

# A simple sand filter to reduce guinea worm disease in Nigeria

by M. K. C. Sridhar

O. O. Kale

J. D. Adeniyi\*

**A group of medical students with no previous engineering experience built a sturdy demonstration filter to remove water fleas (*Cyclops*), which carry guinea worm disease, from drinking water.**

IDERE is a small town located 120km from Ibadan. It had a population of about 8,100 in 1983 with an additional population of 2,613 distributed in its 50 farm settlements. Guinea worm infection had increased from a mere 12.3 per cent in 1971 to about 40 per cent in 1981. The residents of Idere town rely mostly upon 13 out of 17 existing ponds, 69 shallow wells and the river Ayin for water. A segment of the population depends on sporadic or irregular piped water supply. In the farm settlements villagers normally resort to ponds.

In every village, one pond is used in the rainy season (April to October) while another one is used in the dry season (November to March). People carry plastic tubs, galvanized iron buckets, metal cans, tubs coated with enamel or plastic jerry cans to the ponds to collect water. The volumes vary from 10 litres to 30 litres. They wade knee-deep into the shallow part of the pond, skim the surface to remove any floating matter and dip the container in to draw water. The container is then lifted on to the head and carried home. At home, the water for drinking purposes is stored in mud pots of 60 to 100 litres capacity with openings that vary from 400mm to 600mm. For other purposes, the water is kept in wide-mouthed pots, plastic or metal tubs, or drums. Some people claim that they add alum to the drinking water to clarify it. Water is generally fetched for domestic use by young children and women.

\*The authors are, respectively, Senior Lecturer in Environmental Health, Professor and Head of Preventive and Social Medicine, and Principal Investigator of the guinea worm project at the Department of Preventive and Social Medicine, College of Medicine, University of Ibadan, Ibadan, Nigeria. All correspondence should go to Dr Sridhar.

In the dry season when the ponds dry up, people wait for the water to ooze out from a small pit and painstakingly scoop out the water using cut dry gourd shells or a metal bowl.

## Change of seasons

The water in the ponds round Idere appears clear in the rainy season, but with the advancement of the dry period, appears whitish, reddish brown, turbid and occasionally muddy. In some ponds blue-green algae are predominant. Samples were collected during the month of November in 1983 which was the beginning of the dry period. They were analysed for acidity, electrical conductivity, turbidity (cloudiness) and suspended solids, and the number of *Cyclops* per litre were counted. Several methods are available for the removal of *Cyclops*. The methods practised, their advantages and limitations in Nigeria are

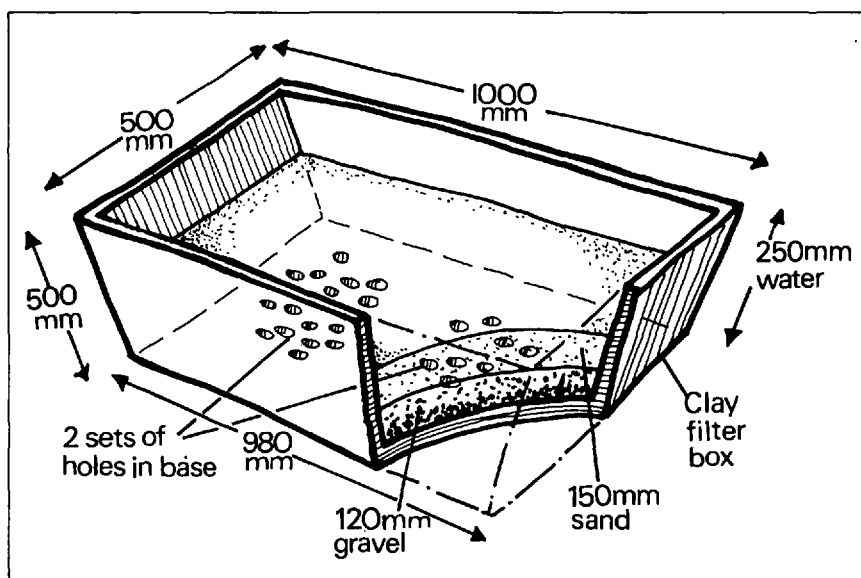
summarized in Table 1 (opposite).

We felt that under Nigerian conditions, a simple sand filter which is sturdy and which can be left at the pond site may be more useful for community needs. The community may co-operate to build such units at a reasonable cost. A demonstration filter was built, to study its feasibility, by medical students who had no training in the construction field. They did not require the help of any mason and even the tools used were not the type used by a professional mason.

The filter consisted of a sand column at least 15cm tall over a gravel column of 12cm in a cement concrete trough with perforations at the bottom. It was not a conventional slow sand filter which must be of an optimum size and have a controlled flow of water and an operator to look after it.

## Construction

The filter was designed in such a way that two people could filter water simultaneously. A site was selected at the Igbo-Ora Community Health Centre, 5km from Idere, where Primary Health Care is available to the Idere group of villages. Grass and stones were removed from an area 100cm by



Sketch of the filter to remove guinea worm-carrying water fleas from drinking water

Method	Advantages	Limitations in Nigeria
<i>Physical methods</i>		
Cloth filter	Cheap; can be carried; can be cleaned.	People may not use a standard mesh-sized cloth; leaves a mark which cannot be removed; needs replacement at frequent intervals; may be torn while in use; if not correctly placed, the filtered <i>Cyclops</i> may get into the water; filtration may slow down after some use.
Monofilamentous nylon	Available in standard mesh sizes; choosing an appropriate size, the different stages of <i>Cyclops</i> can be removed; tough and can last longer; no mark is seen after filtration.	Not available in the country; due to import restrictions, sufficient quantity may not be available to the rural user; containers are of different sizes and shapes; the bigger containers which are in normal use may demand more material which increases the price.
Berkefeld filter (Ceramic candle filter)	Clear water can be obtained.	Not suitable for bigger families; cost is prohibitive; not suitable for pond waters due to high suspended matter.
Passing steam into water	Effective in killing <i>Cyclops</i> .	Cost and operation are not practicable.
Provision of sanitary wells	Ideal for the removal of <i>Cyclops</i> and other water associated infections can be controlled.	Expensive for the poor communities; certain geological conditions may not permit the construction of a well; some wells may be seasonal and may dry up in dry periods; farmers or mobile villagers may not like to carry the same water for drinking purposes while at work.
<i>Chemical methods</i>		
'Abate' (Temephos) (0,0,0,0 - tetramethyl 0,0 - thio - p - phenylene phosphorothioate)	Effective in destroying the <i>Cyclops</i> at 1 mg/litre water; as spraying is done once in 5 to 7 weeks, it is easy to operate.	Not easily available and needs to be imported; the water sources are varied in their sizes, depths and to estimate the volume of water is difficult over a year round; application may not be as specified due to low level of literacy; long-range low level toxicities are not yet known.
0.07 to 0.15% Potassium hydroxide	Kills <i>Cyclops</i> in 2-10 minutes.	Not practicable due to several factors in the field: eg. non-availability, cost, operators require a certain level of education
Addition of Potassium permanganate till the appearance of pink colour	Kills <i>Cyclops</i> .	
DDT, 10 ppm	Effective in laboratory	
Zinc dimethyldithio-carbonate (ZIRAME) 0.25 ppm for 24 hours	Effective	
Chlorination	To some extent effective	
Quick lime	To some extent effective	
Asafoetida	To some extent effective	
Marking nuts extract ( <i>Semicarpus anacardina</i> )	To some extent effective	
Juice from the soft inner core of the tender bamboo	To some extent effective	
<i>Biological methods</i>		
Use of fish such as <i>Gambusia</i> and <i>Barbus</i> spp	Good for the removal of <i>Cyclops</i> . Environmentally safe and cheap to maintain.	Most of the ponds dry up for 2 to 3 months of the year; people might consume the fish.

Table I. Methods for removing *Cyclops* from water, and their suitability for Nigeria

50cm. Close to this area, clay-like soil was dug out, mixed with water to make it sticky and a mould for a trough was made at the marked site. It was trapezoid in shape, 100cm long, 50cm wide and 50cm high. After the clay was compacted and the surface smoothed, water was sprinkled on it regularly for a couple of days to reduce the number of cracks forming while it was drying. The mould was allowed to dry for 3 days and any cracks that formed were again filled with moist clay and smoothed.

When the mould was dry, polythene sheets or old rags were spread on it to prevent contact with the concrete. The concrete was made by mixing cement, river-bed sand and gravel (4 to 5mm in diameter) in the ratio of 1:2:4, and mixed thoroughly with an adequate quantity of water. The concrete was then poured into the mould to a thickness of 8cm, compacted with pieces of wood.

On the top of the trapezium (ie. the bottom of the finished filter), two sets of 18 holes of 1cm size were made using dry stems from a nearby tree. These were to form the openings for the water to flow when the filter was complete. For three days, water was sprinkled on while the concrete hardened and then it was left for five days to dry. After this, the filter was lifted using a crow-bar, the adhering clay and the sticks were removed and the filter transferred to a pond at Okinna. It was then installed on two stones 60cm above ground level, high enough to enable two standard size containers (30cm tall) to be placed below to collect filtered water.

#### Filter media

After the installation, the filter trough was filled with gravel of two sizes, 4mm and 2mm diameter, one above the other up to a height of 12cm. This layer was topped with washed clean

sand from a nearby river.

The effectiveness of the filter for the depth of sand column, the appearance of the final filtered water, formation of a crater on top of the sand column, filtration time and the *Cyclops* count after filtration, were all studied.

The results indicate that with a sand column depth of 15cm, the filtered water resembled the pond water and that the *Cyclops* were also removed. As the sand depth increased, the time taken for filtration also increased. Although the time required was longer, the quality of water was much better than that using a 15cm sand column.

Since the filter was fresh and was not left for 'maturation' or 'ripening' for a long period, after filtering 255 litres of water (about the amount collected by 10 users at the pond), the top layer of sand had to be scraped off to improve the filtration rate. This reduced the filtration time from 3 minutes 50 seconds to just 2 minutes.

If labour is given free of charge by the community, the cost of making each filter as described here is only US \$15 for cement and gravel. The unit cost may be further reduced if more filters are constructed and the ratio of the concrete mix is changed.

Perhaps the most important aspect is to determine the attitudes of the

people, the acceptability of the filters and what constitutes proper maintenance. While this will be studied over an extended period of time, a preliminary survey with 65 people who used the pond between 9 am and 1 pm on two days indicated that 51 people would have liked to use it if it was left at the pond. While 13 users were

indifferent, only one did not want to use it: she liked the taste of the raw water in the pond as it was.

### Long-term problem

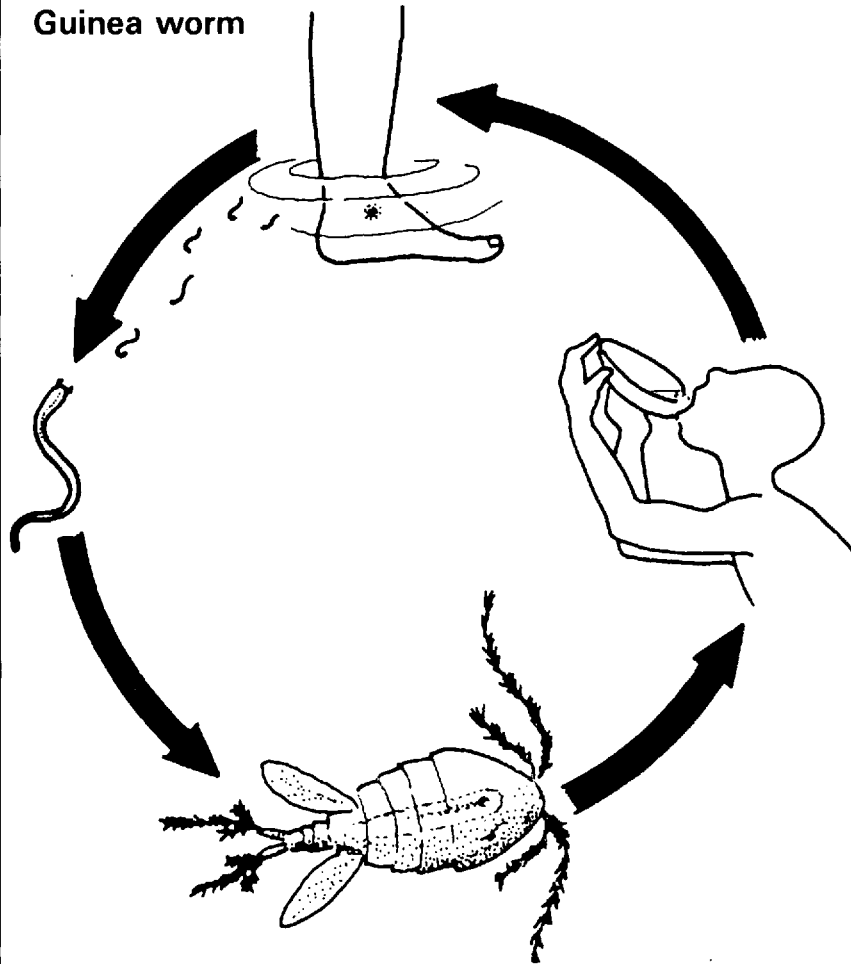
In spite of the advances in the understanding of how guinea worm infection spreads, it is still prevalent in most parts of Nigeria and many other tropical developing countries. It has been well established that the removal of *Cyclops* is a major solution in the control of guinea worm disease. While by using available and simple methods in different parts of the world where guinea worm is endemic, a fall in the infection rate has been recorded, the disease still persists and can appear on an epidemic scale even nowadays. This is because the disease is seasonal and restricted to small, often isolated communities, and there is no effective drug treatment or vaccine. While the methods of preventing guinea worm disease are simple, their organization and effective implementation in remote rural areas are difficult. Prevention and control demands a multi-disciplinary approach. Added to this, in most communities where guinea worm is endemic the majority of people are illiterate and often harbour the notion that guinea worm is inherited or that 'bad' or 'weak' blood causes the worm to protrude.

In the study area, a majority of the villages had only 2 or 3 ponds which acted as transmission sites for the disease. We envisage that one or more filters, like the one reported here, could be placed at each pond in the villages and selected people, for instance primary health care workers, could be trained to construct the filter and maintain it when filtration slows down. The trainees do not require any post-primary or higher education.

We believe that this filter may need to be modified to reduce its weight. If the pond dries up, it may not be possible to move the filter because it is too heavy. So a smaller portable filter of a thinner or light-weight construction made in the same way would be more useful. Alternatively, we suggest that the trunk of an oil palm tree could be cut to the desired length, sides pegged with wood or concrete, the inside pith removed, and a few holes drilled and filled with gravel and sand to make a convenient filter.

The possibility is that people may not bother to filter water and carry it home due to other pressing work, lethargy or lack of patience. Therefore, a unit should be left at source permanently so that the collection and filtration becomes simultaneous. Such

### Guinea worm



Infection occurs from drinking water containing a small waterflea (*Cyclops*) which carries the larvae of the guinea worm (*Dracunculus medinensis*). Transfer of the thread-like larvae can only take place where people use open wells or ponds for their drinking water supplies.

It mainly occurs at the end of the dry season, when water levels are low in ponds and wells. (In the wet season waterfleas sink to the bottom and are not picked up with drinking water drawn from the surface). The larva then matures within the wall of the human digestive system for a year with few symptoms before migrating to the surface of the skin to mature. The female worm can reach up to 120cm in length and looks like a fine wire running the skin, usually in the leg or foot but sometimes in other parts of the body.

The emerging worm creates a

blister by secreting an irritating fluid into the host tissues. This is extremely painful as the result of the body's allergic reaction. It opens to form an ulcer, and the worm's life cycle is completed when an infected person goes to collect water at an open pool or step-well, where they may have to step into the water to fill a pot or bucket. Larvae from the ulcer float off into the water, where they are picked up by another waterflea.

Among the worst effects of guinea worm in humans are reactions caused by the larvae migrating through the tissues. There is swelling, particularly around the joints and abscesses may appear on feet and legs leading to permanent disability for one in 20 victims of the disease. Secondary septic infection also causes complications. Humans do not develop immunity from guinea worm and repeated and multiple infections are common.

a filter should also withstand bad weather and be less attractive to playing children who may interfere with it. This type of filter demands that the consumer should carry an extra bucket or a gourd to transfer the water from the pond to the filter while the main container is kept below the filter. One solution may be to keep a gourd or a metal container permanently by the filter.

There can never be a single solution when dealing with people. Every method has its own place. Many times, all the methods may be applied when they are appropriate to solve a problem. That depends on the attitude, taste and convenience of the user. Habits die hard and long-term success depends on the incorporation of health education into the community's way of life. Further studies are planned on how acceptable the filter that has been described is to the community, and how to incorporate their ideas into the design of such a filter. The construction of filters from local materials will be further investigated.

### Acknowledgements

The filter was constructed by the following medical students: M. A.

	pH value	Turbidity FTV	Suspended solids (mg/l)
Raw Pond Water (Okinna)	7.3	90	35
After filtration through 15cm sand column	7.2	80	20
After filtration through 20cm sand column	7.1	35	15

### Characteristics of pond water after filtration

Anumah, A. S. Ghattaora, A. J. Nzeoma, A. O. Ola, A. J. Oteri, Miss M. A. Ugowe and U. B. Omoh of Group D 82. The materials costs were met by WHO Project No. 800432: Research on Social and Behavioural Aspects of Malaria, Schistosomiasis, Onchocerciasis and Dracunculiasis in the Context of Primary Health Care. Our thanks to Mr W. R. Brieger for his continuous encouragement and interest in this work.

### References

1. Kale, O. O., *Epidemiology of dracunculiasis in Nigeria*, Report of a Workshop: Opportunities for Control of Dracunculiasis, National Academy of Sciences, Washington DC, pp1-25, 1983.
2. Akpovi, S. U., Johnson, D.C. and

Brieger, W. R., Guinea worm control: Testing the efficacy of the health education approach to primary health care, *International Journal of Health Education*, 24, pp229-237, 1981.

3. Duke, B. O. L., Filtering out the Guinea worm, *World Health*, March 1984, p29.
4. Muller, R., Laboratory experiments on the control of cyclops transmitting Dracunculus, *Bulletin of the World Health Organization*, 42, pp563-567, 1970.
5. McCullough, F. S., Cyclopoid copepods: their role in the transmission and control of Dracunculiasis, *Report of a workshop: Opportunities for control of Dracunculiasis*, National Academy of Sciences, Washington DC, pp1-12, 1983.



Sand column	Visible appearance	Crater formed	Filtration time	Cyclops counts
Raw Pond water (control)	Turbid with brownish colour			2 per litre
5cm	Dark brown with sand washed out	Exposed the gravel	Immediately	2 per litre
10cm	Dark brown with less sand washed out	8cm deep	Started after 2 seconds and completed in 1 minute	1 per litre
15cm	Same as pond water	8cm deep	Started after 4 seconds and completed in 2 minutes 15 seconds	0 per litre
20cm	Slightly better than pond water	8cm deep	Started after 15 seconds and completed in 5 minutes	0 per litre

\*The number of cyclops in the pond varied from time to time and maximum recorded during the study was 32 per litre.

### Effectiveness of the sand filter

Pond	Time (hours)	Maximum depth (cm)	pH value	Electrical conductivity	Turbidity (FTV)	Suspended solids (mg/l)	Cyclops count per litre
Asaba	17.00	400	8.0	60	70	50	5
Ashinleka	13.00	20	7.5	34	35	18	N.D.
Basin	17.10	42	7.4	68	70	40	N.D.
Ivaroniku	12.30	39	8.2	110	15	2	1
Iyagoa	12.20	40	7.5	15	50	2	1
Ogba	15.10	40	7.0	1100	35	N.D.	69
Ogbinte	11.55	40	7.1	39	220	200	1
Okinna	15.35	37	7.6	8	75	35	8
Oniyangi	15.30	35	7.8	11	80	15	5
Onjumo	16.05	200	7.7	11	130	42	8

The samples were collected during the beginning of dry period in November 1983.

N.D. = Not detectable.

### Characteristics of water from different ponds in Idere