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Package water treatment facilities for refugee communities

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Package water supply systems have been developed by Oxfam and Imperial College for rapid deployment in emergency situations such as refugee settlements. A component of these is a water treatment unit for treating polluted surface waters by the process of slow sand filtration. Many such units have been deployed at refugee camps in Southern Somalia and have performed well.

Introduction

Relief agencies, such as the UK organization Oxfam, are frequently called upon to initiate or assist with water supply schemes to alleviate human privation and suffering. Where time and expertise are available for longer-term programmes the most appropriate and cost-effective schemes can be worked out, each one related to the nature of the particular water source and the availability of equipment and materials. However, where urgent and sometimes difficult emergency conditions prevail (e.g. refugee communities), there is a need for simpler and quicker solutions.

2. Since 1980 Oxfam and Imperial College, London, have collaborated to design and specify appropriate water supply equipment for emergency situations such as the formation of refugee communities.[1] A collection of equipment modules (packages) have been specified to suit a range of local conditions based on a design population of 5000, a per capita consumption of 23 litres per day, and a guideline total water supply system cost of £3 per capita. Particular requirements for the water supply packages are

(*a*) equipment can be supplied to site complete and ready for immediate installation
(*b*) packages are capable of rapid installation on site by a team of semi-skilled workers and require a minimum of locally procured items
(*c*) packages are still able to function by gravity if no natural elevation is available on site
(*d*) no chemical addition (except possible use of disinfectant) and low energy demand
(*e*) packages can be dismantled and re-erected in a new location.

Some of the equipment developed in this project, such as storage tanks[2] and the pipe distribution system,[3] have been used successfully in Central America and Africa. The treatment package,[4] developed in 1982–83, has been deployed for the

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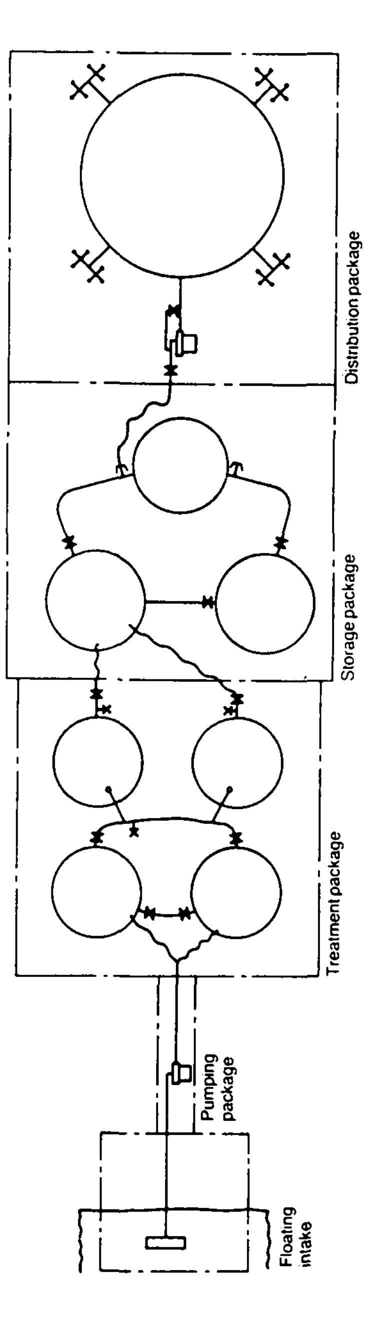

Fig. 1. Plan of the Oxfam/Imperial College water treatment system

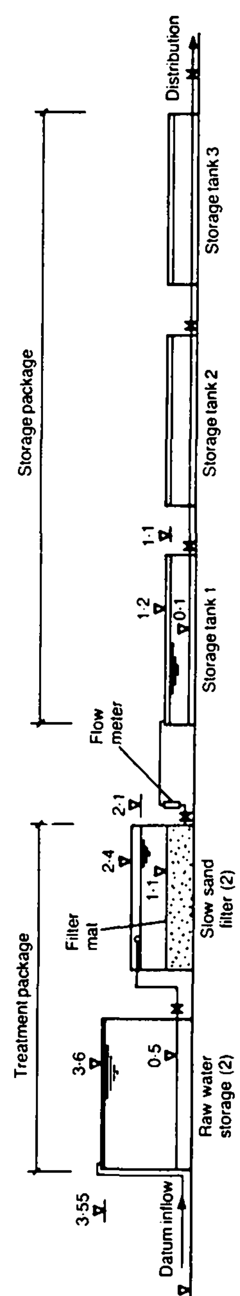

Fig. 2. Section of the Oxfam/Imperial College water treatment package

Fig. 3. Package water treatment facilities at Bur Dhubo Refugee Camp

first time in Southern Somalia in 1984 to provide treated water from the River Juba for refugee communities.[5] By May 1986 twelve package treatment units had been installed or were under construction in Southern Somalia.

Treatment package

3. The treatment package is based on the slow sand filtration principle which does not require chemical addition and the process can, under optimal operating conditions and usually with a pretreatment stage, achieve an acceptable drinking water quality. The package consists of two raw water storage tanks which feed two slow sand filter tanks as shown in Figs 1–3. A complete description of the equipment can be found in the Oxfam field manual.[4] Treated water from the treatment package is designed to discharge into some form of storage before distribution. The raw water storage facility permits short duration, intermittent, daily pumping of raw water into storage and the maintenance of a continuous and uniform flow through the subsequent sand filters. Both the raw water storage and slow sand filter tanks are constructed of bolted galvanized corrugated steel sheets erected on flat ground with an inside butyl rubber lining. The filters are essentially conventional slow sand filters and consist of a layer of sand approximately 0·8 m thick above a plastic pipe underdrainage system. Manual flow control is achieved by means of an adjustable downstream gate valve and rotameter flow meter, and a float valve on the inlet line prevents the filter tank overflowing. For hydraulic advantages, the height and diameter of the raw water storage and filter tanks were designed to give a falling hydraulic gradient for the whole process in the event of a flat ground profile as shown in Fig. 2. The filter outlet connection (inlet to final

storage) is set at a level just above the filter media so that there is no possibility of a temporary drawdown of water from the filter which would be detrimental to the treatment process.

4. To simplify and improve the process of filter cleaning a synthetic fabric layer is placed as a mat on the sand surface to act as the filter 'Schmutzdecke' (Fig. 4). The fabric layer (14 mm thick) is a highly porous (98%), non-woven material made from a mixture of three synthetic polymer fibres. Earlier studies[6] have shown that the fabric can accumulate considerable quantities of silt and biological material which can be easily washed out.

5. Recent studies have shown that the application and periodic removal of the fabric in rolls for washing (Fig. 5) reduces considerably the frequency and extent of sand removal for cleaning.[7] Additional work at Imperial College is currently investigating alternative fabric materials to identify a fabric that will prevent any significant silt penetration into the sand.

6. The treatment package has been designed to give two parallel streams of raw water storage and filtration so that the filter cleaning can be alternated with one stream always in operation. The nominal design population and flow for the package are 5000 and 114 m^3/day, respectively, which gives a nominal filtration rate of 0·084 m^3/m^2h.

Installation and operation

7. In general, the assembly and use of the treatment package in Somalia has been exactly in accordance with the Oxfam field manual[4] for treating polluted surface water with the exception that the number and layout of tanks involved has been modified. For example, at the Horseed, Qorioley II and Bur Dhubo camps two raw water storage tanks feed three slow sand filters instead of two. When

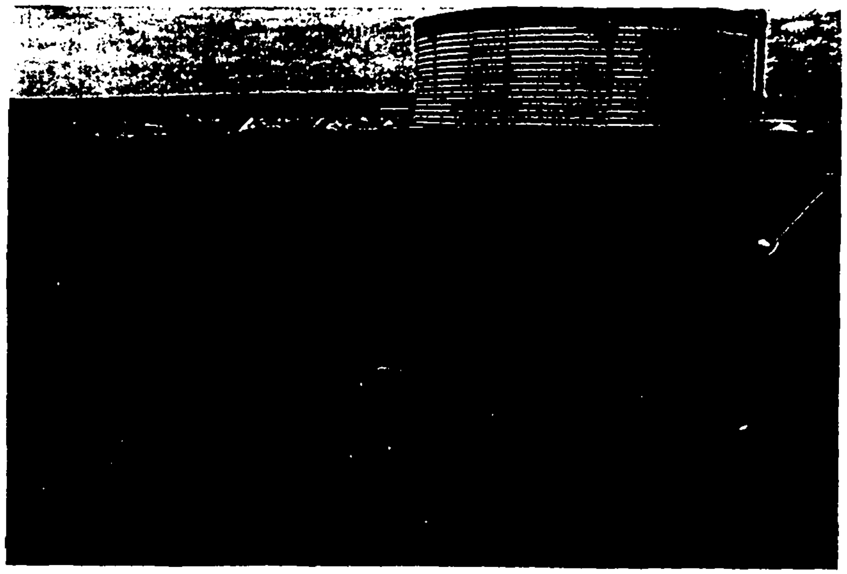

Fig. 4. Slow sand filter unit (showing clean fabric layer)

Fig. 5. Washing of fabric at Maganey Camp

erecting the tanks experience has shown that care is required to avoid damage by wind. Thus it is recommended that tanks should be erected individually at times of little or no wind and that completed tanks should be weighted by partial filling with water or sand (in the case of the sand filters). The construction of the tanks and the connecting pipework in Somalia was done typically by a team of one supervisor, one mechanic/pipe fitter, one truck driver and six labourers, and the average time for installing a complete sand filter plant was 138 man-days (6 per day).

8. At all the units installed in Southern Somalia river water is pumped intermittently from source to the raw water tanks and the location and layout of the package plant were chosen to facilitate gravity flow through the sand filter to the standpipe collection points via the distribution pipes. In general, if an elevated site is not available, an embankment must be built and this was the case for the Qorioley II and III camps. Such a gravity-flow arrangement ensures low water pressures at the standpipe outlets (approximately 1 m head) which minimizes water wastage.

9. In general, river sand was the source of the sand media used in the filter beds and the grading of the sand was examined by sieve analysis to confirm its suitability. The sand was washed before placement in the filter tanks to remove fines, silt and organic contamination and this was carried out by a simple backwashing process in small tank units provided in the treatment package using water from the raw water tanks (Fig. 6); the 3–3·5 m static pressure head of water in the raw water tanks is sufficient to fluidize the sand for cleaning.

Performance

10. In general terms the treatment package is able to treat moderately polluted raw waters to a quality approaching World Health Organisation (WHO) stan-

Fig. 6. Washing and grading of sand media

dards.[8] Full-scale tests in the UK[6] showed that raw water turbidities and E. coli concentrations could be reduced on average from 14 (NTU) and 3000 (per 100 ml) to 0·6 and 40, respectively; average filter run times were 14 days at a filtration rate of 0·08 m^3/m^2h. Limited data from Somalia[5] has indicated reductions in raw water turbidities and faecal coliforms from 60 (NTU) and 2000 (per 100 ml) to 1·5 and 10, respectively; filter run times varied between 16 and 79 days and the filtration rate between 0·04 and 0·05 m^3/m^2h. It is clear that subsequent disinfection of the treated water is necessary to meet WHO bacteriological standards.

11. In May 1986, 180 000 refugees were receiving treated water from package water treatment facilities and a programme of further deployment of these units at other refugee camps is continuing.

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A coastal area management system as developed for Seasalter–Reculver, North Kent

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Paragraph 1 points out that much of the eastern and southern coastline of England is subject to erosion and flooding. The inference is that, in general, the western coastline is not subject to these effects. Is this due to the geological nature of the western coastline or due to a significant difference between the coastal processes acting on that coastline and the coastal processes acting on the eastern and southern coastline?

41. The second sentence of § 2 refers to the possibility of coastal protection works influencing, or being influenced by, other such works within the same coastal process unit, and the second sentence of § 18 says, quite rightly, that great care needs to be taken in the design of groyne fields to ensure that their provision does not cause adverse effects elsewhere in the coastal process unit. The fifth sentence of § 38 says that, by dealing with complete coastal process units in the way recommended by the Authors, there is no need to be concerned with effects on or from works outside the area. Can the Authors be confident that works executed by man will not affect the overall coastal regime; that coastal protection works carried out at one end of a coastal process unit will not alter the coastal regime in such a way as to change artificially the location of the longshore boundary of the coastal process unit, so that these works influence an adjoining section of coastline, considered previously to be in a completely separate coastal process unit, or are themselves influenced by an altered pattern of coastal processes?

42. It is apparent from § 3 and Fig. 2 that the western longshore boundary of the coastal process unit identified by the council corresponds almost exactly with, and that the eastern longshore boundary of that unit corresponds approximately with, the limits of the coastline of the area of North Kent which is the responsibility of Canterbury City Council. Is this a fortunate coincidence or has the council, in identifying the limits of the coastal process unit for the purposes of planning and providing coastal protection against erosion and flooding, chosen to ignore short lengths of coast which are within the true coastal process unit but which are beyond the council's administrative boundaries and on which the effects of coastal processes are negligible?

43. Paragraph 4 claims that the Paper sets out the means of identifying the limits of a coastal process unit in the longshore, offshore and landward directions. However, the matter of defining the boundaries in the general case is covered in one paragraph only (§ 5) of the Paper. While the definitions of the seaward and landward boundaries are set out, there is no description of the investigations, which may well be extensive, necessary to identify the geographical lines of these

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