Note

A Note on the Effect of Chlorination of Sewage Effluents on Faecal Coliform to Faecal Streptococci Ratios in the Differentiation of Faecal Pollution Sources

P.A.E. ROSSER and D.P. SARTORY

Hydrological Research Institute, Department of Water Affairs, Forestry and Environmental Conservation, Private Bag X313, Pretoria, 0001

Abstract

Chlorination of sewage effluents results in the lowering of faecal coliform (FC) to faecal streptococci (FS) ratios, from levels typically indicating human faecal waste. This is due to a greater resistance shown by faecal streptococci to chlorination. The use of FC:FS ratios to predict pollution type must, therefore, be treated with caution.

Introduction

Faecal coliforms (FC) and faecal streptococci (FS) are the two main groups of bacteria used to indicate faecal pollution. Geldreich, Clark and Huff (1964) suggested that the use of the FC:FS ratio may be a valuable tool for assessing faecal pollution sources in water. After analysing faecal samples from humans and a wide range of animals, Geldreich and Kenner (1969) reported that a FC:FS ratio of 4,0 or greater was indicative of human faecal pollution and an FC:FS ratio equal to or less than 0,7 was indicative of animal faecal pollution. Geldreich (1976) reported a value of 0,6 for animal faecal pollution.

Geldreich and Kenner (1969) recommended that the use of the FC:FS relationships would only be valid for 24 h after the pollution has been discharged into the stream as the two groups die off at different rates. Feachem (1975), however, concluded that, depending on whether the ratio rises or falls with time, the source could still be identified. He stated that an originally high ratio which falls is indicative of human faecal pollution, and low ratios which subsequently rise are indicative of non-human faecal pollution.

Chlorination of sewage effluent also alters the FC:FS ratio (Lin, 1974). In a preliminary study Lin analysed 18 unchlorinated effluent samples finding a mean FC:FS ratio of 11,2. For 63 chlorinated effluent samples the ratio averaged 0,72. The values from the chlorinated effluents are indicative of non-human faecal waste and would thus invalidate the use of the FC:FS ratio as a pollution type indicator whenever chlorination of effluents is applied. Lin ascribed this reduction of the ratios due to chlorination to faecal streptococci being more resistant to chlorination procedures than faecal coliforms.

An opportunity to monitor the effect of chlorination of purified sewage effluents was presented when the Pretoria Municipality started in 1979 to chlorinate the final effluent from a sewage works situated in the catchment of the Roodeplaat dam. This began in October 1979. This study was supplemented by a small scale laboratory experiment. This note presents data on the effect of chlorination of purified sewage effluents on FC:FS ratios.

Materials and Methods

Samples were routinely collected over a period of six months from the sewage works, north east of Pretoria, covering periods before and after commencement of chlorination of the effluent (12.10.1979). Secondary purified unchlorinated sewage effluent samples were also collected from this sewage works for the laboratory study. On arrival at the laboratory (within 2 h of collection) the samples were pooled in a five litre flask, thoroughly mixed and placed on a magnetic stirrer. A 100 cm^3 subsample was taken from this unchlorinated effluent for bacteriological analysis. Chlorine was then added to the flask in the form of sodium hypochlorite solution while the sample was continuously stirred. At various times intervals (up to 30 min) further 100 cm^3 subsamples were decanted into sterile bottles containing 1 cm^3 of a solution of sodium thiosulphate (100 g/ℓ) to neutralise the residual chlorine.

The residual chlorine levels were determined with a Lovibond "1000" Comparator (The Tintometer Co., Salisbury, U.K.) using the N,N-diethyl-p-phenylene diamine (Palin-DPD) method for total residual chlorine.

Faecal coliforms and faecal streptococci were enumerated using the membrane filtration method (Standard Methods, 1975). Throughout the study Millipore HC membranes were employed. Faecal coliform bacteria were enumerated on M-FC broth (Difco Laboratories) without rosolic acid (Presswood and Strong, 1978; Sartory, 1980). The plates were incubated for 20 to 24 h at 44,5°C ± 0,2°C and all blue colonies were recorded as faecal coliforms. The faecal streptococci were enumerated on m-Entereococcus agar (Slanetz and Bartley medium, Oxoid CM 377). The plates were incubated for 48 h at 35,5°C ± 0,5°C and all deep red colonies were recorded as faecal streptococci. Where dilutions were required, quarter strength Ringer solution was used.

Results

The results of the laboratory experiment are depicted in Figure 1. The initial residual chlorine level was 1,2 mg/ℓ. The level fell to 0,8 mg/ℓ after 30 min. The results show a rapid die-off rate for faecal coliforms compared to that of faecal streptococci. After 5 min contact time there was a 97% reduction in faecal coliforms and a 66% reduction in faecal streptococci. The FC:FS ratio dropped from an initial 4,4, as would be expected from an effluent of a sewage works, to 0,4 after 5 min and 0,02 after 30 min, indicating non-human waste. Similar results were obtained in repeat experiments using higher doses of chlorine, but with increased die-off rates, particularly for faecal coli-

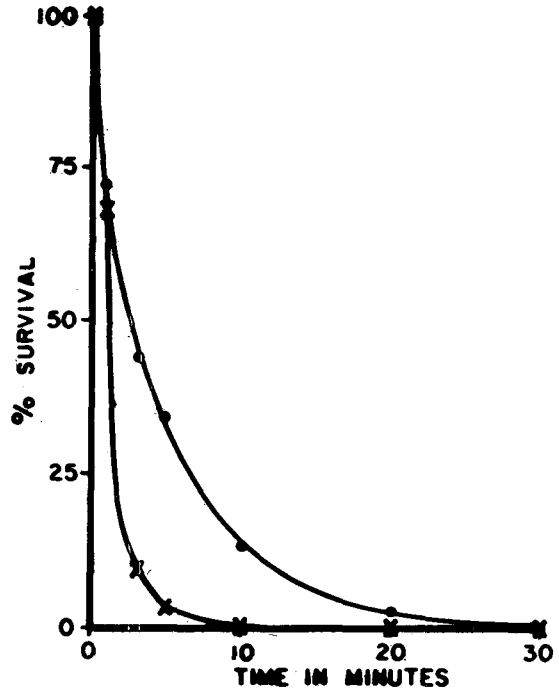

Figure 1
Die-off of faecal coliforms x-x *and faecal streptococci (● — ●) in chlorinated secondary purified sewage effluent. Initial residual chlorine = 1,2 mg/ℓ*

forms. These results substantiate the view that faecal streptococci are more resistant than faecal coliforms to chlorination procedures.

Table 1 shows the FC:FS ratios of routine effluent samples collected at the sewage works during 1979, before and after commencement of chlorination of the effluent. Out of 15 samples collected before inception of chlorination, 10 were clearly indicative of human faecal pollution. Three samples show low ratios, not indicative of human faecal pollution. These low ratios were probably a result of stormwater overflow that entered the sewage works during that period. The mean FC:FS ratio for the period is 15,7. Of the results for the period following inception of chlorination of the effluent, three out of eleven samples had a ratio indicating animal faecal pollution of effluent from a works treating mainly human waste. Except for one sample with a ratio higher than 4,0, the rest indicated neither human nor animal pollution. The mean ratio was 1,7.

TABLE 1
FAECAL COLIFORM (FC):FAECAL STREPTOCOCCI (FS) RELATIONSHIPS IN A SECONDARY PURIFIED SEWAGE EFFLUENT FROM A SEWAGE WORKS BEFORE AND AFTER COMMENCEMENT OF CHLORINATION

Date	FC:FS Ratio	Comments	Mean
1979			
05.06	32,5		
19.06	52,2		
26.06	4,0		
03.07	8,1		
10.07	1,5	low ratios as	
17.07	1,7	a result of	
24.07	0,6	stormwater over-flow	
31.07	6,3		15,7
07.08	3,3		
14.08	4,8		
21.08	7,2		
28.08	5,8		
18.09	12,1		
25.09	79.4		
02.10	16,3		
12.10		chlorination begins	
16.10	2,0		
23.10	1,2		
30.10	3,0		
06.11	3,4		
13.11	4,4		
20.11	0,6		1,7
27.11	1,2		
11.12	0,1		
1980			
08.01	1,6		
15.01	1,3		
29.01	0,1		

Discussion

The results of this study show that faecal streptococci are more resistant to chlorination than are faecal coliforms. This is in agreement with the generally accepted statement in the water supply industry that chlorine doses sufficient to kill *E. coli* may not be sufficient to totally eliminate faecal streptococci (Windle Taylor, 1958; Mead, 1966). This greater resistance to chlorine by faecal streptococci results in a significant lowering of the FC:FS ratio following chlorination of purified sewage effluents. The data of Lin (1974) and our results show that, when purified effluents are chlorinated, much reduced FC:FS ratios are recorded, in some cases indicating animal faecal pollution from a domestic sewage source. Thus the indicative power of the FC:FS ratio to differentiate pollution types is abrogated. In this day and age, where even small scale sewage works chlorinate their effluent, the use of the FC:FS ratio to predict faecal pollution type must, therefore, be treated with great caution.

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