Efficiency of the *Euroguard* domestic water treatment unit with regard to viruses, phages and bacteria

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Abstract

The reduction in numbers of human viruses as well as bacteria and phages in water treated by the commercial *Euroguard* water filter-cum-purifier for the domestic treatment of drinking water was evaluated. Drinking water seeded with laboratory strains of viruses, bacteria and phages which indicate faecal pollution, as well as sewage-contaminated river water and secondary treated waste water containing naturally occurring organisms, were passed through the unit which consists of a candle prefilter, activated carbon filter and ultraviolet irradiation compartment. At the prescribed flow rate of not more than 1 $\ell \cdot min^{-1}$, numbers of poliovirus, hepatitis A virus, adenovirus types 40 and 41, rotavirus SA11, human rotavirus, coliphage MS2, somatic coliphages, *Escherichia coli*, *Streptococcus faecalis*, *Clostridium perfringens*, total coliform bacteria, faecal streptococci and the heterotrophic plate count were reduced by more than 99.99% in all waters tested. In all test runs, including those on secondary waste water which was not intended to be used in the unit and represents a "worst-case" situation in practice, the quality of the treated water was well within microbiological limits of international specifications for drinking water.

Introduction

The *Euroguard* water filter-cum-purifier is manufactured and marketed by Eureka Forbes Ltd, Bombay, India. *Euroguard* is designed for the relatively inexpensive, convenient and reliable domestic on-line purification and decontamination of drinking water. The unit measures 360 x 300 x 100 mm, weighs 6 kg and is designed for mounting on an internal wall at a water supply. Treatment is based on a polypropylene candle prefilter for the removal of gross impurities, an activated carbon filter for the removal of organic compounds, and an ultraviolet light irradiation compartment for disinfection. *Euroguard* is intended for the treatment of freshwater from sources such as wells, springs, streams or lakes which are not abnormally polluted. The output is 1 $\ell \cdot min^{-1}$. Compared with the wide variety of other systems for similar purposes (Abbaszadegan et al. 1993), *Euroguard* has a number of safety devices to monitor and ensure fail-safe operation. These include a photoresistor which measures the ultraviolet light output. The resistor is connected to an automatic shut-off solenoid valve, green and red indicator lamps, and an audio indicator which plays a pleasant tune as long as treatment proceeds satisfactorily.

This study deals with an assessment of the efficiency of *Euroguard* with regard to human viruses, phages and bacterial indicators of faecal pollution selected on the basis of involvement in waterborne transmission of diseases, resistance to water treatment processes, and application in water quality specifications (Grabow et al., 1984a, 1984b, 1992, 1993; IAWPRC Study Group on Health Related Water Microbiology, 1991). The evaluation of the unit was based on a guide standard and protocol for testing microbial water purifiers formulated by a multidisciplinary task force of the United States Environmental Protection Agency (Abbaszadegan et al., 1993).

Materials and methods

A *Euroguard* test unit was obtained from Eureka Forbes Ltd, Bombay, India, and operated strictly according to manufacturer's instructions.

Tests were carried out on thiosulphate-dechlorinated tap water (Grabow et al., 1984a) seeded with various combinations of laboratory strains of human viruses, phages and indicator bacteria, on river water polluted with secondary treated waste water, and also on secondary treated waste water. Test runs were carried out in the laboratory at an average temperature of 25°C. Two-litre volumes of water were used in each test.

The origins and methods of enumeration of laboratory test strains of human viruses by most probable number (MPN) assays using microtitre plates, have been described previously (Grabow et al, 1992). Micro-organisms used were: a vaccine strain of poliovirus type 1 and hepatitis A virus strain pHM-175 (Grabow et al., 1984a; Bosch et al., 1991a); simian rotavirus SA11 and human rotavirus strain HRV-3 (Sato et al., 1981; Grabow et al., 1984a; Bosch et al., 1991b); and adenovirus types 40 and 41 (Grabow et al., 1992). Male-specific coliphage MS2 and somatic coliphage V1 were enumerated by plaque assays (Grabow et al., 1984b; 1993). *Escherichia coli*, *Streptococcus faecalis* and *Clostridium perfringens* were enumerated by membrane filter techniques (Grabow et al., 1984a). The same methods were used for the detection of viruses, phages and bacteria in test samples of river water (Apies River in Pretoria 500 m downstream of the Daspoort waste-water treatment plant discharge) and secondary treated waste water (Pretoria Daspoort waste-water treatment plant) (Grabow et al., 1984b). Methods for pour-plate standard (heterotrophic) plate counts and membrane filter counts of total coliform bacteria and faecal streptococci in river water and treated waste water have been described by Grabow (1990).

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Received 9 February 1994; accepted in revised form 29 November 1994.

TABLE 1
REDUCTION IN NUMBERS OF SEEDED LABORATORY STRAINS OF VIRUSES, COLIPHAGES AND FAECAL INDICATOR BACTERIA IN TAP WATER

Water and organisms	n	Count per 100 mℓ				Mean % reduction
		Before treatment		After treatment		
		Range	Mean	Range	Mean	
Escherichia coli	7	5-86 x 10^4	23 x 10^4	0-33	5	99.99783
Streptococcus faecalis	7	14-80 x 10^5	44 x 10^5	0-98	16	99.99996
Clostridium perfringens	3	4-18 x 10^4	10 x 10^4	0	0	>99.999
Coliphage MS2	5	5-50 x 10^3	16 x 10^3	0-1	1	99.99375
Coliphage V1	4	2-35 x 10^5	4 x 10^5	0	0	>99.999
Poliovirus	3	3-17 x 10^6	5 x 10^6	0-193	47	99.99906
Hepatitis A virus	3	4-58 x 10^5	16 x 10^5	0	0	>99.999
Adenovirus 40	3	4-54 x 10^4	25 x 10^4	0	0	>99.999
Adenovirus 41	3	10-89 x 10^4	56 x 10^4	0	0	>99.999
Simian rotavirus SA11	3	9-38 x 10^4	17 x 10^4	0	0	>99.999
Human rotavirus HRV-3	3	3-94 x 10^6	27 x 10^6	0-10	5	99.99998

n = number of tests

Results

Average turbidity of the dechlorinated tap water was about 0.2 NTU. *Euroguard* treatment reduced the turbidity of river water on average from 1.8 to 0.8 NTU, and that of secondary treated waste water from 2.1 to 0.8 NTU. *Euroguard* treatment did not have a significant effect on the pH of test water, which was on average 7.8 for the tap water, 7.6 for the river water and 6.8 for the treated waste water.

Numbers of viruses, coliphages and indicator bacteria in seeded tap water, as well as naturally occurring indicator bacteria and coliphages in river water and treated waste water, were generally reduced to zero or a few survivors in exceptional cases (Tables 1 and 2). Data on the reduction of naturally occurring cytopathogenic viruses are based only on low numbers of viruses (mean: 6 viruses/100 mℓ) detected by direct titration in treated waste water (Table 2).

The efficiency summarised in Tables 1 and 2 remained unchanged after 68ℓ of seeded tap water, 10 ℓ of river water and 8 ℓ of secondary treated waste water had been passed through the unit. The capacity of the unit in terms of the volume of water and quality of water that would reach the point where performance becomes unacceptable, has not been investigated in detail because it would involve a wide variety of variables and conditions. The efficiency of the built-in safety devices for unacceptable performance, including the warning lights, audio indicator and the automatic shut-off solenoid valve, has also not been evaluated in detail. However, in test runs the green light and audio indicator were never activated, and the solenoid valve was never opened, before the ultraviolet light hab been warmed up and had been functional for about 3 min. In experiments, when the power supply to the ultraviolet light lamp was disconnected, the green light and audio indicator were similarly never activated, and the solenoid valve never opened.

Discussion

Results obtained indicate that under prescribed conditions of operation *Euroguard* is capable of reducing numbers of laboratory strains as well as naturally occurring bacteria, phages and viruses in waters of divergent quality to levels within limits internationally accepted for drinking water (Helmer et al., 1991; WHO, 1993). The tap water tested contained numbers of seeded organisms much higher than those expected in water for which the unit is intended to be used. Likewise, the secondary treated waste water used in test runs was also of much poorer quality than that for which the unit was designed. The results of these tests on highly turbid and heavily polluted waters which represent "worst case" situations in practice, indicate that the efficiency of *Euroguard* makes

TABLE 2
REDUCTION IN NUMBERS OF NATURALLY OCCURRING VIRUSES, COLIPHAGES AND INDICATOR BACTERIA IN WASTE AND RIVER WATER

Water and organisms	n	Count per 100 mℓ				Mean % reduction
		Before treatment		After treatment		
		Range	Mean	Range	Mean	
River water						
Heterotrophic plate count	3	9-84 x 10^4	36 x 10^4	43-50	45	99.9997
Total coliforms	3	3-51 x 10^2	29 x 10^2	0	0	>99.9655
Faecal streptococci	3	2-44 x 10^1	14 x 10^1	0	0	>99.2857
Somatic coliphages	3	23-46 x 10^1	41 x 10^1	0	0	>99.7561
Cytopathogenic viruses	3	0	0	0	0	?
Treated waste water						
Heterotrophic plate count	3	29-61 x 10^5	36 x 10^5	5-9	6	99.9998
Total coliforms	3	20-55 x 10^3	20 x 10^3	0	0	>99.995
Faecal streptococci	3	2-20 x 10^1	7 x 10^1	0	0	>98.5714
Somatic coliphages	3	60-93 x 10^1	85 x 10^1	0	0	>99.8701
Cytopathogenic viruses	3	0-15	6	0	0	>83.3333

n = number of tests

provision for a substantial safety margin. This safety margin was demonstrated for laboratory strains of indicator organisms and viruses generally associated with drinking-water quality and waterborne diseases, as well as naturally occurring indicators in water with turbidity and content of organic compounds for which the unit is not intended. The river water used in this study would appear to approximate the quality of water for which *Euroguard* was designed. This includes the low numbers of cytopathogenic viruses (Table 2) (Grabow et al., 1984b).

By implication the unit would seem to comply with guidelines suggested for microbial water purifiers by a multidisciplinary task force of the United States Environmental Protection Agency (Abbaszadegan et al., 1992). According to the guide standard and testing protocol suggested by the task force for such units, they should be capable of at least a 99.9999% removal of *Klebsiella terrigena*, a 99.99% removal of poliovirus and rotavirus, and a 99.9% removal of *Giardia*, under conditions of operation for which the unit is intended, as well as realistic "worst case" quality situations. In the present evaluation of the *Euroguard* unit, the removal of *K. terrigena* has not been tested, but evidence has been presented that related bacteria, as well as the more resistant streptococci and *C. perfringens* bacteria (Grabow, 1990), were removed at the suggested levels of efficiency. Evidence has also been presented that *Euroguard* removes poliovirus and rotavirus, as well as additional viruses and highly resistant phages, at higher levels of efficiency than suggested by the task force. Although the removal of cysts and oocysts of intestinal protozoa such as *Giardia* and *Cryptosporidium* has not been investigated, information on the removal of cysts and oocysts by filters such as the polypropylene candle filter and activated carbon filters involved (Abbaszadegan et al., 1993; Whitmore and Carrington, 1993), and the inactivation of cysts and oocysts by ultraviolet light (Chang et al., 1985) at the levels of efficiency concerned (Table 1), would seem to indicate that the possibility of viable cysts and oocysts passing through the unit is negligible. This conclusion is supported by the efficiency of removal and inactivation of bacteria, viruses and phages (Table 1).

Although the reliability of the built-in safety devices, including the warning lights, audible alarm and automatic shut-off solenoid valve, has not been evaluated in detail, observations in test runs and experimental disconnection of power to the ultraviolet light source, suggest that they function reliably. For instance, the solenoid valve would not allow water to pass through the unit when the ultraviolet light was not in operation, warmed up and functional at the required level of efficiency.

General impressions of *Euroguard* were that it functions well under prescribed conditions of

operation, and that it would certainly appear capable of satisfactorily reducing the numbers of health-related micro-organisms in water for which it is intended to be used. However, in terms of installation, operation, maintenance and servicing such as the replacement of activated carbon or the ultraviolet light lamp, the unit may require a level of expertise and dedication not always associated with the market for which it is intended. The fundamental dependence on a supply of electricity may also eliminate the suitability of the unit for a substantial part of the target market. In addition, the capital outlay may be beyond the reach of many potential customers.

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