6th WEDC Conference: March 1980: Water and waste engineering in Africa

SULEYMAN O ADEYEMI

LOCAL MATERIALS AS FILTER MEDIA IN NIGERIA

INTRODUCTION

For purely economic reasons, sand from the nearest river-bed to water treatment plants are being used as filter media. Besides, Nigeria is endowed with other materials which can be suitable as filter media. Examples of such material are bituminous coal, coke coal, and ceramics.

However little is known about the properties of these materials in their local form. In spite of this, local sand is being substituted for imported sand as filter media in many of the new treatment works.

The common practice is to determine the suitability or non-suitability of the sand simply on the basis of sieve analysis alone. This is definitely an insufficient basis to accept or reject any sand as filter media.

Even when the particular sand has been selected, the problem of operating the filter optimally arises because of the lack of sufficient knowledge of its characteristics.

The objective of the research project is to determine the suitability of any of the local materials, develop performance criteria through pilot plant studies and improve design and operation in order to meet the desired quality goals.

However in this paper, we will report the results of the studies conducted to determine the physical characteristics of the sample sand from various locations in the country, full-scale plant studies of the performance of a filter plant using local sand as media, and pilot plant studies to compare the performance of some of the local sand.

PHYSICAL CHARACTERISTICS

Some of the physical properties presently measured include percentage solubility, percentage usable, % too coarse, %too fine, specific gravity, size, fall velocity, sphericity. Others that need to be measured are filtrability index and durability.

Table 1 shows the properties of the stock sand from a number of locations in the country. It can be seen that for most of the sample sand, their effective sizes lie outside the standard requirements of 0.35 - 0.70mm (1). The uniformity coefficient for a few of the sample sand falls within the acceptable range of 1.3 - 1.7 (1).

The obvious inference is that only a small percentage of the stock sand is directly usable as filter media. However in a country where labour is still relatively cheap, it may not be uneconomical to use the graded stock.

The percentage solubility of the samples is well within the specification and a lot of them were found to be clean.

The sphericity for most of the different sizes in each stock sand ranges from 0.4 to 0.8.

The values in the table represent the averages. They do not compare well with the value for Leighton Buzzard ($\psi = 0.85$) or NCB anthracite ($\psi = 0.7$) (2).

FULL-SCALE STUDIES

The 5.5mgd (25 l/d) Zaria water treatment plant commissioned in 1975 has been using the sand from the bed of river Galma as its filter media. The filter media consists of 24 inches (61cm) sand of 14 mesh - 25 mesh grading, 4ins (10.2cm) of coarse sand (6mesh - 14mesh), 10ins (25.4cm) of pebbles (6mesh - ½"). The average filter flow rate is 2.2gpm/ft^2 (1.4mm/s).

The purpose of the full scale plant studies is to evaluate the performance of the filtration process over a period of time. The performance criteria include filtrate quality, Break through Index and head loss pattern.

For the periods of study, the effluent

Table 1: Properties of the stock sand

Sources	Specific gravity	P_{10}	$U = \frac{P_{60}}{P_{10}}$	Solubility %	ψ	P_1%	P_2%	P_3%
Jibiya	2.62	0.17	3.41	0.2	0.6	28.0	52.2 d=0.48mm	80.2 d=1.25mm
Minna	2.66	0.22	2.50	0.3	0.57	80.0	42.0 d=0.48	NIL
Gora	2.54	0.34	4.41	0.3	0.63	30.0	15.0 d=0.43mm	45.0 d=1.0mm
Batsari	2.66	0.25	6.60	0.4	0.58	24.0	23.6 d=0.46mm	47.6 d=1.0mm
Lagos	2.75	0.22	1.82	1.4	0.53	20.0	78.0 d=0.5mm	NIL
Sokoto	2.71	0.30	3.33	0.2	0.53	42.0	17.9 d=0.47mm	59.8 d=1.0mm
Kaduna	2.64	0.30	1.77	1.1	0.51	60.0	49% d=0.48mm	NIL
Kwall	2.69	0.34	2.33	0.6	0.49	50.0	12% d=.45mm	62.0 d=1.1mm

P_1 = % Usable
P_2 = % too fine
P_3 = % too coarse

turbidity was consistently less than 1.0JTU averaging about 0.6JTU. The turbidity removal was ususally about 90% just after backwashing declining to 60% just before the next backwashing.

Figure 1 is a graph of filter quality as a ratio of the inlet quality (C/co) with filter run time. The rise which is referred to as the filter breakthrough is terminated at value of 0.28. This is higher than the acceptable value of 0.2 for a 24ins filter depth (3).

Figure 2 shows the headloss pattern for a typical filter run. The graph is almost linear indicating that there is filtration (or clogging) with depth. This is a desirable phenomenon for deep bed filters.

The average breakthrough Index K = 1.28×10^{-3}. It falls between the values for water receiving average degree of pretreatment and high degree of pretreatment (4).

PILOT PLANT STUDIES

The purpose of the pilot plant studies was to compare the performance of the stocksand from river Galma with anthracite coal-sand media under both coagulated and uncoagulated influent water.

The studies was then extended to compare the performance of three sand samples which closely satisfy standard specification for physical properties (Zaria, Kaduna and bar beach, Lagos).

The pilot plant was set up at the Zaria water treatment plant.

The pilot filter containing the river Galma sand performed equally well as the dual media with the effluent turbidity much less than 1.0JTU for coagulated influent water. As expected the performance of both

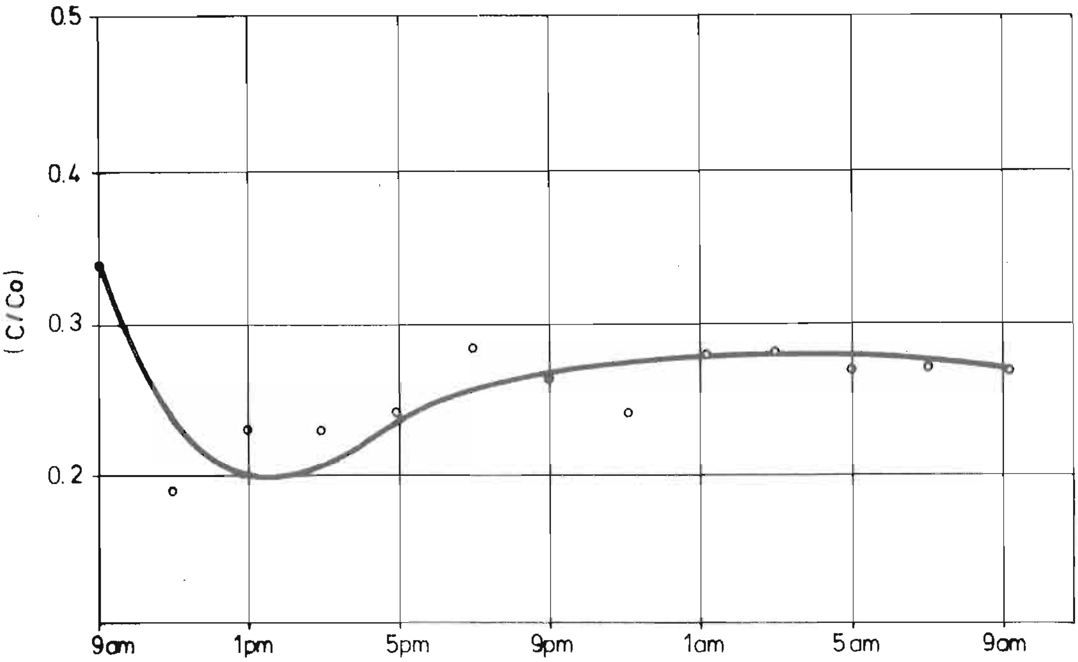

FIG. 1 FILTRATE QUALITY (C/Co) VARIATION WITH TIME OF FILTER RUN.

filters were poor for uncoagulated influent water.

Figure 3 shows the headloss pattern for both pilot filters. Characteristically, the headloss developed by the dual media is lower, less rapid, and more linear. However the headloss pattern for the pilot filter is not different from that of the full scale.

The comparative peformance studies clearly show that the Lagos bar beach sand and river Kaduna sand perform better than the river Galma sand in terms of turbidity removal efficiency, filter run length time and head-loss development.

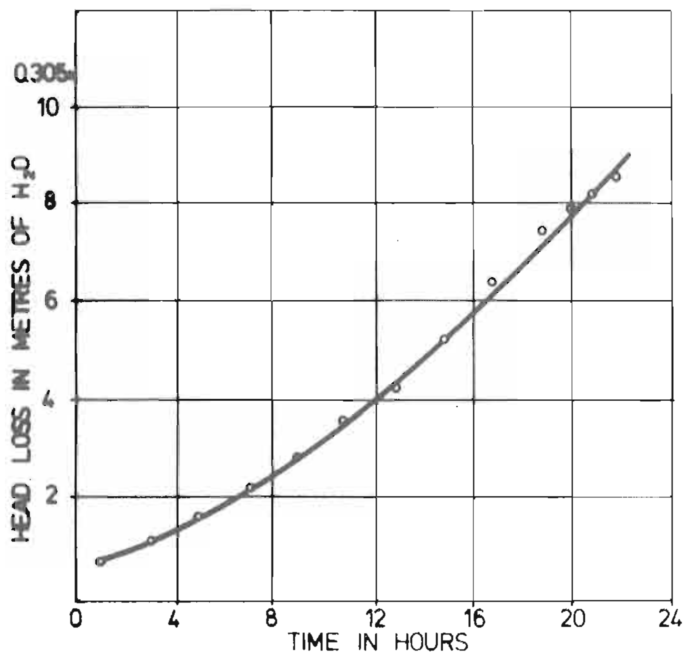

FIG.2 HEAD LOSS Vs TIME OF FILTRATION.

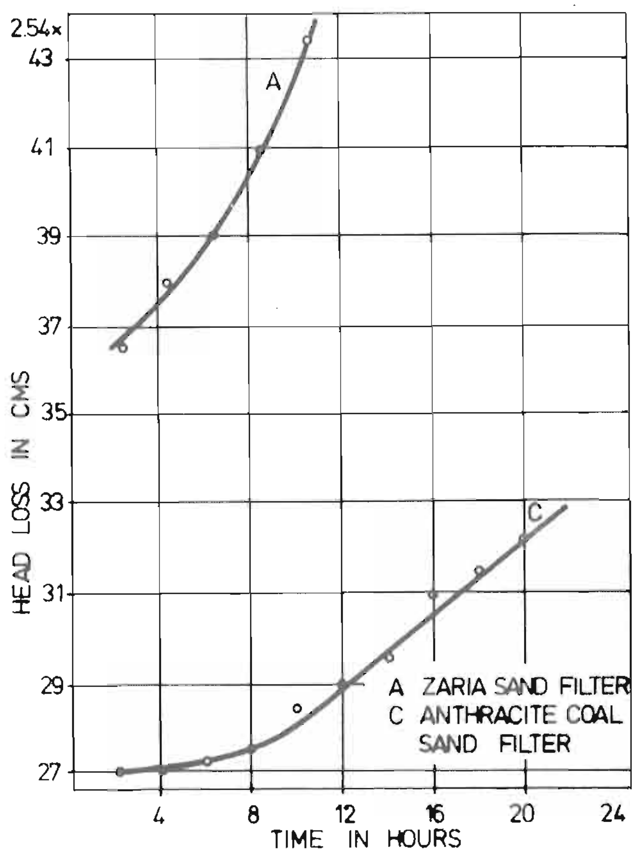

FIG.3 HEAD LOSS Vs TIME OF FILTRATION

CONCLUSION

The standard specification set for the various physical properties of a filter media can be met by the locally available sand even if it will require major regrading. But in a country with cheap labour, this may not be too uneconomical.

However the other aspect that is under active study is the modification that can be made to the present design criteria and standards (such as ideal filtration rate, optimum filter depth, type of flocculant and dosage) in order to make them more relevant to local materials, and conditions.

REFERENCES

1. Culp G.L. and Culp R.L. New Concept in Water Purification, Van Nostrand Co., New York, 1974 (A book).

2. Ives, K.J. Specification for grannlar filter media, Effluent and Water Treatment Journal, June 1975, 296-305.

3. Cleasby J. L. "Filtration" in Physico-chemical process for water quality control Wiley-Interscience, 1972 (A book).

4. Fair, M.F. Geyer J.C., Okun D.A. Water and wastewater engineering volume II Wiley and Sons, 1966 (A book).

KALYANPUR Y BALIGA

DEVELOPMENT OF SMALL SCALE SYSTEMS FOR IRON REMOVAL FROM GROUNDWATERS

Direct transfer of technology of iron removal systems for groundwater treatment in use in developed countries is considered not desirable for developing countries in general, and small scale water supplies in particular. A research project was undertaken from July 1976 to July 1979 at the University of Science and Technology, Kumasi, Ghana, which this paper describes.

The methodology of the research project consisted of:

1. Identification of candidate systems from literature, correspondence and International visits.
2. Field survey to supplement available groundwater quality data as well as identification of a level of iron concentration acceptable to rural consumers, (vis-a-vis the Standards), for treatment targets.
3. Laboratory studies of candidate systems including modification of conventional systems.
4. Field testing of promising systems for development into technologies for practical application and dissemination.

After analysis of available information, a project staff visited India, Bangladesh, Tanzania and Malawi. Consequently the Domestic Iron Removal Unit (DIRU) and the Madras-type system were selected for testing in Ghana. In addition a conventional system was also selected to evaluate possible improvement of iron removal efficiency by plain sedimentation through the use of granular media in a sedimentation tank, in conjunction with slow sand filtration.

The field survey was carried out using questionnaires to assess user attitudes, and a field laboratory kit to determine ground water quality. A total of 187 boreholes were seen in 83 towns and villages of which 73 were found in operating condition at the time. An average iron concentration of 1.38 mg/l in the range of 0-19 mg/l was found, with 12 samples out of 47 showing concentrations above 1.0 mg/l. The highest concentration considered to be acceptable by some respondents was found to be 4.0 mg/l though others considered levels as low as 1.45 mg/l as unacceptable. It was found that

some respondents was found to be 4.0 mg/l though others considered levels as low as 1.45 mg/l to be unacceptable. It was found that iron concentration alone may not be the basis for accepting or rejecting water.

The laboratory experiments using synthetic water showed that only about 11% of iron precipitates were removed by plain sedimentation with raw water iron levels in the range of 1.8-3.5 mg/l for a detention time of 60 minutes. Removals up to about 30% were observed when gravel of approximate size of 50mm was used as the granular medium in the sedimentation tank under a detention time of 60 minutes based on void volume. Slow sand filtration following aeration and granular media sedimentation, under flow rates from 0.12-0.4 $m^3/m^2/h$ produced satisfactory effluent with iron concentration in the range of 0.17-0.03 mg/l. The relevant ranges of pH and alkalinity were 6.9-7.8 and 67-92 mg/l respectively. While studies of granular media sedimentation tank extended to about 100 days of operation, filter studies were limited to five days of operation at each rate of flow.

Time constraints compelled the field testing of DIRU without prior laboratory studies. The DIRU was set up at a village near a borehole with a handpump. The iron concentration however was found to vary unusually very much in the range of 8.5-72.0 mg/l. During the operation of the unit with each bucketfull of water being poured intermittently, results of 17 days of operation showed an average effluent concentration of 42.0 mg/l. However continuous operation at flow rate of 0.72 $m^3/m^2/h$ on filter, for a two hour period on two days, gave an average effluent concentration of 0.12 mg/l from an average influent concentration of 15.8 mg/l. These results should be considered tentative in view of the short-term nature of testing.

It was considered desirable to modify the non-submerged filter of basic DIRU into a submerged filter to improve performance. The modified DIRU was able to produce an average effluent quality of 0.06 mg/l iron from an average influent of 15.9 mg/l based on two days operation of two continuous hours each.

Under similar operating conditions, but with two basic DIRU in series, average effluent concentration of iron was found to be 0.3 mg/l (evidently influenced by a single high value of 1.3 mg/l). Other modifications have been proposed but not tested. Because of the limited nature of the field testing programme so far carried out, it is recommended that more extensive field testing be carried out, including a prototype based on laboratory studies.

Acknowledgement is made of financial and material support of Health Sciences Division of International Development Research Centre Ottawa, Canada, and the assistance of project and management committee staff.

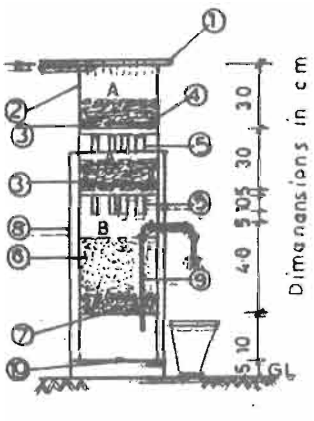

FIG 3(a) MODIRU-1

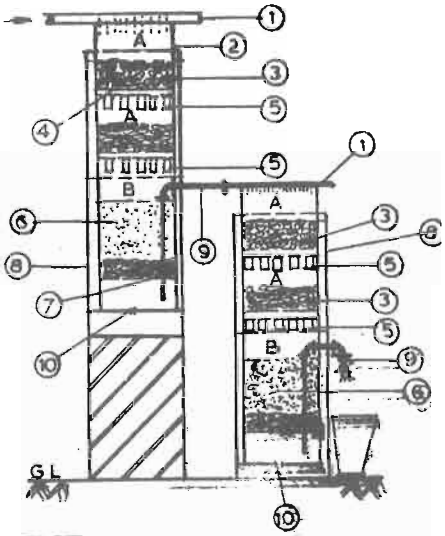

FIG [illegible] DIRU-4

MODULAR COMPONENTS

A. CONTACT AERATOR   B. SUBMERGED FILTER

LEGEND

1. 25mm PIPE INLET WITH HOLES AT 25mm C/C
2. GALVANISED IRON SHEET CYLINDER OF 37cm dia
3. 25cm CHARCOAL LAID 15cm DEEP
4. PLATE WITH 1·4cm HOLES AT 2·5cm C/C
5. VENTILATORS 2·5cm x 10cm
6. SUBMERGED SAND FILTER WITH 30cm COARSE SAND OVER 5cm LAYER OF 1·25cm GRAVEL
7. PLATE WITH 1·25cm HOLES AT 1·25 C/C
8. WOODEN FRAME
9. ø 2·5cm OUTLET PIPE
10. DRAIN