15th WEDC Conference

Water, Engineering and Development in Africa

Kano, Nigeria: 1989

# Ferruginous groundwater treatment with bida sands

S.A. Muyibi, O.B. Odumosu and P.A. Omozokpia

## INTRODUCTION

The results of chemical analysis of groundwater in Bida area of Niger State, Nigeria show high levels of iron content which varies from 10-30mg/1 which far exceeds the WHO recommended limit of 0.3-1mg/1.

The high iron content is due to the Nupe sandstone geological formation which is made up of thick sand-stone and iron-stone flat topped hills with soils of the ferrosol types at higher elevations changing to reddish brown feruginous tropical soils in th lower terrain.

Most boreholes drilled in this area have been abandoned due to unavailability of the necessary facilities for treatment.

The investigatory work described in this paper aims at determining iron removal in ferruginous ground water to acceptable levels using a laboratory scale model aeration - sedimentation - slow sand filtration (upflow type). Sands used for the slow sand filter were obtained from different locations around Bida with commercial deposits.

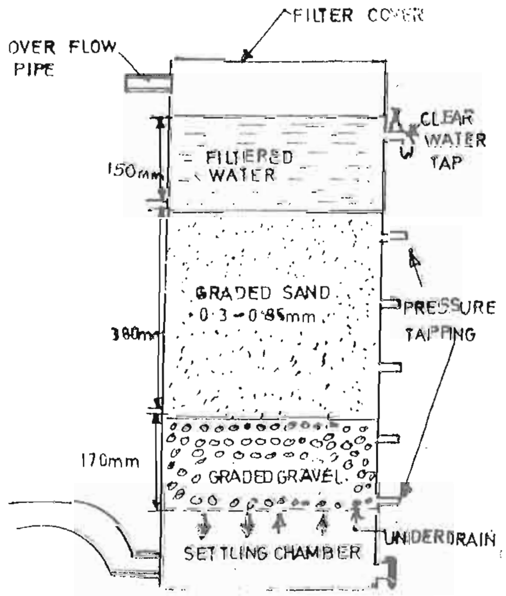
## EXPERIMENTATION

### Laboratory Scale Model

The model consists of four units viz a feeding system; aeration unit, sedimentation unit; and slow sand filter (upflow type).

The feeding system consist of two storage tanks (one ground level and the other overhead) filled with groundwater from the Federal Polytechnic, Bida borehole as required. The raw water flows through a pipe and falls through a height of 450mm into the aeration unit which consists of a perforated plate and sheet baffle wall with an opening at the bottom to allow flow into the sedimentation basin.

The sedimentation basin has a calibrated V-notch outflow for flow measurement. The settled water flows to an open channel which has a drop hole exit for connection to a 25mm diameter plastic tubing to the bottom of the slow sand filter unit. The slow sand filter system adopted is the "Upflow type in which raw water flows in from the bottom of the filter and the clear water collected on top of the fine sand layer" (ref. 1). The slow sand filter unit has pressure tappings which is connected to a manometer board. For details of model see (fig. 1).



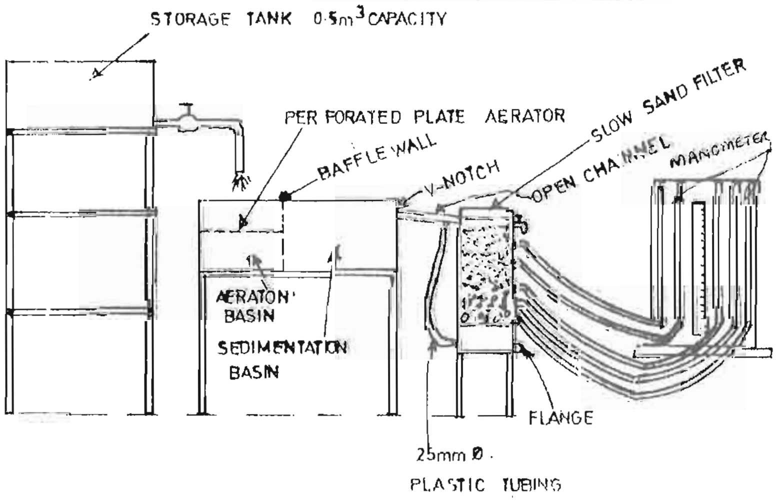




FIG. 1. Schematic diagram of aeration - Sedimentation-filtration system.

## Physical Properties of Bida Sands

Sand samples for the filter were collected from three locations viz River Gbako at Mana (near Bida Water Works), River Kaduna at Wuya and River Musa near National Cereals Research Institute - Badeggi. All sand samples were washed and dried and physical tests carried out on them with the results shown below in Table I. It will be observed that all three sand samples have the required physical properties required for slow sand filters.

FILTER PACKING DETAILS

| | Sand Grading | | |
|---|---|---|---|
| River Gbako | Sieve | below | 0.800mm |
| Sand Sample | Size | " | 0.600mm |
| | Size | " | 0.300mm |
| River Kaduna | Sieve | below | 0.800mm |
| Sand Sample | Size | " | 0.600mm |
| | Gravel Packing | | |
| | retain | 13.2mm | |
| | " | 4.75mm | |

TABLE I

Summary of Physical Properties of Bida Sands

| Sand Sample | Uniformity Coefficient (UC) | Effective Size(ES) | Specific Gravity(S.G) | Solubility Test 0.2 HCL Weight loss% in 24 hours |
|---|---|---|---|---|
| 1. River Gbako(Mana) | 2.5 | 300μm | 2.64 | NIL |
| 2. River Musa(NCRI) | 2.42 | 212μm | 2.68 | NIL |
| 3. River Kaduna(Wuya) | 1.62 | 370μm | 2.63 | NIL |

Recommended values for Uniformity Coefficient for slow sand filters: 2.5-3.5 (ref. 2) and less than 3.0, preferably less than 2.0 (ref. 3)
Effective size: 250μm - 350μm (ref. 2) and 150μm - 400μm (ref. 3)

TABLE II

Summary of Chemical Analysis
River Gbako Sand

| Parameter | Raw Water | MONITORING HOURS | | | | | |
|---|---|---|---|---|---|---|---|
| | | 4 | 8 | 12 | 16 | 20 | WHO (ref. 4) |
| pH | 5.94 | 6.90 | 6.88 | 6.76 | 6.76 | 6.68 | .5-9.2 |
| Turbidity J.T.U. | 14.4 | 0.25 | 0.22 | 0.09 | 0.08 | 0.04 | 0.2-3 |
| Iron(mg/l) | 20.00 | 2.00 | 1.36 | 1.18 | 0.46 | 0.35 | 0.1-1 |

## Start Up

After the V-notch was calibrated, the filter was filled slowly with raw water from the Federal Polytechnic borehole to a depth of about 150mm above the top sand layer using the feeding system. The filter was left in this state for 3 days for maturation.

## Experimental Procedure, results and Discussion

After the filter has matured, the control valve for the feeding system was adjusted to maintain a constand head over the weir with constant flow of 3.81/min and the filter allowed to run for about 2 hours for the whole system to stabilize.

The initial piezometric heads were recorded and repeated every 2 hours at an average of 6 hours per day. The filtration rate was also measured throughout each day's monitoring. Water samples were also collected at the end of each day to determine its quality. See Fig II and III for the pressure head variation with time and filtration rate variation with time at constant discharge. The result of laboratory examination of the treated water is shown below in Table II and III.

TABLE III

River Kaduna Sand

| Parameter | Raw Water | MONITORING HOURS | | | | |
|---|---|---|---|---|---|---|
| | | 4 | 8 | 12 | 16 | 20 |
| pH | 5.94 | 6.95 | 6.90 | 6.86 | 6.80 | 6.80 |
| Turbidity | 14.4 | 0.70 | 0.55 | 0.52 | 0.50 | 0.45 |
| Iron mg/1 | 20.0 | 3.64 | 1.82 | 1.73 | 0.91 | 0.75 |

Discussion

From tables II and III it is observed that the iron content decreases with time. The decrease for River Gbako Sand Sample is however more pronounced than that of River Kaduna sand packing.

This may be due to the fact that the River Gbako sand sample is better graded than River Kaduna sand sample (See table on filter packing details) It is therefore imperative that sand grading be taken into consideration in the choice of sand for use as filter material.

From FIGS II and III it is observed that as filtration proceeds the filtration rate initially increases to a peak value before declining. The pressure head also builds up in the top sand layers before declining due to clogging of available pore space for filtration.

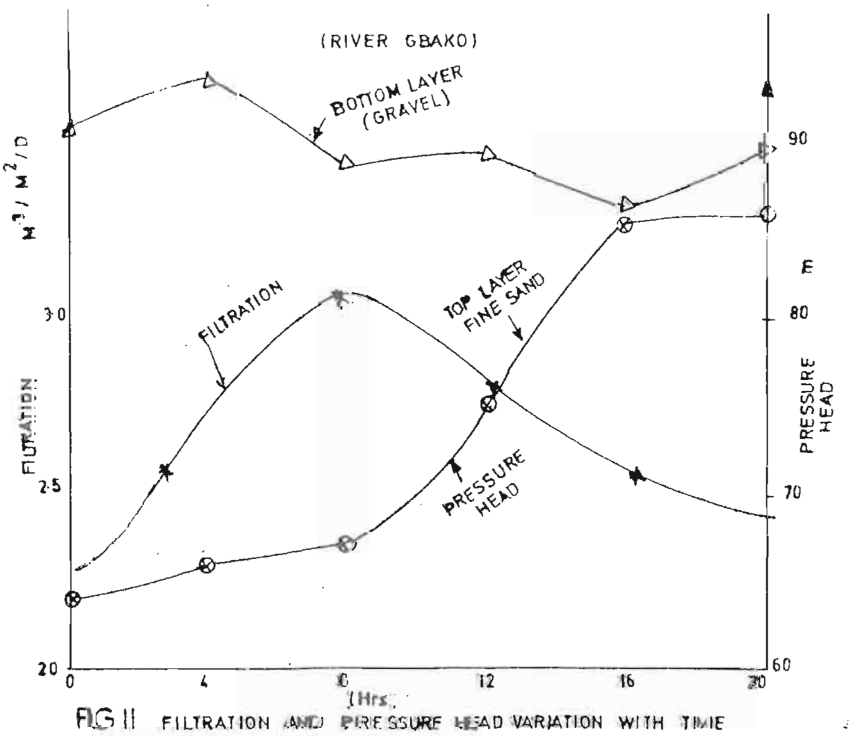


FIG II FILTRATION AND PRESSURE HEAD VARIATION WITH TIME

CONCLUSION

The main conclusions are as follows:

1. Borehole water with high iron content can be effectively treated using an aeration-Sedimentation-slow sand filtration system to achieve recommended minimum standards set by WHO.
2. The system can be easily adapted in developing countries using local personnel and materials.
3. Studies should be carried out to determine the optimum maturation period for start up to increase the water quality.
4. Studies should be carried to determine the efficiency of other aeration methods like multiple tray aerators, cascades etc. to achieve rapid aeration.

ACKNOWLEDGEMENT

Credits: The authors are grateful to the Federal Polytechnic, Bida, Nigeria for providing the research grant to the Civil Engineering Department. Special thanks go to Engr. A. V. Mukoro, the Head of Civil Engineering Department for his support in helping us secure the grant; to Mallam Bature Abdulsalam, Laboratory Technician in the Civil Engineering Department for carrying out all the necessary measurements and Mr. Terry Okpokwu of the Chemistry Laboratory for carrying out the chemical analysis.

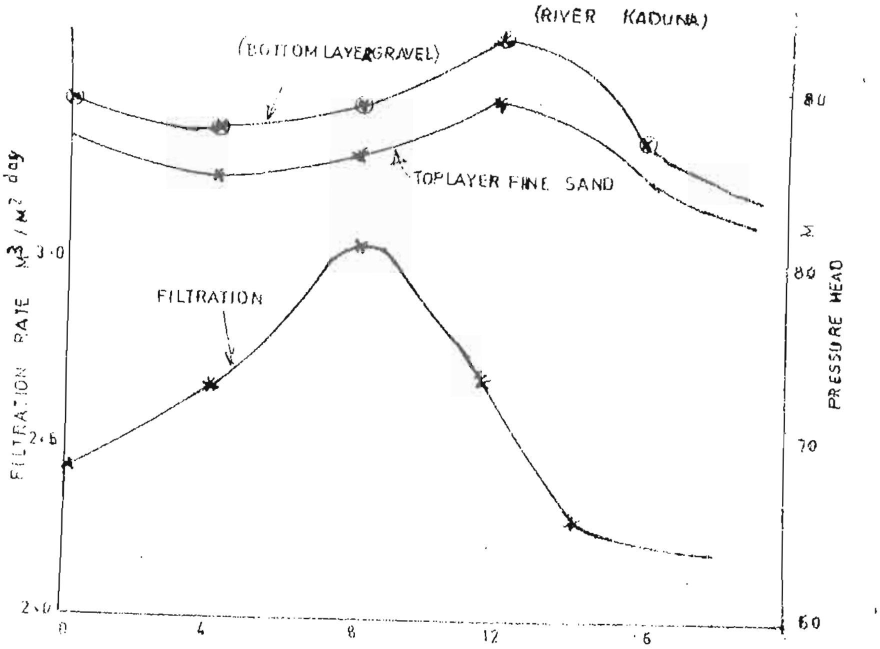



FIG III FILTRATION AND PRESSURE HEAD VARIATION WITH TIME


REFERENCES

1. PATNAIK, S.M. Small iron removal plants, Developing world water, WEDC, Grosven or Press LTD., London, 1987 p. 218-219

2. NEW YORK STATE DEPARTMENT OF HEALTH, Manual of Instruction for water treatment plant operators, New York, 1976.

3. ELLIS, K.V., Slow sand filtration, Developing World Water, WEDC. Grosvenor Press Int. LTD. London, 1987 p. 196-198.

4. INSTITUTION OF WATER ENGINEERS AND SCIENTISTS, Water Supply and Sanitation in Developing countries, IWES, London, 1983, p. 133.