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Slow Sand Filtration for Cercariae Removal in Rural Egypt

by

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"إزاله السركاريا بواسطه المرشحات الرمليه البطيئه فى مصر"

ملخص الدراسة:

فى سنة ١٩٩٠ وقعت جامعة المنصوره عقدا مع المركز الدولى لتطوير البحوث الكندى وذلك للقيام بعمل أبحاث حقليه لإختبار قدرة المرشحات الرمليه البطيئه فى معالجة مياه الشرب للقرى المصريه.

وتم بناء المحطة التجريبيه فى محطة رافع سندوب والتى توجد بها ٣ وحدات نقالى لمعالجة مياه الشرب بواسطة المرشحات الرمليه السريعه وتتكون المحطه التجريبيه من مأخذ للمياه على ترعة البحر الصغير ومرشح زلط خشن وأربعة مرشحات رمليه بطيئه وكان من أهداف هذه الدراسة هو معرفه قدرة المرشحات الرمليه البطيئه فى ازاله السركاريا المسببه لمرض البلهاريسيا. فلقد تم اضافه لتر يحتوى على ١٠٠٠٠ سركاريا الى احد المرشحات الأربعة. واخذت عينات مقدارها ٢٠ لتر لمدة سته ساعات من عدة مخارج على المرشح وذلك لمدة يومين حيث تبين أن المخرج النهائى للمرشح خالى تماما من السركاريا فى حين انه عند ارتفاعات اخرى خلال رمل المرشح تم التعرف على السركاريا فى العينات المأخوذه.

هذا وخلال التجارب الحقليه على المرشحات الرمليه البطيئه تم أخذ ٢٠ عينه من كل من المرشح الخشن والوحدات النقالى وكذلك احد المرشحات الرمليه البطيئه التى لم توضع فيها السركاريا وتبين من القياس عند مخرج هذه الوحدات أن السركاريا تمكنت من الخروج من المرشح الخشن والوحده النقالى بينما لم تتمكن من الهروب من المرشح البطئ. مما يؤكد قدرة المرشحات الرملية البطيئه فى ازالة السركاريا.

Abstract

In 1990, El-Mansoura University signed a contract with the International Development Research Center IDRC to conduct an integrated research to field test the process of slow sand filtration. One of the many purposes of this project is to demonstrate the efficiency of the SSF in removing cercariae.

A pilot plant was constructed and installed in Sandoop Compact

Water Treatment Plant in El-Mansoura City. The pilot plant consists of an intake, Upflow Roughing Filter (URF), and four SSF's. The raw water source was El-Bahr El-Saghier Canal, a branch of the Nile River.

A slug of 10000 cercariae units in one liter was dropped on the water surface at each of three filters, no presence of cercariae at the final effluent of the SSF were detected. At some depths across the sand layer positive samples were identified.

During this study twenty samples from the effluent of the tested slow sand filters; the URF, and the compact treatment plant were collected. Out of the 20 samples positive results showed nil after the SSF, 5 after the URF and, 3 after the compact unit. These results indicated the efficiency of the SSF in removing cercariae.

Keywords

Cercariae, Slow Sand Filter, (SSF), Upflow Roughing Filter (URF), compact rapid sand filtration treatment plant.

Introduction

Belharzia is not only found in Egypt but it affecting more than 200 million persons in 73 countries. Schistosoma has been existing in Egypt since the pharaonic times. Belharzia is caused by agents of thegenus Schistosoma. Two species of this genus are existing in Egypt, Schistosoma Mansoni and Schistosoma Hematobium. Schistosoma Mansoni which is the causative species of intestinal bilharziasis while Shistosoma haematobuim which is the causative species of urinary bilharzia.

Schistoma heamatobium lives in the pelvic venous plexuses surrounding the urinary bladder, prostate, seminal vesicle and lower third of the uteros, while Schistosoma Mansoni lives in the mesenteric venous plexuses draining the large intestine. It may live also in the portal system.

Cercariae are relatively short-lived (up to 48 h), non-feeding organisms which have large glycogen reserves. The length of life of a cercariae is dependent upon these glycogen reserves, and any extrinsic factors, such as turbulence or temperature, which may stimulate use of them will therefore reduce viability. (Jordan and Webbe, 1980)

The number of cercariae which die during penetration of mouse abdominal skin steadily increases with the age of the cercariae. An initial mortality level of about 30 % is observed for 2-hour-old cercariae, which rises to 50 % at 8 hours and 85 % at 24 hours. (Jordan and Webbe, 1980)

In the Egyptian rural area Schistosoma miasis is an endemic disease. Over 57% of the rural population in some governorates are said to be infected. The most important effect of this desease is the reduction in productivity of the infected persons accordingly this greatly effects the national economy of Egypt. (Fadel 1989)

Eventhough, it has been reported that slow sand filters are capable of removing Giardia Cysts effectively, their capability of removing cercariae from surface waters still requires to be examined. Cercariae is very mobile, Giardia Cysts are not. This was demonstrated during the field studies.

In recent years there has been a notion on the part of some sanitary engineers to assume that slow sand filtration is an old fashioned method of water treatment that has been completely superseded by the rapid sand filtration process. This idea has definitely been shown to be mistaken. Under suitable circumstances, slow sand filtration may not only be the most economical and simplest, but also the most efficient method of water treatment. Its advantages have been proven in practice over centuries, and it is still the method of choice for water purification even in certain highly industrialized cities as well as in rural areas and small communities.

Eventhough it was reported that cercariae were recovered in the effluent of sand filters of researche work, (Unrau and Richard 1961, Bernarde and Johnson 1971), the conditions of their experimental work were different. The filtration rate employed was intermediate between conventional slow sand and rapid sand filtration.

The general objective of the SSF project was to develop a simple, cost effective, easy to operate and maintain, and effective technology for water treatment in rural areas of Egypt. One of the many specific objectives is to develop preliminary design and operational guidelines for producing cercaria free water, during which a review of possible surrogate parameters as indicators of cercariae removal will be considered.

Methodology

Pilot Plant:

The pilot plant consisted of an upflow roughing filter (URF) followed by four slow sand filters (SSF) in parallel as shown in Fig. 1. The raw water source for the pilot plant was from EL-Bahr EL-Saghier canal (a branch from the Nile River). The raw water was pumped to the pilot plant by means of two pumps that were operated alternatively, each pump ran for 45 minutes.

The URF and the four SSF's were reinforced concrete pipes, each with 3.50 m height and 2.25 m in diameter. The URF and SSF filter configuration and media characteristics are as shown in Fig. 2, and 3. The SSF's were run under constant head and flow.

Cercariae Production:

Cercatiae were produced in the laboratory This was accomplished by obtaining schistosoma eggs from infected patients, hatch the eggs into miracidia and infect victor snails collected from canals and drains. The snails were kept in covered trays in a secure room with light control. Cercariae were then harvested as required by techniques developed by Bourgeois of the John Hopkins University. (Kawata 1982).

A liter of cercariae with a concentration of 10,000 units was dropped into the influent of filter # 2 on July 7^{Th}, 1991. Samples at 5 depths in the filter media were collected twice daily for 2.5 days. It is noteworthy to mention that filter 2 was in operation for 40 days before adding the cercariae i.e. the schmutzdeke was very mature. The filtration rate was 6.5 m^3/m^2/day which is considered a high filtration rate. The sand depth was 0.8 m. The samples were 20 liters in volume and continuously collected over 6 hrs.

A second test cercariae removal was conducted on July 21^{Th}. A slug was dropped in the influent of filter # 1. The filtration rate of this filter was 4.5 m^3/m^2/day. The sand depth was of 1.4

m deeper than that of filter # 2. At 6 depths within the sand media, samples were collected two times per day for 2.5 days. As in the first test, the sample volume was 20 liters and was collected continously over 6 hours. The filter was only 5 days in operation.

A third test was conducted on July 28Th. This time filter # 3 was employed for this purpose. The filter sand depth was 0.8 m, and the filtration rate was 4.5 m^3/m^2/day. As that in test 1, 20 liter samples were collected from 5 depths twice a day for 2.5 days. Table 1. illustrates the three test conditions. The filter was 5 days in operation.

During the month of July 20 samples were collected from the effluent of the URF, and compact unit, and from filter # 4, where no cercariae were introduced to test the presence of cercariae.

Results and discussions

Fig.4, 5, and 6. illustrate the tabulated results of the three tests. The results indicated that cercariae can be completely removed from the treated water by the SSF. regardless of the flow rate and media depth values employed in this study.

In the first test, the highest flow rate and the smallest media depth employed in this project, cercariae did not escape in the effluent. Eventhough it was very close to escape, since positive samples was found at the gravel layer outlet port.

In the second test, cercariae was found at the bottom of the sand layer but nothing was detected in the gravel layer.

In the third test, as in the previous tests no cercaria was detected at the filter effluent. Again, some samples were positive at different depth of the sand media.

In the three tests, positive samples were detected close to the outlet after 36 hrs of adding the slug. At this time, Cercariae are in a week stage of their life cycle, which lasts for 48 hrs. It is important to mention that the total retention time for the water to transport from the raw stage to the consumer in the URF-SSF system is more than 24 hrs. This period is enough for weakening the Cercariae, if they found their way with the discharged water at the treatment plant effluent. Based on the design criteria obtained in this study, the retention period for the water in the URF is 5 hrs, and 17 hrs for the SSF at the best design flow rate of 4.5 m^3/m^2/day.

Twenty samples were collected from the effluent of one of the slow sand filters not involved in cercariae testing, the URF, and the compact unit. The samples were examined for the presence of cercariae. The results indicated that no cercariae were recovered at the effluent of the SSF, while five samples were positive in the effluent of the URF and three samples were positive in the effluent of the compact unit.

In case of the compact units employed in Egypt, the situation is dangerous especially when the plant is running out of chlorine for disinfection. This is because of the short retention period of the system, which do not exceed 5 hrs.

Conclusions

The study conducted at the SSF pilot plant at El-Mansoura City reveals many important conclusions. The one deal within this paper is the ability of SSF in removing cercariae. The three tests conducted showed that under the circumstances of flow rate and media depth employed in these test, cercariae were completely removed. However at some depths of the sand media positive samples were identified.

Cercariae escaped from both the URF and the compact rapid sand filter treatment plant. A dangerous situation may arise when the compact units are running out of chlorine, a condition which happens frequently in Egypt.

There was no need for finding certain surrogate parameters as indicators of cercariae removal because of the complete removal of cercariae.

In case of cercariae escaping from The URF - SSF treatment plant, it will not be in the harmful stage because of the long retention period. This condition is not applicable in the compact units treatment plant because of its short retention period.

Acknowledgement

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Table 1. Tests conditions

Test #	Date	Filter #	flow rate $m^3/m^2/day$	Sand depth	Effective Size
1	7-9 July	2	6.5	0.8	0.6 m with 0.18 mm 0.2 m with 0.37 mm
2	21-23 July	1	4.5	1.4	0.6 m with 0.18 mm 0.8 m with 0.37 mm
3	28-30 July	3	4.5	0.8	0.6 m with 0.18 mm 0.2 m with 0.37 mm

List of Figures

Notes:-
1- Splitter box to U.R.F and S.S.F
2- U.R.F outlet and splitter box to S.S.F
3- S.S.F outlet
4- Inspection chambers

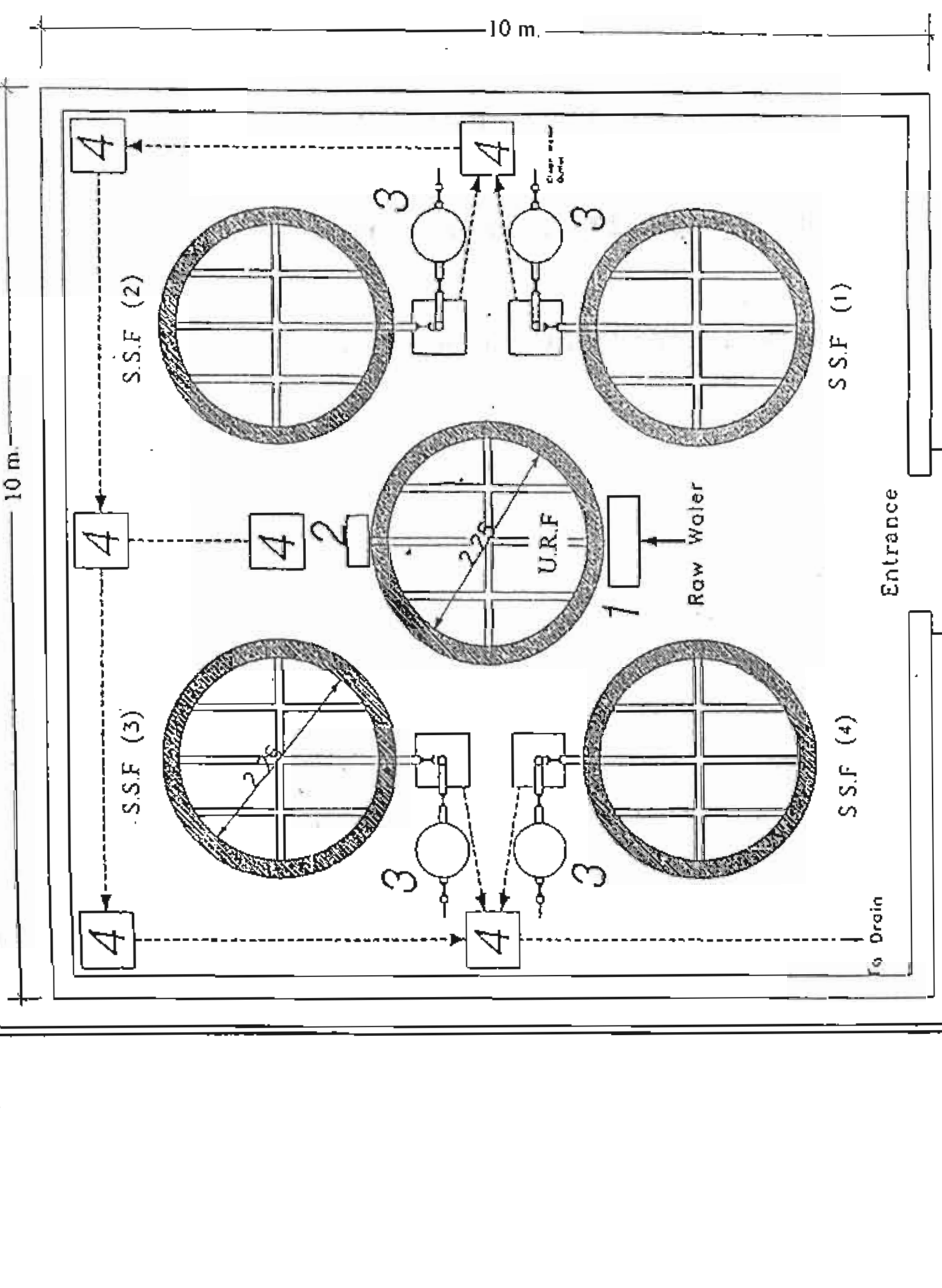

Figure (1) : General layout of the pilot plant

Operation mode: Valve 1 and 3 are open
Valve 2 is closed.

Washing mode: Valve 3 and 2 are open
Valve 1 is closed.

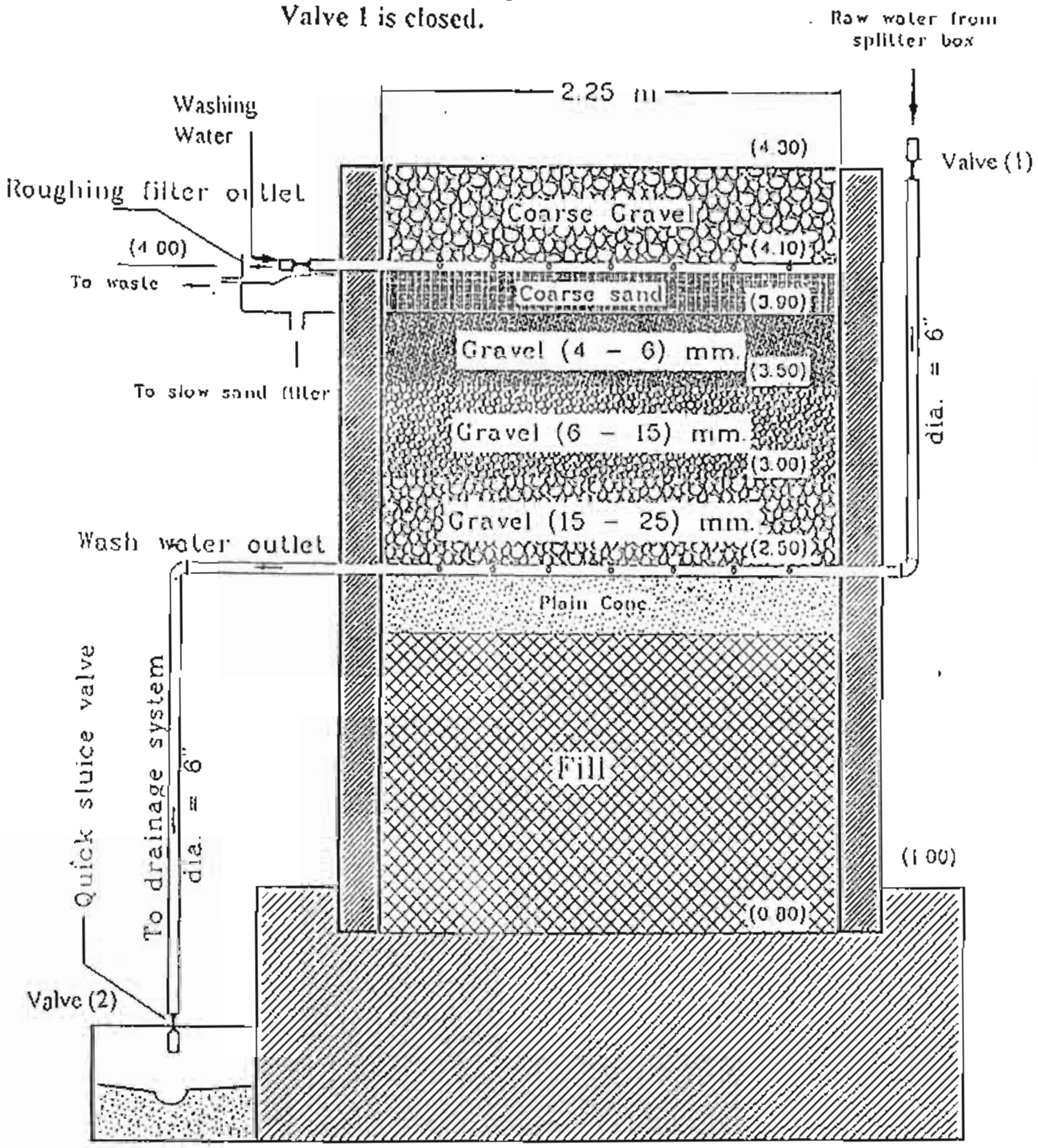

Figure (2) : Cross section of the pilot upflow roughing filter

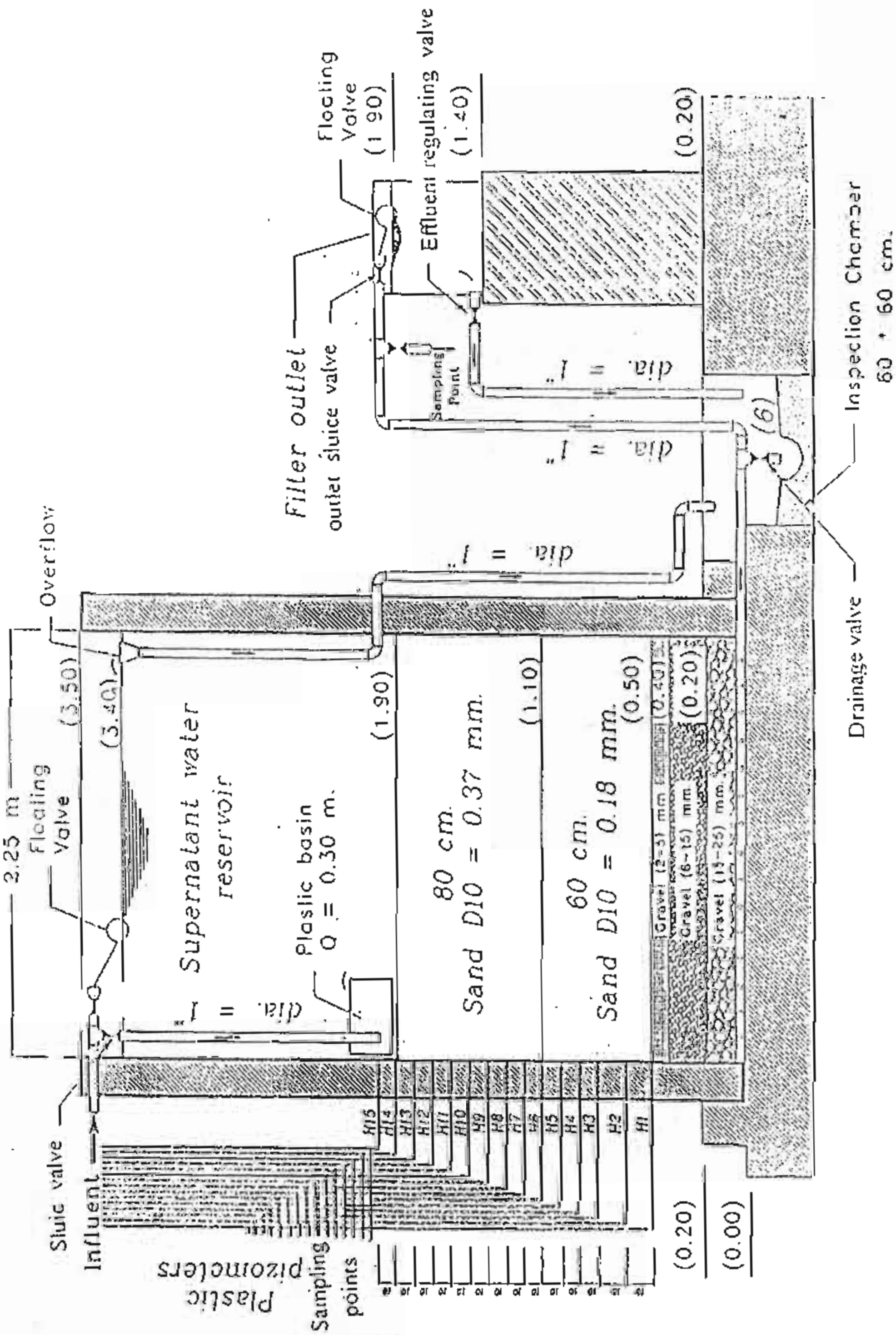

Figure (3) : Cross section of the slow sand filter

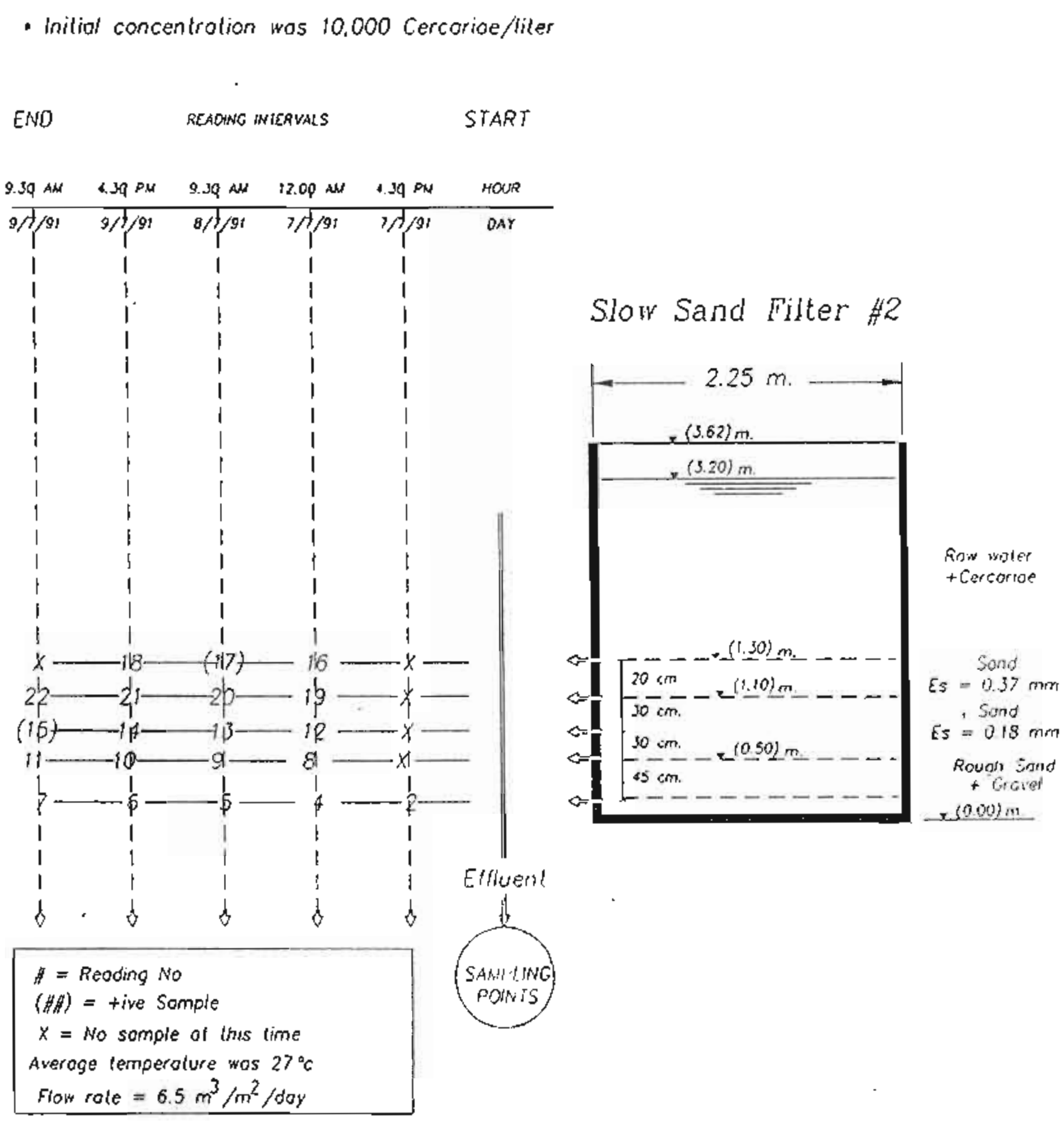

Fig. 4. Setting up test #1 for Cercariae removal

• Initial concentration was 10,000 Cercariae/liter

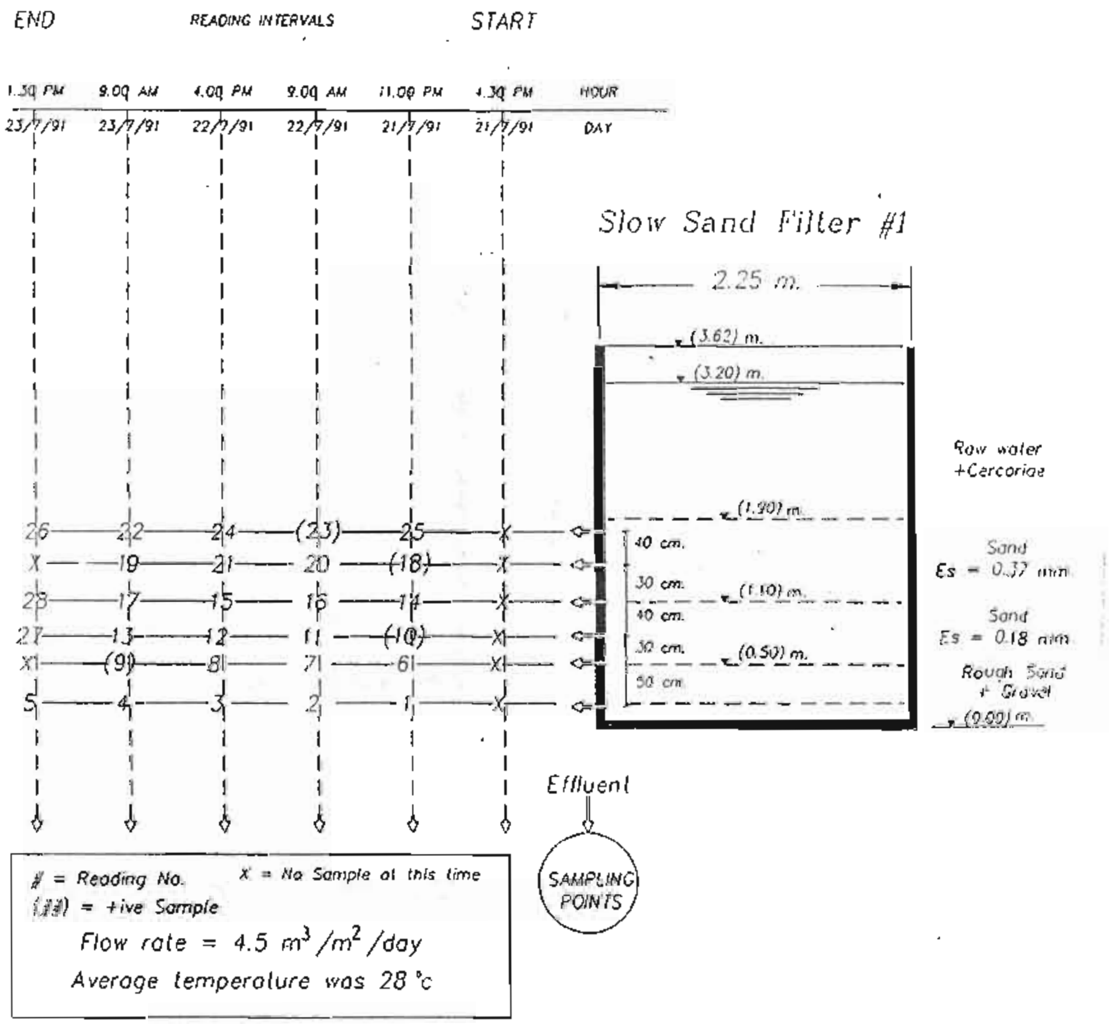

Fig. 5. Setting up test #2 for Cercariae removal

* Initial concentration was 10,000 Cercariae/liter

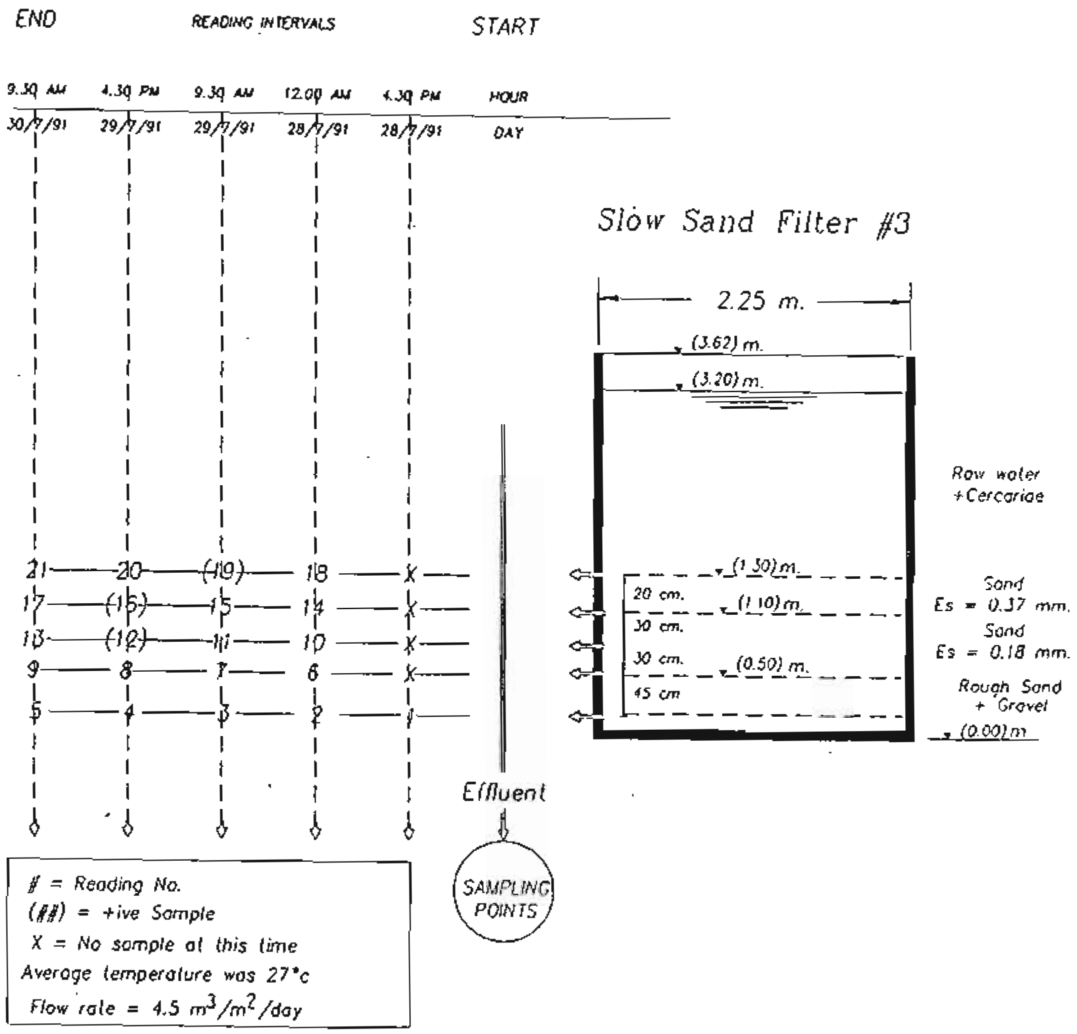

Fig. 6. Setting up test #3 for Cercariae removal