Evaluation of the microbial quality of water supplies to municipal, mining and squatter communities in the Bindura urban area of Zimbabwe, in relation to incidences of specific enteric diseases.

H. Nyati

National University of Science and Technology, Applied Biology and Biochemistry Department, P.O. Box AC939, Ascot, Bulawayo , Zimbabwe.

e-mail: hnyati@nust.ac.zw

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Abstract

A survey of the microbiological and chemical quality of water supplies in the Bindura urban and peri-urban area was carried out over a three year period from January 2000 to July 2003. Bindura is the provincial city of Mashonaland Central, situated 88 km from the national capital, Harare. Large-scale farming and mining activities in the area predispose water bodies to eutrophication and chemical pollutants raising concerns about the safety of local water supplies . In this study , thermotolerant (faecal) coliform levels, total aerobic bacterial counts and physicochemical profiles were determined for municipal and borehole water as well as water supplies to mining and squatter communities. Although municipal and mining compound water supplies were of satisfactory microbial and chemical quality, borehole water supplies showed a seasonal fluctuation with higher coliform counts in the wet season from November to March. Stream water supplies to a squatter camp in the peri-urban area consistently recorded coliform levels greater than 1800 per 100 ml and total aerobic plate counts of up to 2.8×10^6 cfu/ml. All cholera incidents recorded in 1999 and 2000 at the Provincial hospital were from peri-urban settlements and surrounding commercial farms while 1045 to 2 632 cases of Dysentery were also reported each year at the Provincial Hospital during the period 1997- 2002 .

Keywords: Bindura, Zimbabwe, water quality, thermotolerant coliforms , Dysentery, Cholera, Typhoid.

1. INTRODUCTION

Bindura, a mining town is located in a commercial farming area and draws its water from the local Mazoe River. The population is estimated at 34 000 in the municipal area, with an additional 10 000 in the peri-urban mining settlements [8]. Agricultural activities in the surroundings include both crop-farming and animal husbandry , while mining activities are limited to gold and nickel processing. Whereas the town council is responsible for the treatment of water supplies for residents within the Bindura municipal area, mining companies are responsible for the treatment of water supplies to their peri-urban communities and also maintain their own sewage treatment ponds.

Concerns about the effect of mining and farming activities on the quality of water supplies in the area and the potential hazards associated with the use of untreated stream water by peri-urban gold-panning settlements prompted a survey of the microbial and chemical quality of municipal and private water supplies in the Bindura urban and peri-urban area. The area is located in Natural Region II which receives a fair amount of rainfall (750 – 1000 mm) annually and has recorded one of the highest incidences of cholera and dysentery in the country [9, 10, 11, Fig 1].

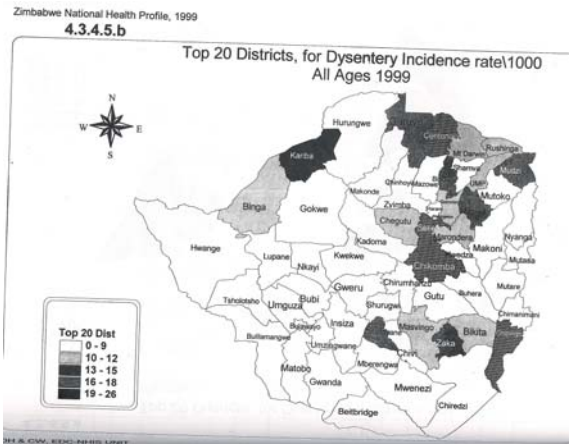

Figure 1. Top 20 Districts for Dysentery incidence rate/1000, Zimbabwe 1999.
(From Ministry of Health & Child Welfare National Health Profile 1999)

2. MATERIALS AND METHODS

2.1 Sampling

Samples were drawn at fortnightly intervals from the Mazoe River adjacent to the treatment plant, inlet at the treatment plant, treated water at the plant and from domestic taps, boreholes, and a stream at a gold-panning camp.

2.2 Microbiological analysis

Thermotolerant (faecal) coliforms were enumerated by the 5 tube most probable number method at 44^{o}C in MacConkey and Brilliant Green bile broths. *Escherichia coli* was confirmed on Eosin Methylene Blue Agar streak plates.

Total heterotrophic plate counts were determined by 1mL plate count agar pour- plates at 22^{o}C.

2.3 Chemical analysis

Chloride levels and total hardness were determined by titrimetry, nitrate by ion-selective electrode, iron by atomic absorption spectrometry, and sulphate by gravimetry.

Table 1. Thermotolerant coliform levels and total heterotrophic bacterial counts in river water and treated municipal water supplies.

Sampling Date	Coliforms/100mL				Plate count/mL			
	Mazoe River	Inlet	Treated water Plant	Household	Mazoe River	Inlet	Treated water Plant	Household
17/07/2003	-	-	<1	<1	-	-	-	-
29/04/2003	1600	49	<1	<1	200	300	<1	<1
18/03/2002	-	84	<1	<1	300	350	<1	<1
26/06/2001	-	221	<1	<1	200	130	<1	<1
15/05/2001	-	79	<1	<1	430	400	<1	<1
13/02/2001	-	542	<1	<1	550	400	2	4
18/01/2001	>1800	900	<1	<1				
26/09/2000	-	49	<1	<1				
10/08/2000	-	49	<1	<1				
21/06/2000	-	221	<1	<1				
23/05/2000	348	542	<1	<1				
08/05/2000	1600	542	16	2				
12/04/2000	-	17	<1	<1				
23/03/2000	-	542	<1	<1				
07/03/2000	13	2	<1	<1				
16/02/2000	-	161	<1	<1				
02/02/2000	161	54	<1	<1				
18/01/2000	-	54	<1	<1				

3. RESULTS AND DISCUSSION

Over the three year study period, coliforms were not detected in 100mL samples of municipal and mining compound water supplies (Table 1 , Table 2), with the exception of one sample (Table 1 , 08/05/2000) where underchlorination at less than 2 ppm residual chlorine allowed survival at 16 thermotolerant coliform cells per 100mL. The microbial quality of raw water from the inlet at the treatment plant fluctuated seasonally, with coliform counts ranging from 2 per 100mL in March 2000 to 900 per mL in January, 2001.

Table 2. Thermotolerant coliform levels and total heterotrophic bacterial counts in mining compound water supplies.

Sampling date	Coliforms/100mL	Total plate counts/mL
07/09/2001	<1	<1
21/09/2001	<1	<1
23/10/2001	<1	<1
06/11/2001	<1	<1

Borehole water supplies also showed a seasonal fluctuation in quality, with no detectable coliform cells in 100 mL samples during the winter season and up to 240 cells per 100mL in the rainy season due to underground seepage (Table 3).

Borehole 1 was located at the same estate where the municipal sewage treatment ponds were sited, while borehole 2 was privately owned and was located only a distance of 30 metres from the stream used by the gold-panning community.

Table 3. Thermotolerant coliform levels and total heterotrophic bacterial counts in borehole water supplies.

Sampling date	Coliforms/100mL	Total plate counts/mL
Borehole 1		
26/09/2000	<1	16
18/01/2001	11	200
13/02/2001	>240	3 000
15/05/2001	8	2 000
26/06/2001	<1	10
Borehole II		
18/03/2002	49	30
21/04/2003	79	100

Chemical parameters were within World Health Organisation specifications (Table 4), with the exception of high iron levels at 0.6 mg/L [1, 5, 6, 7] Stream water supplies at the gold-panning camp under study consistently showed coliform counts exceeding 1800 per 100mL (Table 5) . Overflows from nearby mining compound sewage treatment ponds is thought to be the main source of contamination and the high coliform counts in the stream. Residents confirmed that they used the stream water for laundry and bathing purposes, while 25% used the water for the cleaning of kitchen utensils, and in some instances for cooking purposes.

Table 4. Physico-chemical profile of river, municipal and bore-hole water supplies.

Parameter	River	Municipal	Borehole	WHO guidelines Max. mg/L)
Hardness ($CaCO_3$)	75	38	88	200
SO_4	56	11	28	250
Cl^-	12.8	20.8	8.6	250
NO_3	30	28	25	50
TDS	214	114	338	1 000
Conductivity	344	210	430 mS/m	
Cyanide	not detectable	-	-	0.07
Iron	0.60	-	-	0.30
pH range	7.52–7.73	6.93-7.36	7.05-7.80	<8.0

Table 5. Thermotolerant coliform levels and total heterotrophic bacterial counts in gold panning water supplies.

Sampling date	Coliforms/100mL	Total plate counts/mL
18/03/2002	>1800	$6x10^4$
20/04/2002	>1800	$8x10^5$
23/05/2002	>1800	$2x10^6$
18/07/2002	>1800	$8x10^5$

Between 1 045 and 2 632 cases of dysentery were reported each year from 1997 to 2 002 at the provincial hospital (Table 6), with 11 and 3 dysentery related deaths recorded in 1999 and 2000, respectively . National Statistics indicate Mashonaland Central Province and Bindura district as having the highest incidence of dysentery (12.3 per 1000) in 1999, compared with 1.4 per 1000 in Bulawayo, the second largest city in the country. In addition, of the total 4081 cholera cases reported in the country in 1999, 1 862 (46%) were from Mashonaland Central, which represents only 8% of the country's population [11]. All the reported cholera cases in Bindura (28 and 54 in 1999 and 2000, respectively) were from the peri-urban settlements.

Table 6. Diarrhoeal disease incidences reported at Bindura Provincial Hospital and nationally from 1997 – 2002.

	Bindura			National		
	Dysentery	Cholera	Typhoid	Dysentery	Cholera	Typhoid
1997	2351	0	0	213379	0	3
1998	2632	0	0	114075	0	3
1999	2178	28	2	99246	228	2
2000	2038	54	0	-	-	-
2001	1045	0	0	-	-	-
2002	1804	0	0	-	-	-

From Zimbabwe Ministry of Health and Child Welfare,1997 ; 1998; 1999 and Bindura Provincial Hospital records.

4. CONCLUSIONS

The microbial and chemical quality of municipal and mining compound water supplies in Bindura is within WHO specifications, with the exception of high iron levels, while borehole water was of variable microbial quality and dependent on the season. Stream water supplies to gold panning settlements were highly polluted and unsuitable for domestic use. Since the gastroenteritis outbreaks occurred mainly in areas where the use of untreated water supplies for domestic purposes is common practice, a health-education programme discouraging contact with untreated surface waters and encouraging chlorination and boiling of such water before use is recommended for the control of water-borne enteric infections. Suggested further work includes serotyping of strains from stream water at the squatter camp for possible epidemiological linkage with clinical isolates.

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