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A LABORATORY STUDY ON TUBE SETTLING

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INTRODUCTION

The term tube settling used herein refers to the use of shallow settling devices with a detention period a fraction of that of conventional settling tanks to achieving comparable settling efficiencies. The settling device can be short pieces of pipes, closely spaced plates or tubes of any convenient shapes. The application of tube settling in water treatment so far is mostly for coagulated raw water (1, 2). Very little appears to have been done in exploring the potential of the use of tube settlers for plain sedimentation of raw water as a possible economical pretreatment process especially for applications in developing countries.

OBJECTIVE

The objective of the study is to investigate the settling efficiency of a small-scale tube settling device using natural raw water from an irrigation canal as well as synthetic raw water, both without coagulation. The use of canal water is significant since many small communities in Pakistan rely on such a source for their drinking water supplies. In other words, the results obtained should be relevant to practical conditions.

DESCRIPTION OF APPARATUS

The schematic sketch of the experimental set up is shown in Figure 1. It consisted of a raw water reservoir, a constant head tank, a raw water recirculation system including an electric centrifugal pump, the tube settling tank (high rate settlers) and a rotameter for flow control. The suspended particles were kept in suspension in the raw water reservoir by an electric stirrer.

The constant head tank had a main section and an overflow section. The main section measured 15 cm by 15 cm and 12.8 cm deep to the over flow level. The raw water was first pumped from the reservoir into the main section of the constant head tank in such a way that the incoming jet would provide substantial stirring to prevent sediment in the constant head tank. The supply to the tube settling tank was led off near the bottom of the inlet side of the main section of the constant head tank. The excess water in the constant head tank flowed over the top of its partition into the overflow section for return by gravity to the raw water reservoir. The pumping rate was kept greater than the flow to the tube settling tank.

The tube settling tank rectangular in plan was made of No. 22 galvanized iron sheet. The tank was 89.5 cm long and 18.5 cm wide with an overflow depth of 10.5 cm. It had an inlet compartment and an outlet compartment. Both compartments extended to the full width of the tank and were 8 cm wide. A perforated baffle was provided at the inlet side and an overflow weir at the outlet side. The tube settlers were formed by fourteen No. 22 galvanized iron sheet plates, each 61 cm long and 18.5 cm wide spaced at a clearance of 6.3 mm by glass tubing along the two sides of the tank.

The rotameter was inserted in the feedline between the constant head tank and the tube settling tank.

METHODOLOGY

The canal water was normally taken fresh from a nearby irrigation canal in the morning of the day a run was to be made in plastic containers of approximately 5 and 10 liters. The use of small containers was to facilitate agitation before feeding the raw water into the raw water reservoir.

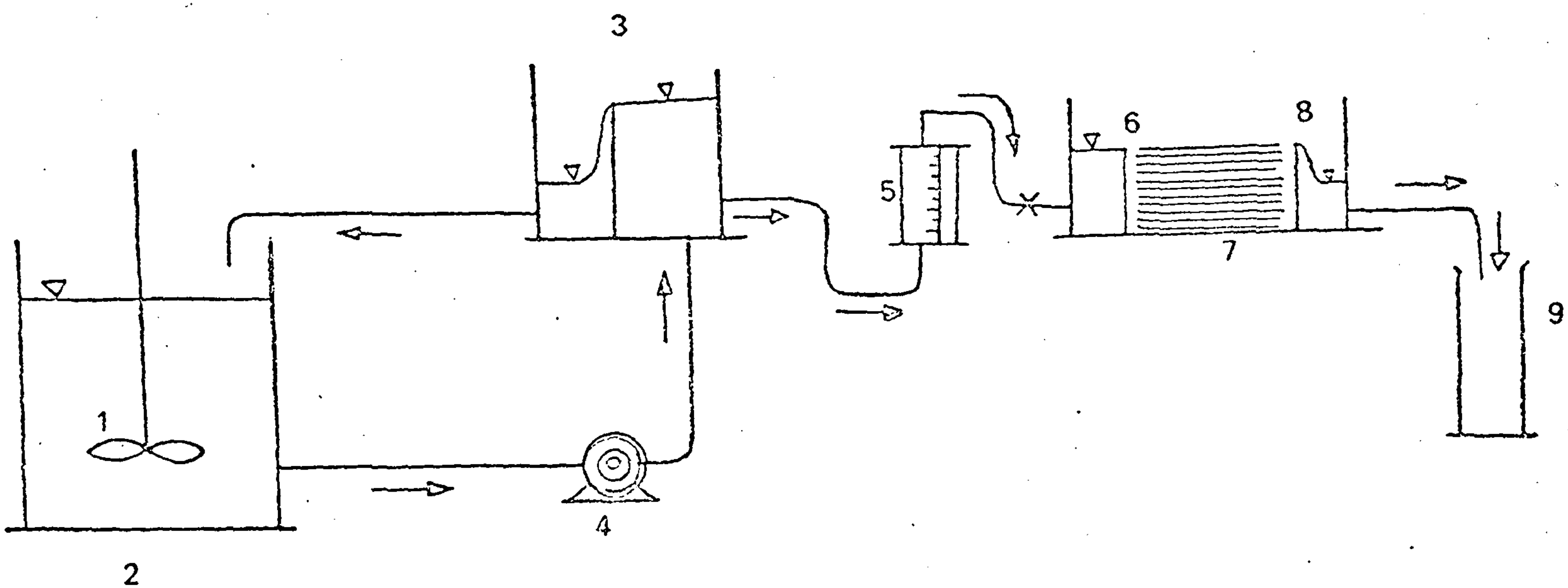
Synthetic raw water was prepared with tapwater and Chinese Fuller's earth at the rate of 50 grams per 40 liters on the day a run was to be made.

Flow rate control was obtained by setting the float in the rotameter at a given reading. The actual flow was checked by a stopwatch and a plastic 1-litre measuring cylinder. Water temperature was measured by a mercury thermometer every hour. Hourly raw water samples were taken from the raw water reservoir for turbidity determinations on a Hach Turbidimeter, Model 2100A during a run.

Effluent samples were taken at 15-minute intervals from zero hour for turbidity measurements. Effluent sampling continued until a steady turbidity reading was reached.

The settling tank was filled to overflow level with tapwater and settled water from the previous run before each run.

FIG. 1 SCHEMATIC SKETCH OF EXPERIMENTAL SET-UP



1. Electric Stirrer
2. Raw Water Reservoi
3. Constant Head Tank
4. Pump
5. Rotameter
6. Perforated Baffle
7. Tube Settling Tank
8. Overflow Weir
9. Effluent Sample

EXPERIMENTAL RESULTS

(a) Synthetic raw water :

Ten runs were made in January and February 1975, using synthetic raw water. Table 1 presents the results. The efficiency achieved was quite encouraging. It was therefore decided to proceed to the second stage using natural uncoagulated canal water as the influent. Notice that the raw water turbidity varies even though the same dosage of Fuller's earth was used in each run.

TABLE 1

Tube Settling of Synthetic Raw Water

Run	Water Temp. °F	Flow Rate ml/min	Raw Water Turbidity JTU	Effluent Turbidity JTU	Efficiency %
1	56	279	100	13	90.7
2	55.5	430	150	19	86.4
3	55.5	725	180	23	83.6
4	56	216	125	12	91.4
5	57.5	182	160	15	89.3
6	55	116	130	9	94.6
7	54.5	79	105	6.9	95.1
8	57.5	96.5	175	7	95
9	60	101	130	8	96.3
10	60.5	221	130	10.2	92.7

(b) Canal raw water:

Ten runs were made from May to June 1975 using raw water from the canal. The experiment was interrupted due to heavy flood-damages of the canal intake in the fall, the season of high turbidity for canal water. Hence, the results were somewhat inadequate for highly turbid raw water. Table 2 presents the results indicated as Run 1 to Run 10 for May to June 1975. Runs 11 to 15 were made from September to November 1974 when the canal water had a turbidity level of less than 100 JTU.

TABLE 2

Tube Settling of Canal Raw Water

Run	Water Temp. °F	Flow Rate ml/min	Raw Water Turbidity JTU	Effluent Turbidity JTU	Efficiency %
1	78	76	10[illegible]	22	78
2	82	90	110	25	77.3
3	87	95	175	26	85.1
4	74	96	160	30	81.4
5	82.5	109	175	30	82.9
6	75	116	160	33	79.4
7	81	157	170	45	73.5
8	83	154	280	90	67.9
9	74	164	250	80	68
10	74	203	280	102	63.5
11	81	63.5	70	7.5	89.3
12	71	68.4	24	5.7	76.2
13	69.5	61	23	4.3	81.4
14	64	120	20	4.2	79
15	62	123	14	3.7	75.4

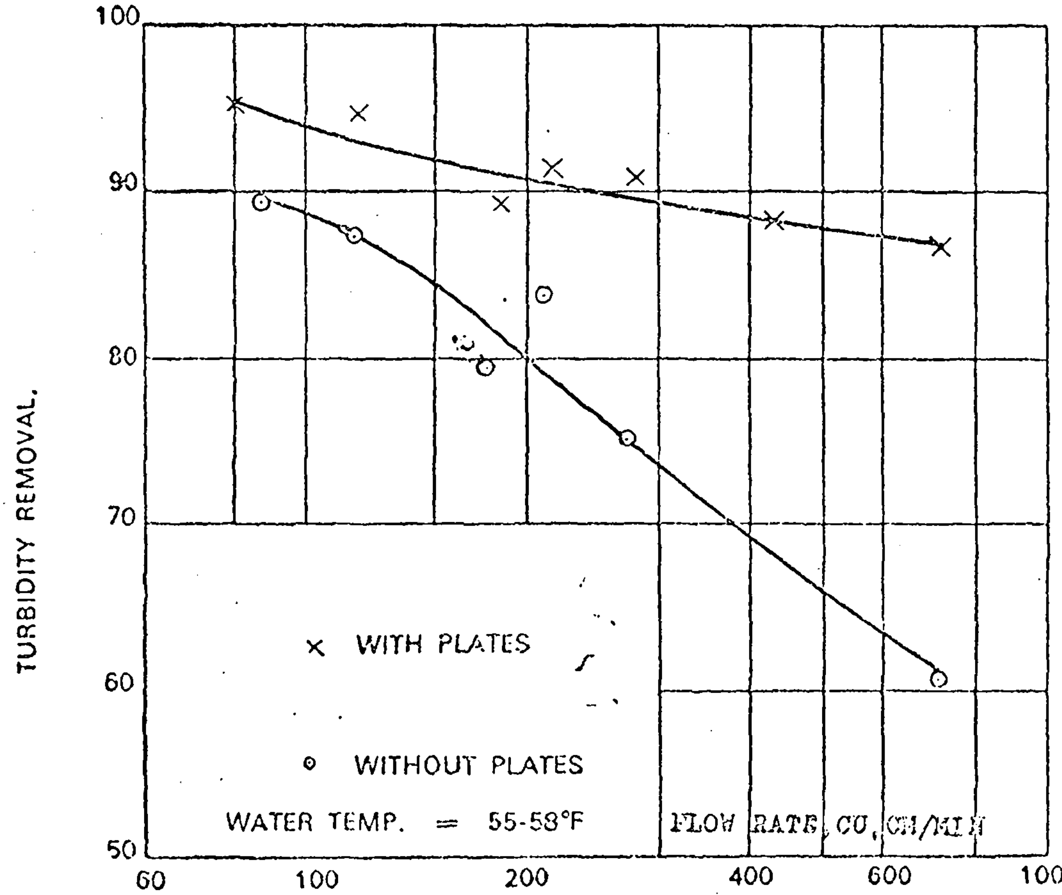


FIG. 2
EFFECT OF PLATES ON SETTLING EFFICIENCY (SYNTHETIC RAW WATER)

(c) Effect of Plates on Settling Efficiency:

Six runs were made with the plates removed from the settling tank to observe the effect of the presence of plates on settling. These runs used synthetic raw water prepared from Chinese Fuller's earth as in (a) and were made during the same period as for the runs in (a) to minimize the temperature effect. Fig. 2 presents the comparison of the results of the two sets of runs, one with plates and the other without plates. Notice that the set with plates is the same one presented in Table 1.

DISCUSSION AND CONCLUSIONS

It is easy to see that settling efficiency of a given tube settling system varies substantially with the characteristics of raw water.

For the canal water studied, the tube settling device can provide good pretreatment without coagulation at moderate level of raw water turbidity. Performance tends to deteriorate as raw water turbidity reaches the level of 250-280 JTU. In view of the limited results on highly turbid water, further study is necessary before definite conclusions can be made.

The presence of plates does improve the settling efficiency especially at higher flow rates. Since the experimental settling tank without plates is still a shallow settler, the improvement of efficiency due to the plates compared with that of conventional settling tanks of, say, 3 meters deep would be more substantial than that indicated in Fig: 2.

Acknowledgement

The study was in a way inspired by the global programme of the WHO International Reference Center on Community Water Supply for slow sand filtration systems and was intended as the contribution from the Institute of Public Health Engineering and Research, Lahore, Pakistan, to the Programme. The opinions expressed do not necessarily represent the views of the World Health Organization.

The help rendered by Arshad Mahmud Rana and Jamshad Qureshi Research Assistants and Mohammad Rafique and Aslam Khan, Stenographers is gratefully acknowledged.

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PERFORMANCE OF LABORATORY SCALE

HIGH RATE SETTLER USING CANAL WATER AS INFLUENT

OCTOBER, 1975

Date	Flow Litres/minute	Influent Turbidity, FTU	Effluent Turbidity, FTU	% Removal	Temperature °F
9-6-75	92.2	160	27	83.1	74.0
10-6-75	110.0	175	30	82.8	82.5
17-6-75	116.0	160	33	79.4	75.0
18-6-75	157.6	170	44	74.1	81.0
21-6-75	155.0	280	90	68.0	83.0
25-6-75	165.0	250	80	68.0	74.0
27-6-75	210.0	280	95	66.1	74.0
28-6-75	166.7	200	77	61.6	80.0
19-8-75	45.0	280	85	69.0	84.0
21-8-75	41.3	260	70	73.0	84.0
22-8-75	48.4	210	72	65.7	81.0
14-10-75	41.2	95	4.0	95.8	75.0
15-10-75	41.0	55	3.0	94.4	80.0

REPORT ON VISIT TO PATTOKI WATER TREATMENT PLANT

PATTOKI, PUNJAB, PAKISTAN

JULY, 1975

1. PURPOSES OF VISIT

The Visit was kindly arranged by Mr. Fazal Qureshi, Chief Engineer, Public Health Engineering Department, Punjab. Mr. Iqbal Hussain, Research Officer of the Department, took all the trouble to accompany the writer during the visit.

At present, WHO is very keen in studying and promoting slow sand filter systems especially for developing countries. The Pattoki Plant is a slow sand filtration Plant nearest to Lahore using canal water as the source. Raw Water turbidity is sometimes fairly high and pretreatment appears to be ~~in~~ adequately provided by plain sedimentation. The purposes of the visit were therefore:

(1) To observe the working of the system.

(2) To examine the general practice in operating a treatment plant for relatively small communities in the Punjab.

(3) To investigate the potential to use the Plant as an H.E. class field workshop.

The kindness of Mr. Qureshi, Mr. Hussain and persons involved in making the visit possible is gratefuly acknowledged.

2. Description of the System

The Water supply system was completed about three years ago and serves presently a population of about 10,000 out of the total population of 20,000 in the served area. Ten standposts are provided for the general Public. Hence, the actual number of persons benefited may exceed 10,000. Daily supply is limited to four hours with a total quantity of 300,000 gals.

The main treatment facilities include two settling tanks of 270'x270' each with a total capacity of 5.4 mg, three slow sand filters of 60' x60' each, and a cylindrical clear water tank of 50' in diameter and 9' in depth. A 50,000 gal overhead tank is also located in the Plant. The supply system employs a total of 14 persons.

Raw water flows about 3700' by gravity from the canal to the settling tanks. Settled water is pumped into a high-level tank for distribution to the filters. Filtered water flows by gravity into the clear water tank and is chlorinated in the tank before being pumped into the overhead tank.

3. OPERATION OF THE PLANT

The settling tanks are operated on a fill-and-draw basis with a five-day cycle. In other words, water is drawn from one tank continuously for five days while the other tank is being filled with raw water. Since the consumption of five days is less than the capacity of one settling tank, the withdrawal operation does not empty the tank. The exception is during canal cleaning when both tanks will be emptied for the period. Hence the settling tanks serve the purpose of sedimentation as well as emergency storage. Sludge accumulation is apparently not serious. There appears no need of cleaning after three years' operation.

The operation of the three slow sand filters is on a rotation basis. At anytime, one would be filtering , one would be being emptied for cleaning and the third one would be being made ready for filtering. This means that only one filter is actually in use at any time. Each cycle takes a week, indicating a filter run of seven days which is extremely low for slow sand filters. The dirty surface layer is scraped off the sand bed and is discarded at each filter cleaning. The filter is refilled with new sand every six months. No sand washer is used or provided.

Chlorination is done by dumping a calculated amount of bleaching powder into the manhole of the clear water tank four times a day. No check was made as to the residual chlorine in the system during the supply period. Health statistics are not available locally to judge the effectiveness of Plant Operation in controlling Water-borne diseases.

4. Treatment Plant performance

Following samples were taken during the visit:

sample 1. Raw Water.

2. Settled Water from Settling Tank No. 1. (Being filled).

3. Settled Water from Settling Tank No. 2 (being withdrawn).

4. Filtered Water.

Turbidity measurements were made at the Institute with a Hach Turbidimeter by the writer himself and the results are as follows :-

Sample	Turbidity, JTU.
1.	160
2.	3.6
3.	6.5
4.	3.6

5. General Comments.

It was not the aim of the visit to offer advice on any aspects of the treatment Plant. The time was also short to be able to make a thorough check on the precise conditions of the system. The following are therefore general comments based on brief observations and limited laboratory data.

It appears that pretreatment is performing satisfactorily. On the other hand, the filters are not doing too well judging from the small turbidity reduction.

The system provides an excellent opportunity for further studies. For instance, the improvement of the withdrawing operation may reduce the turbidity of settled water introduced into the filter in view of the low turbidity in the tank being filled. It would be also of interest to see the possible difference in performance if the settling tanks are operated on a continuous flow basis.

The operation of the filters seems to need more studies. The flow control is done by varying the water depth in the filter. This is not too common in other countries. However, this approach does give a much simpler design, making a close study worthwhile. Critical studies are also necessary to examine the facts that only one out of three filters is in use at any time, the filter run is much too short and the filtered water quality appears not as good as it should be under the circumstances.

The treatment facilities are useful, to a certain extent, for M.SC students to observe the working of slow sand filtration Plant.

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Refdues