Lined/Un-lined	Lined	Un-lined	lined	lined	lined	lined	lined	lined	lined	lined	lined	lined
Volume of pit (Cu.m)	45.30 (1.282)	49.90 (1.412)	45.65 (1.292)	52.2 (1.477)	35.3 (0.998)	39.2 (1.109)	42.8+ (1.211)	59.60 (1.687)	48.6 (1.375)	53.9 (1.525)	47.3 (1.338)	57 (1.613)
In cft (Cu.m)				12.2 (0.345)	12.5 (0.354)	7.75 (0.219)	7.85 (0.222)					
No. of Users per day	6.5	8.0	5.0	9.0	8.0	6.15	6.65	6.34	6.93	8.82	9.13	11.18
Actual duration (yrs.)	7.50	6.58	3.50	6.71	4.50	5.71	4.08	3.62	3.71	2.62	4.58	4.08
Rate of filling in cft(litres)/capita/day	.00258 (0.073)	.00263 (0.074)	.00296 (0.084)	.00472 (0.108)	.00372 (.105)	.00570 (.161)	.00721 (.204)	.00526 (0.149)	.00648 (0.183)	Not calculated		

The measurements taken on (a) total depth of liquid and solids in the pit (b) depth of free water table (c) depth of sludge accumulation and (d) depth of the consolidated solid mass for all the pits have plotted in arithmetic graph paper and monthly variations of each of the parameters shown there. These graphs are not presented in the paper for lack of space.

#### 4.1 Total liquid depth and the depth of free water level.

Except for pit No. 1 which was almost a dry pit, in all other pits the liquid depth fluctuated in accordance with the fluctuation of the free water table in the pit. But a

closer examination revealed that in the initial stages there was hardly any difference between the level of free water and that of the liquid of the pit whereas with the passage of time a difference in these two levels gradually builds up and rises to a considerable extent after 2 to 4 years time.

During the initial stage the pit can continue even if the top of the pit is just a shade above the free water level; whereas in the later stages the depth of the pit must be more than the free water table plus the difference between the liquid depth and the depth of free water.

T A B L E = II

Table showing the maximum difference between the highest level of liquid and the highest free water table in cm. (ft. & inch)

Pit No.	Difference between liquid and free water levels between							
	0-1 yr.	1-2 yr.	2-3 yr.	3-4 yr.	4-5 yr.	5-6 yr.	6-7 yr.	7 yr. & above
2	20.32(0'8")	0	2.54(0'1")	2.54(0'1")	17.78(0'7")	68.58(2'5")	N.K	-
3	2.54(0'1")	0	-	-	-	-	-	-
4	0	27.74 (0'11")	2.54 (0'1")	2.54 (0'1")	30.48 (1'0")	76.2 (2'6")	101.6 (3'4")*	-
5	33 (1'1")	-	149.8 (4'11")	134.02 (4'5")	-	-	-	-
6**	7.62 (0'3")	61 (2'0")	5.08 (0'2")	63.54 (2'1")	104.14 (3'5")	48.26 (1'7")	-	-
7	27.74 (0'11")	27.74 (0'11")	22.84 (0'9")	53.34 (1'9")	-	-	-	-
8	15.24 (0'6")	10.16 (0'4")	50.8 (1'8")	71.12 (2'4")	-	-	-	-
9	22.86 (0'9")	15.24 (0'6")	35.56 (1'2")	91.44 (3'0")	-	-	-	-
10	33 (1'1")	119.38 (3'11")	N.K	-	-	-	-	-
11	0	38.1 (1'3")	-	-	61 (2'0")	-	-	-
12	7.62 (0'3")	10.16 (0'4")	71.12 (2'4")	10.16 (0'4")	10.16 (0'4")	-	-	-
Average	11.78 (4.64")	28.19 (11.1")	36.32 (12.3")	54.61 (19.5")	53.34 (19")	65.20 (21.67")	-	-

\* After completion of 6th year in pit No.4 at first a difference of 1m 1.5cm (3'4") was noticed. After 7 months passed 6 years. another rise of water level commenced when the difference shot upto 1m 77.8 cm (5'10") resulting in filling up of the pit.

\*\* In pit no. 6 after the lapse of 2 yrs. the pit depth was increased by 48.26 cm (19") by raising the pit over the ground; allowing thereby extra static head to be built up which might have permitted additional seepage to occur and the pit meanwhile got one month's rest.

Due to repeated use, the soil conditions undergo changes - its porosity, permeability etc. get modified; at the same time the pit contents also suffer a good deal of changes - its viscosity and suspended matter content increase. In effect, a considerable difference between the top level of the liquid in the pit and that of the free water builds up and some difference is maintained during use. In table II the differences between the highest water table and the corresponding liquid level have been depicted. It may be seen from the table that the commencement of tangible difference between the free highest water table and the corresponding highest liquid level in the pit starts at different times in different pits. The average values suggest that by the second year the difference is 30-48 cm (1'0") whereas the highest difference is over 63 cm (2'1"), 5 to 6 years after commencement of the pit. But possibly one would be more interested to note the highest

differences of such levels that was obtained in each of the pits and this value varied from 48.26 (1'7") to 1m 19.38 cm (3'11") averaging a value of 84.45 cm (2'9.25") above the highest free water table in the pit.

#### 4.2 The behaviour of the consolidated solid

It was observed that a considerable time was really taken to have a steady build up of a consolidated sludge mass leading to reduction of volume of the pit. However, sporadic building up of consolidated mass varying from small amount of a high order have been found to occur in almost all the pits. However, the steady value, varying in each of the pits was observed to occur after a lapse of a lowest period of 1.25 yrs. to a highest value of 4.92 yrs. (except in pit No. 1) the average being 2½ yrs. The maximum value of depth of consolidated sludge was found to vary a great deal viz 7.62 cm (3") being the lowest, 106.68 cm (3'6") being the

highest one, the average of highest and lowest value works out to be 52.32 cm. (1'8.6"). However, the average rise of consolidated sludge mass after a steady value is reached, taking all pits together, works out to be 19.86 cm. (7.82 inches).

5. CONCLUSION

5.1 The latrine pit should be regarded as filled up when at any particular point of time it cannot accept any further load. This is not necessarily due to the complete filling of the pit with solid sludge. Such a condition is generated due to the complex action of fluctuation of water table, modification of permeability, change in viscosity of the liquid mass in the pit owing to solid sludge accumulation.

5.2 Again the sludge accumulation has been observed to fluctuate to a great deal and it reaches a steady value after a passage of a considerable time viz. about 2½ years, when it starts rising.

Therefore, observation for a comparatively short period on the formation of solid accumulation and trying to predict the rate of fill does not seem to be a correct method of finding out the rate of filling of a latrine pit. A prolonged field study is essential in order to correctly assess the actual rate of fill.

5.3 From the observations it is found that in water table pits a build up of a difference between the free water table and the liquid level in the pit is generated, possibly because of the modified conditions of the pit liquid and that of the soil conditions. This difference between the liquid level and free water table level tends to increase with passage of time and after attaining a high value of 84.49 cm. does not seem to vary much even if the pit lasts for a much longer period. Thus in order to fully utilise the pit, the top of the pit must be at least 84cm. (2'9") to 91cm. (3'0") above the highest free water table in the place.

5.4 The rate of filling of the latrine pit has been found to be dependent on the actual duration of the pit i.e the period through which it gets filled up. The rate of filling is found to vary inversely with the actual duration. In other words the longer a pit serves, lesser is the rate of filling. The relationship in the form  $R = \frac{1}{Kt^n}$  where R is rate of filling in cft/person/day, t-actual duration of the pit in years and K and n are constants.

From the observed data and the curve of best fit the value of the constants have been determined and K is found to have a value of

47.5 and n has a value of 1.05. Thus the equation is finally of the form.  $R = \frac{47.5}{47.5 \cdot 1.05} \dots \dots \dots (1)$

The plot on observed data and that based on the above equation are found to run very close to each other. It is further observed from the above that the effect of actual duration is more pronounced with low values of t i.e upto 4-5 years after which the effect is dampened out.

5.4.1 The average rate of filling of 0.000128 cu.m. (0.00453 cft)/capita/day based on actual observation works out to a capacity requirement of 0.0454 cu.m (1.606 cft)/capita/year or 0.227 cu.m. (8.03 cft)/year for 5 membered family. Hence a 76.2 cm. (2'6") dia and 3m 4.8 cm. (10') deep pit is expected to last for a period of 6 years for a family size of 5. The top of the pit, however, should be more than 84 cm. (2'9") above the highest free water level for full utilization of the pit. This is in fairly good agreement with what was believed earlier in Singur area that the average life of a dug-well of RCA latrine pit is about 5 years serving an average family of 5 members.

5.4.2 The authors would suggest different values of Rate of filling of the pit corresponding to the ranges of duration in typical high water-table alluvial soil as in table III, the values having been computed as per the equation (1) above

T A B L E - III

Actual duration expected in years	Rate of filling in cft/cap/day (litres/cap/day)
1 & less	0.02 (0.56)
2-3 yrs	0.0085 (0.24)
4-5 yrs	0.0044 (0.12)
6 yrs & above	0.0026 (0.07)

5.4.3 Most of the pits are usually intended to last about 4 to 5 years and hence the filling rate of .0044 cft i.e 0.12 litres per capita per day which is incidentally also quite close to the average of the observed values is recommended for general use.

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