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Roughing filtration with polystyrene beads

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IN EMERGENCY SITUATIONS due to natural disasters, war or famine the lack of adequate clear water can lead to dehydration, disease and even death. When such a situation arises in developing countries, international aid agencies and non governmental organisations are often asked to provide safe drinking water. The most commonly used emergency treatment method for drinking water is disinfection. Efficient application of disinfection requires raw water of low turbidity. Pre-treatment of raw water containing solid matter is therefore necessary. One common method in emergencies is chemical flocculation in conjunction with sedimentation for solid matter separation. However, the use of chemicals increases the reliance on technical expertise and external agencies for the continuation of effective water treatment after the emergency has passed. In addition, such treatment methods can often not be integrated into a rural treatment plant after the emergency because of the unavailability of chemicals, inadequate dosing equipment, difficult operation and maintenance procedures, or lack of local technical skills and trained operators.

An alternative is prefiltration using roughing filters which are simple, efficient and chemical free. It also can be used by local agencies or authorities after the emergency has passed. Practical experience shows that roughing filters can achieve a particulate matter reduction of 90 per cent or more (Wegelin 1986); furthermore, they can improve the bacteriological water quality (i.e. a 1 -2 log reduction of faecal coliforms has often been recorded), and reduce colour and dissolved organic matter to some extent.

Figure 1. Roughing filter

In an upflow roughing filter water flows at low velocity through a coarse medium in an upward direction. The filter bed is sometimes composed of material decreasing in size in the direction of the flow and others of media of a constant size. The basic components are the filter box which contains the media, the media bed, the underdrain system, the inlet and outlet construction and the flow control devices (Figure 1). Little is known about the mechanisms responsible for the removal of suspended and colloidal material; mechanical, physical, biological and chemical processes all play a role in upflow roughing filtration (Wolters et al., 1989). Filter design is defined by six design variables which can be selected within a certain range: filtration rate, average size of filter medium, individual thickness of filter medium, number of filter fraction and area of filter bed. Any inert, clean and insoluble material can be used as filter medium as long as it has a large specific surface and high porosity.

The principal disadvantage of roughing filters in emergencies is the filter medium which is commonly gravel. Gravel may be unavailable in some locations and is difficult to transport long distances because of its weight.

This paper will describe work that has been undertaken at WEDC to develop a portable roughing filter using polystyrene beads in place of natural stone as filter medium.

Experimental method

The filter model chosen was the vertical upflow type using a single size aggregate. The vertical upflow type was chosen because it incorporates a simple self cleaning mechanism and occupies minimal floor space when compared to horizontal flow roughing filters.

Two identical filters were set up to run in parallel in the laboratory, one with polystyrene media and the other with gravel of similar size. The manufactured water quality for turbidity was chosen to be within the indicative raw water quality limits for water treatment systems as Galvis et al (1993): turbidity 100 to 200 NTU. The filters ran for 40 days. The filtration rate was 0.75m/h. Two 300mm diameter PVC pipes were used to hold the media. The filter media depth was 1.0m and the under drain was 0.5m in depth. The polystyrene media was ‘S’ shaped with an average size of 22 x 14 x 12mm; the stones were from angular crashed granite of sieve size 25.4 to 9.6mm. The set up of the filters can be seen in Figure 2.

Figure 2.

A second experiment was conducted using water from a nearby stream. This time both filters contained polystyrene media, but with different shapes and sizes: filter A contained a 0.05m depth of ‘S’ shaped media (11 x 8 x 7mm) and 0.75m of smaller ‘S’ shaped media (6 x 4 x 3mm); filter B contained 0.05m depth of ‘S’ shaped media (11 x 8 x 7mm) and a depth of 0.75 of polystyrene beads (average 3 - 4mm). The rate of filtration was 0.75 m/h.

A third experiment again used the stream for raw water supply. Both filters contained the same type of media, but with a different filter bed depth. Filter A contained 0.1m of ‘S’ shaped media (11 x 8 x 7mm) and 90cm of polystyrene beads (4mm); filter B contained 0.1m of ‘S’ shaped media and 0.65m polystyrene beads. The rate of filtration was 1m/h.

Results

1st experiment

The results from the first experiment can be seen in figures 3 and 4 where polystyrene is compared to gravel for turbidity removal.

Both filters produced a series of results that showed an equivalent removal efficiency for both polystyrene and gravel for turbidity, with an average turbidity removal of 42 per cent and 41 per cent respectively.

Once the fact that polystyrene could replace successfully gravel was established, the next step was to compare different types of polystyrene media which were commercially available.

2nd experiment

The results are presented in Figure 5. As it can be seen, the removal efficiency for the polystyrene beads is overall slightly better than the ‘S’ shaped media. The removal efficiency for the polystyrene beads can exceed 90 per cent in some cases. It is interesting to note that the peaks in the removal percentage correspond to peaks in raw water turbidity; in other words, the more turbid the raw water, the better the filter works.

3rd experiment

In the third series of testing, the effects of different filter media depths and a higher filtration rate were observed.

The results are presented in Figure 6. Filter A had overall a slightly better removal rate, but the difference is not significant. It is suggested that the filter media depth between 1.0 and 0.75m did not affect significantly the removal rate. The average removal rate for turbidity was 45 per cent; again, due to the low turbidity of the raw water, the removal efficiency was low for turbidities < 10 NTU, but were greater than 60 per cent for turbidities > 30 NTU.

Discussion

Existing literature suggests similar removal efficiencies for various configurations of roughing filters using stones or gravel as media; Wegelin (1980) produced results with similar aggregates to the first series of testing giving removal efficiencies of 50 to 65 per cent. Upflow roughing filters in Colombia have resulted in the removal efficiency of 69 to 83 per cent for upflow roughing filters in series and 46 to 71 per cent for upflow roughing filters in layers (Galvis et al, 1993). The low removal rate of the first set of experiments was propably due to the large size of media used. The results of these experiments suggest that upflow roughing filters using polystyrene beads will produce similar results.

Conclusions

Polystyrene beads are as efficient at removing turbidity from natural and artificial water as gravel of a similar size.

The optimum removal efficiency for low turbidity water was observed using polystyrene beads of 4 mm diameter, a bed depth between 0.75 and 1.0 m and a filtration rate of 0.75 m/h. This may only be true however for waters of reltaively low turbidities. Larger media may have to be used or filters in series if the turbidity is very high. A portable roughing filter can be built using this configuration.

There is no significant difference on the removal efficiency between the two bed depths of 0.75 and 1.0 m.

Turbidity removal rate varies with inlet turbidity. As inlet turbidity increases so does the removal rate.

References

GERADO, G., TEUN, V.J., FERNANDEZ, J., and FABIOLA, B., 1993, “Pre-treatment alternatives for Drinking Water Supply System, Selection, Design, Operation and Maintenance”, Occasional Paper 22, IRC International Water and Sanitation Centre, Netherlands.

WOLTERS, H., SMET, J.E.M., and GALVIS, G., “Pretreatment Methods for Community Water Supply”, in chapter 8, edited by Smet J. E. M. and Visscher J. T., 1989, IRC.

WEGELIN, M., 1986, “Horizontal Flow Roughing Filtration, a Design, Construction and Operation Manual”, IRCWD Report No 06/86, Switzerland.

WEGELIN,M., 1980, “Slow Sand Filter Research Report”, Report 2, University of Dar Es Salaam, Tanzania.

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Figure 3.

Figure 4.

Figure 5.