

An assessment of the water quality of the Isinuka springs in the Transkei region of the Eastern Cape, Republic of South Africa

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Abstract

The physico-chemical properties of Isinuka springs, a "wonder" water resource in Port St Johns area of Eastern Cape Province, were investigated over three seasonal regimes. Water samples were collected from the five spring sources, along Isinuka river and from Ferry Point Cottage spring and analysed for their quality parameters. Most of the water quality variables measured were found to show seasonal fluctuations. Isinuka spring water is not fresh as it contains high salt contents and the results indicate that it is not suitable for drinking without treatment. The water is moderately hard, salty and fairly neutral with pH ranging from 6.87 to 8.33. One of the five sources continually emits a characteristic odour and the five spring sources were characterised by very high concentrations of TDS, turbidity, Cl⁻ and NH₄⁺-N which exceeded the maximum permissible levels recommended for drinking waters. The NO₃⁻-N and NO₂⁻-N were, however, present at levels far below the critical value of 10 mg/l above which the occurrence of blue baby syndrome (methaemoglobinaemia) due to NO₂⁻ poisoning might be a problem in pregnant women and bottle-fed infants. Water from Ferry Point Cottage spring met the water quality guidelines for drinking water.

Introduction

Surface waters (e.g. rivers, streams and ponds), groundwater, rain-water and springs are the main sources of water available to the rural settlement dwellers in South Africa. The qualities of these water bodies vary widely depending on location and environmental factors. Among the factors determining the qualities of natural waters, groundwaters and springs in particular, are the chemical composition of the underlying rocks, soil formations and the length of time that the water body has been trapped underground (Van der Merwe, 1962). To protect the water sources, several national and international policies and acts have been enacted (DWA, 1997; SDWA, 1996;) and criteria and guidelines established for water quality standards (EEC, 1980; SABS, 1984; USEPA, 1996; WHO, 1984 and 1993)

From the data available in the literature, there is an increasing awareness of the need to control the pollution of South African water resources (SWLR, 1995; DWA, 1986) and to protect their quality (Quilbell et al., 1997; Jagals, et al., 1997 and Dallas and Day, 1993). The present study focuses on the water qualities of Isinuka springs and the adjoining river. The location of the springs has become a popular tourist centre in the Port St Johns' area and is believed to be a mystery water source. The springs are also the main source of domestic water supply for the villagers. Its historical background suggests some latent scientific value which is worthy of investigation. The physico-chemical properties of Isinuka springs are reported and the results are compared with data from the Isinuka River, together with recommended water guidelines for drinking and domestic uses.

Ferry Point Cottage provides the only other spring source available in the Port St Johns' area. In addition to evaluating the suitability of its water for domestic uses, the spring will serve as a

control and reference. It is also envisaged that the baseline data will contribute to the understanding of the physical and chemical behaviour of other spring sources in the region.

The study areas

Isinuka springs and river

Isinuka springs are situated approximately 20 km west of Port St Johns, a town noted for its beautiful beaches and holiday resorts in the Transkei Region (Fig. 1). There are five spring sources strategically located on top of a mountain about 800 m a.m.s.l. The springs have long been considered a sacred source in the Eastern Cape Province of South Africa as they are believed to possess some potent qualities and mystical powers for curing all diseases. The location and description of the five spring sources are given in Table 1. Down the mountain valley is the Isinuka River which drains into the Umzimvubu River, an important water body discharging into the Indian Ocean at Port St Johns.

In Isinuka Village, there is a small well associated with the original source of the Isinuka spring. This source dried up when the public was denied free access to the spring and the water was partially commercialised. The well emits a pungent gas and because of this, the area is called "VICKS". Visitors to Isinuka believe that by inhaling the gas their headaches, backaches and other body problems can be cured.

Ferry Point Cottage spring

Ferry Point Cottage is a bed-and-breakfast (B&B) guest house located by the mountain side south-west of Port St Johns and close to the point where ferries are boarded on Umzimvubu River. The name of the Cottage was derived from its location. The spring's source is on top of the mountain. The management of the cottage depends solely on this water source and are therefore interested in its suitability for drinking and other domestic uses.

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Figure 1

Map of Port St Johns showing Isinuka and Ferry Point locations

Materials and methods

Sampling protocol

Water samples were collected from the five Isinuka spring sources once during winter, spring and summer seasons while the river (upstream and downstream) and Ferry Point Cottage spring were sampled over two seasons. Samples for dissolved oxygen (DO) determinations were separately collected in glass bottles while plastic bottles were used for other parameters. The integrity of the DO samples was preserved in the field by the modified Winkler's method (*Standard Methods*, 1975) and stored in coolers containing ice-chests immediately after collection. The samples were analysed by appropriate certified and acceptable international standard methods (*Standard Methods*, 1975).

Laboratory analysis

The physico-chemical variables considered in this study comprised the quality parameters, micro-nutrients and anions. Colour, odour, and taste were observed in the field while the pH, temperature, conductivity and salinity were determined *in situ* in the field immediately after samples were collected and later in the laboratory. Samples were analysed by both classical and automated instrumental methods as appropriate (*Standard Methods*, 1975; Skong and Leary, 1992; Hammer, 1975 and Faniran et al., 1994). All the reagents used were of analytical grade and the instruments were pre-calibrated appropriately prior to measurement. Replicate

TABLE 1
Location and description of sampling point

Sampling point and code	Description of sample locations and field observations
ISS01	Spring Source 1: A pond-like spring about 1 to 2 m wide is located on top of the mountain. The source emits a characteristic and unpleasant odour and its water has always appeared to be cloudy. The sediment which is darkish-brown, is used by visitors and other believers in the spring for curing acne and other skin diseases.
ISS02	Spring Source 2: The spring is approximately 1.5 m from Source 1 on top of the mountain. It has a very narrow spout about 10 to 15 cm in diameter. The water is tasty, odourless, colourless and clear.
ISS03	Spring Source 3: This source is about 3 m from Source 2 and 4½ m from Source 1 on top of the mountain. The width is about the same as that of Source 2 and the characteristic features are similar, i. e. the water is odourless, colourless and has a pleasant taste.
ISS04	Spring Source 4: The spring is on the mountain descent from Sources 1 to 3 and directly above the cave-like source five. It has about the same size as Sources 2 and 3. It is also odourless, colourless and has a pleasant taste.
ISS05	Spring Source 5: This is situated inside a cave at the bottom of the mountain. Water drips from the top of the cave constantly onto a light brown sediment. The sediment is used for curing skin diseases and for skin care. The water could not be tasted due to the heavy impact of human activities. It is, however, odourless and cloudy.
ISS06	Isinuka River: This is a sampling point upstream in the Isinuka River. It flows over rocks and had, at best, pebble sediments where possible.
ISS07	Isinuka River: A sampling point downstream in the Isinuka River about 100 m below the man-made water pond by the side of the Isinuka River where people wash. The point is approximately 250 m directly from Isinuka Village.

TABLE 2
Water quality of Isinuka springs during the winter season

Parameter	ISS01	ISS02	ISS03	ISS04	ISS05
Taste	Not tastable	Tasty	Tasty	Tasty	Not tastable
Colour	Cloudy	Colourless	Colourless	Colourless	Cloudy
Odour	Emits odour	Odourless	Odourless	Odourless	Odourless
*T(°C): Ambient	20	20	20	17	17
Sample	16	18	18	18	18
pH	8.65	8.52	7.42	9.36	7.98
Turbidity (NTU)	63.20	0.31	0.32	1.73	nd
Conductivity (mS/cm)	3.40	9.01	9.16	8.86	8.21
Salinity (mg/l)	2.90	5.10	5.20	5.00	4.60
Alkalinity (mg/l)	370.7	515.3	590.0	554.7	438.3
Hardness (mg/l)	121.8	114.4	121.4	109.8	91.76
TS (mg/l)	2 098	3 833	4 600	4 292	3 332
SS (mg/l)	91.80	47.80	42.30	40.70	40.90
TDS (mg/l)	2 006	3 585	4 558	4 252	3 291
DO (mg/l)	10.87	15.47	13.73	14.33	13.70
COD (mg/l)	1 151	7 841	5 441	1 592	4 828
NH ₄ ⁺ -N (mg/l)	0.51	30.13	17.23	20.83	11.17
NO ₃ ⁻ -N (mg/l)	0.39	0.01	0.01	0.16	0.18
NO ₂ ⁻ -N (mg/l)	0.57	0.09	0.01	0.01	0.03
Cl ⁻ (mg/l)	699.7	1 050	1 086	1 018	953.0
SO ₄ ²⁻ (mg/l)	144.67	92.67	78.33	95.33	83.67
SO ₃ ²⁻ (mg/l)	1.40	0.30	0.30	0.20	0.53
Phenol (mg/l)	1.11	0.03	0.02	0.12	0.26

nd: Above instrument maximum detection limit
*: Temperature at sampling time

analyses were carried out for each determination to ascertain reproducibility and quality assurance.

The pH was measured in the field with a Merck Model WTW 320 pH meter and in the laboratory using a Hanna Microprocessor Bench Model HI931400 pH meter. Both instruments were calibrated with standard buffers at pH 4, pH 7 and pH 10.

The turbidity was determined using a Cole Palmer turbidimeter model 8391-45 while the conductivity, salinity and total dissolved solids (TDS) determinations were carried out on Merck conductivity meter Model WTW LF597, a multiCal-calibration system with integrated test value memory. The TDS was further analysed gravimetrically using glass-fibre filter papers.

The anions, micro-nutrients, chemical oxygen demand (COD) and phenol were analysed by photometric method on Merck Spectroquant Model SQ118 Photometer. Samples for COD analysis were digested with Merck Thermoreactor Model TR300. Dissolved oxygen (DO) was measured with a YSI Dissolved Oxygen Meter Model 5000 and by Winkler's method. Total dissolved solids (TDS) and suspended solids (SS) were analysed gravimetrically as previously described (Faniran et al., 1994).

Total alkalinity (as mg/l CaCO₃), total hardness and the chloride concentrations in the water samples were measured by titrimetric methods. The alkalinity was measured by titration of the sample with 0.1 M hydrochloric acid to pH 4.5 using methyl orange indicator while the water hardness was analysed by titration of the buffered water sample with standard EDTA at pH 10 using Eriochrome Black-T as the indicator. The chloride content was determined by argentometric method. The sample was titrated under

neutral conditions with a standard silver nitrate solution using potassium chromate as the indicator.

Results and discussion

Isinuka River and spring

The physical and chemical characteristics of Isinuka spring and river water for the different seasons are presented in Tables 2 to 5. The mean concentrations of the five spring sources are given in Table 6 and compared in Table 7 with the acceptable limits recommended by the South Africa Bureau of Standards (SABS, 1984), United States Environmental Protection Agency (USEPA, 1996) and World Health Organisation (WHO, 1984 and 1993). Similar comparisons for water quality parameters of Isinuka River and Ferry Point Cottage spring are shown in Tables 8 and 9. The variation of the mean values of Isinuka spring water quality parameters are given in Figs. 2 to 6.

General characteristics

Water samples collected from the five spring sources had a good taste and were odourless except spring Source 1 which continuously emitted an unpleasant characteristic smell through-out the period of investigation. Sources 1 and 5 were always cloudy and continually impacted by human activities while the other three sources were clear and colourless. On the other hand, Isinuka River water was tasteless, odourless and colourless. From Tables 2 to 5, it will be observed that the sample temperatures were generally lower than

TABLE 3
Water quality of Isinuka springs during the spring season

Parameter	ISS01	ISS02	ISS03	ISS04	ISS05
Taste	Not tastable	Tasty	Tasty	Tasty	Not tastable
Colour	Cloudy	Colourless	Colourless	Colourless	Cloudy
Odour	Emits odour	Odourless	Odourless	Odourless	Odourless
*T(°C): Ambient	22	22	21	21	20
Sample	14	16	16	17	15
pH	7.84	7.72	8.33	7.70	6.73
Turbidity (NTU)	85.53	66.57	5.65	1.76	nd
Conductivity (mS/cm)	5.45	8.63	9.45	9.01	8.49
Salinity (mg/l)	2.93	4.90	3.40	5.10	4.77
Alkalinity (mg/l)	63.90	78.30	165.0	3.30	118.3
Hardness (mg/l)	229.0	116.8	137.5	186.6	98.53
TS (mg/l)	1 622	2 936	3 351	2 895	2 761
SS (mg/l)	63.40	41.70	37.90	38.50	42.60
TDS (mg/l)	1 559	2 894	3 317	2 857	2 718
DO (mg/l)	13.47	12.50	12.50	12.13	12.33
COD (mg/l)	945.3	1 216	4 712	2 626	2 844
NH ₄ ⁺ -N (mg/l)	7.75	7.76	5.55	4.81	3.03
NO ₃ ⁻ -N (mg/l)	Nd	Nd	Nd	Nd	Nd
NO ₂ ⁻ -N (mg/l)	0.48	0.07	0.02	0.02	0.03
Cl ⁻ (mg/l)	625.7	1 016	1 144	1 091	1 027
SO ₄ ²⁻ (mg/l)	144.3	155.0	99.33	131.0	98.33
SO ₃ ²⁻ (mg/l)	14.50	1.90	0.90	1.01	7.53
Phenol (mg/l)	0.62	1.13	0.35	0.41	0.08

nd: Above max. detection limit; Nd: Not determined; *: Temperature at sampling time

TABLE 4
Water quality of Isinuka springs during the summer season

Parameter	ISS01	ISS02	ISS03	ISS04	ISS05
Taste	Not tastable	Tasty	Tasty	Tasty	Not tastable
Colour	Cloudy	Colourless	Colourless	Colourless	Cloudy
Odour	Emits odour	Odourless	Odourless	Odourless	Odourless
*T(°C): Ambient	25	25	23	23	24
Sample	24	22	21	21	24
pH	7.26	6.87	6.98	7.31	7.91
Turbidity (NTU)	86.83	2,27	1.62	1.42	nd
Conductivity (mS/cm)	8.45	9.22	9.27	8.97	8.95
Salinity (mg/l)	5.10	5.20	5.20	5.10	4.80
Alkalinity (mg/l)	506.7	688.7	234.7	258.8	236.7
Hardness (mg/l)	328.2	226.2	293.0	280.7	170.7
TS (mg/l)	3534	3398	3479	3403	3161
SS (mg/l)	69.60	39.10	31.70	47.10	46.20
TDS (mg/l)	3 465	3 359	3 447	3 356	3 115
DO (mg/l)	1.73	6.23	7.87	9.83	9.87
COD (mg/l)	67.00	471.3	342.7	1 982	2 193
NH ₄ ⁺ -N (mg/l)	5.41	1.29	1.59	1.75	2.26
NO ₃ ⁻ -N (mg/l)	0.90	7.20	0.13	3.23	3.57
NO ₂ ⁻ -N (mg/l)	0.12	0.01	0.01	0.01	0.08
Cl ⁻ (mg/l)	1 223	1 205	1 148	1 150	1 113
SO ₄ ²⁻ (mg/l)	125.7	123.3	73.00	57.00	70.33
SO ₃ ²⁻ (mg/l)	3.10	0.60	0.50	0.50	1.50
Phenol (mg/l)	2.66	0.07	0.12	0.09	1.10

nd: Above instrument detection maximum limit; *: Temperature at sampling time

TABLE 5
Water quality of Isinuka River in the spring and summer seasons

Parameter	Spring			Summer		
	ISS06	ISS07	Mean	ISS06	ISS07	Mean
Taste	Tasteless	Tasteless		Tasteless	Tasteless	
Colour	Colourless	Colourless		Colourless	Colourless	
Odour	Odourless	Odourless		Odourless	Odourless	
*T(°C); Ambient	16	20	18.00	25	22	23.50
Sample	10	11	10.5	23	21	22.00
pH	7.53	7.31	7.42	7.63	7.35	7.49
Turbidity (NTU)	49.00	37.10	45.03	0.59	0.60	0.60
Conductivity (mS/cm)	4.90	4.55	4.68	7.69	3.63	5.66
Salinity (mg/l)	2.53	2.40	2.47	0.02	1.80	0.91
Alkalinity (mg/l)	595.0	519.0	557.0	93.03	118.3	105.7
Hardness (mg/l)	24.80	36.45	50.63	82.03	90.00	86.02
TS (mg/l)	219.2	92.50	145.85	49.40	47.70	48.05
SS (mg/l)	6.10	5.80	5.95	4.60	14.50	9.55
TDS (mg/l)	213.1	66.70	139.9	44.80	33.20	39.00
DO (mg/l)	14.13	14.40	14.27	14.37	12.20	13.31
COD (mg/l)	144.7	181.7	143.2	508.7	533.0	520.8
NH ₄ ⁺ -N (mg/l)	0.28	0.39	0.34	0.47	0.13	0.30
NO ₃ ⁻ -N (mg/l)	Nd	Nd	Nd	1.77	0.23	0.50
NO ₂ ⁻ -N (mg/l)	0.05	0.03	0.04	0.01	0.01	0.01
Cl ⁻ (mg/l)	115.3	165.3	140.3	95.00	445.0	270.0
SO ₄ ²⁻ (mg/l)	46.00	10.33	28.17	24.00	27.00	25.50
SO ₃ ²⁻ (mg/l)	1.10	0.93	1.02	0.30	0.30	0.30
Phenol (mg/l)	1.11	0.03	0.55	0.08	0.11	0.10

Nd: Not determined; *: Temperature at sampling time

TABLE 6
The mean values and range of the water quality of the five Isinuka springs in winter, spring and summer seasons

Parameter	Winter		Spring		Summer	
	Mean	Range	Mean	Range	Mean	Range
*T(°C): Ambient	18.80	17-20	21.20	20 - 22	24.00	23-25
Sample	17.60	16-18	15.60	14 - 17	22.40	21-24
pH	8.15	7.42-8.65	7.70	6.73 - 8.53	7.21	6.87 - 7.91
Turbidity (NTU)	16.39	0.31-63.20	39.83	1.76-85.53	25.54	1.42-86.83
Conductivity (mS/cm)	8.13	3.40-9.16	8.21	5.45-9.45	8.97	8.45-9.27
Salinity (mg/l)	4.56	2.90-5.20	4.62	2.93-5.10	5.15	4.80-5.20
Alkalinity (mg/l)	493.8	370.7-590.0	85.76	3.30-165.0	385.1	234.7-688.7
Hardness (mg/l)	111.6	91.76-121.83	153.7	98.53-229.0	259.7	170.7-328.2
TS (mg/l)	3 512	2 098 - 4 600	2 813	1 622.3 - 3 351	3 395	3 161- 3 534
SS (mg/l)	55.66	40.70-91.80	44.82	37.90-63.40	46.74	31.70-69.60
TDS (mg/l)	3 539	2 006 - 4 558	2690	1 559 - 3 317	3 348	3 115 -3 464.7
DO (mg/l)	13.62	10.87-15.47	12.59	12.13-13.47	7.11	1.73-9.87
COD (mg/l)	4 171	1 151- 7 841	2 469	945.3 - 4 712	1011	67.00 - 2 193
NH ₄ ⁺ -N (mg/l)	15.99	0.51-30.13	5.78	3.03-7.76	2.46	1.29-5.41
NO ₃ ⁻ -N (mg/l)	0.15	0.01-0.39	Nd	Nd	3.01	0.13-7.20
NO ₂ ⁻ -N (mg/l)	0.14	0.01-0.57	0.17	0.01-0.48	0.06	0.01-0.12
Cl ⁻ (mg/l)	960.9	699.7- 1086	980.6	625.7-1144	1188	1113-1223
SO ₄ ²⁻ (mg/l)	98.93	78.33 - 144.7	125.6	98.33-155.0	89.87	57.00-125.7
SO ₃ ²⁻ (mg/l)	0.55	0.02-1.40	5.17	0.90-14.50	1.24	0.50-3.10
Phenol (mg/l)	0.32	0.02-1.11	0.52	0.08-1.13	0.81	0.08-1.13

Nd: Not determined; *: Temperature at sampling time

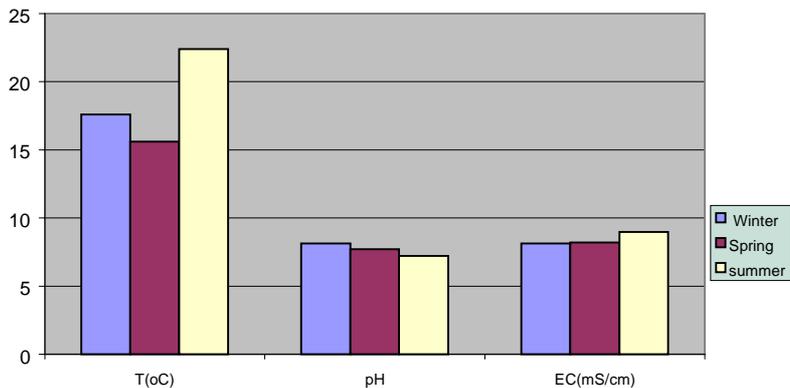


Figure 2
Seasonal variations of the mean values of temperature, pH and conductivity (m/S/cm) in Isinuka springs

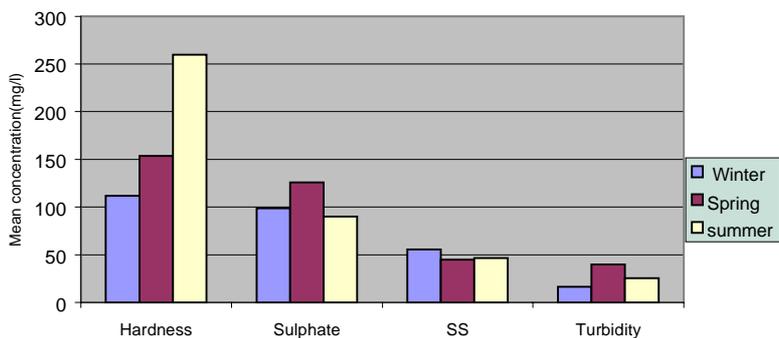


Figure 3
Seasonal variation of the mean concentrations (mg/l) of SO_4^{2-} , DO, hardness, SS and turbidity in Isinuka springs

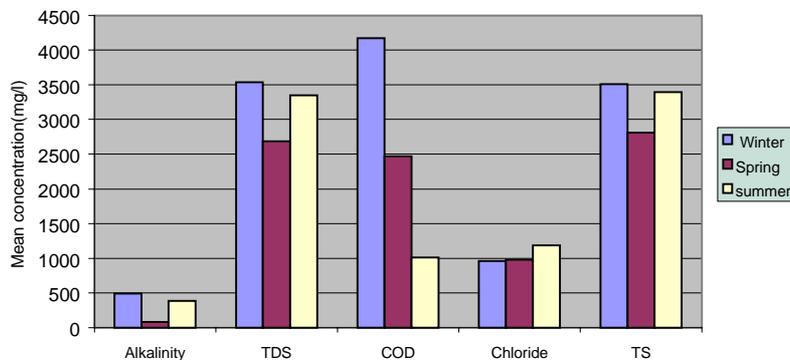


Figure 4
Seasonal variation of the mean concentrations (mg/l) of Cl^- , alkalinity, TDS, TS and COD in Isinuka springs

the ambient temperatures. Shown in Fig. 2 is the variation of the mean values of sample temperatures over the sampling seasons.

pH

The pH of the springs varied from 6.73 to 8.33 and, over the three seasons of investigation, fell within the range of pH 4 to pH 9 associated with most natural water and 6.5 to 8.5 stipulated for drinking and domestic waters. The springs are slightly basic in winter and spring with pH means of 8.15 and 7.7 respectively and neutral in summer (mean pH = 7.21) except Source 5 (the clay-like

source) which is slightly neutral (pH = 6.73) in spring and slightly basic in summer (pH = 7.91). Figure 2 depicts a decreasing response of pH of the springs to seasonal changes from winter to summer. The river is, however, neutral (pH range = 7.3 to 7.63) and relatively unaffected by seasonal variation (Table 5).

Conductivity

The conductivity of the springs and river water is within the limits of acceptable standards for domestic water and did not vary significantly over the sampling seasons except spring Source 1. As shown in Table 6 and Fig. 2, the mean conductivity of the springs increased from winter (mean = 8.13 mS/cm) through spring (mean = 8.21 mS/cm) to summer (mean = 8.97 mS/cm). The same trend was observed for the river with a mean of 4.60 mS/cm in spring and 5.66 mS/cm in summer (Table 5). However, the conductivity of the Isinuka River water was generally slightly lower than those of the springs.

Turbidity, SS and TDS

Tables 6 and 7 show that the mean values of turbidity, SS and TDS of the springs are high and fall outside the maximum recommended limits for domestic and drinking waters. As can be seen in Fig. 3, the turbidity was highest in the spring (mean = 39.83 NTU) and lowest in winter (mean = 16.39 NTU). The river was fairly turbid in spring with a mean of 43.05 NTU compared to the recommended value of 5 NTU but very low in summer (0.60 NTU).

SS and TDS are common indicators of polluted waters. As shown in Table 7, the maximum recommended concentration for TDS in drinking waters by SABS (1984) is 450 mg/l compared to 500 mg/l by USEPA (1996) and 1 000 mg/l by WHO (1993). The mean values of TDS for the springs in winter, spring and summer seasons were 3 538.38, 2 688.98 and 3 348.20 mg/l respectively (Table 6). These not only exceeded the maximum acceptable limits but are also greater than 2 450 mg/l considered to be the critical value above which some longer-term health problems might be anticipated due to excessive concentrations of dissolved particles in water (Kempster et al., 1997). Spring Source 1 had the highest SS contents. It was generally above 60 mg/l throughout the study period as compared to the other springs where the concentrations were below 50 mg/l (Tables 2 to 4). The variations of the mean values of SS and TDS with seasonal changes are given in Figs. 3 and 4. For the Isinuka River, the corresponding mean values of TDS were 139.90 and 9.55 mg/l in spring and summer while the SS means were 5.95 and 9.55 mg/l respectively.

Salinity and chloride levels

Although no standard has been established for salinity of domestic waters, Tables 2 to 4 show that the springs are saline and are by no means freshwater bodies. The salinity varied from 2.90 mg/l in spring Source 1 in winter to 5.20 mg/l in spring Source 3 during winter and summer. With the exception of Source 1, the salinity of the springs is virtually unaffected by seasonal changes. The increase

TABLE 7 Seasonal mean values of Isinuka spring water quality compared with the maximum limits recommended for drinking and domestic uses						
Parameter	SABS (1984)	USEPA (1996)	WHO (1993)	Winter	Spring	Summer
pH	6-9	6.5-8.5	6.5-8.5	8.15	7.70	7.27
TDS (mg/l)	450	500	1 000	3 538	2 689	3 348
Turbidity (NTU)	1.0	0.5-5	5	16.39	39.83	25.54
Conductivity (mS/cm)	70	Ns	400	8.13	8.21	8.97
Hardness (mg/l)	300	Ns	500	11.64	153.69	259.76
Cl ⁻ (mg/l)	100	250	250	960.90	980.60	960.58
NH ₄ ⁺ -N (mg/l)	1	0.10 ^a	1.50	15.99	5.78	2.46
NO ₃ ⁻ -N (mg/l)	6	10.0	50	0.15	Nd	3.01
NO ₂ ⁻ -N (mg/l)	Ns	1.0 (0.1) ^a	3.0	0.14	0.17	0.06
SO ₄ ²⁻ (mg/l)	200	250	250	98.93	125.60	89.87
Phenol (mg/l)	Ns	0.005 ^a	Ns	0.32	0.52	0.81

Ns: No standard;
Nd: Not determined
a: EEC maximum undesirable concentration limit (1980)

TABLE 8 Seasonal mean values of Isinuka River water quality compared with the maximum limits recommended for drinking and domestic uses					
Parameter	SABS (1984)	USEPA (1996)	WHO (1993)	Spring	Summer
pH	6-9	6.5-8.5	6.5-8.5	7.42	7.49
TDS (mg/l)	450	500	1000	639.90	611.45
Turbidity (NTU)	1	0.5-5	5	45.03	0.60
Conductivity (mS/cm)	70	Ns	400	4.68	5.66
Hardness (mg/l)	300	Ns	500	30.63	86.02
Cl ⁻ (mg/l)	100	250	250	140.33	270.60
NH ₄ ⁺ -N (mg/l)	1	0.10 ^a	1.50	0.34	0.30
NO ₃ ⁻ -N (mg/l)	6	10.0	50	Nd	0.50
NO ₂ ⁻ -N (mg/l)	Ns	1.0 (0.1) ^a	3.0	0.04	0.01
SO ₄ ²⁻ (mg/l)	200	250	250	28.17	125.50
Phenol (mg/l)	Ns	0.005 ^a	Ns	0.55	0.10

Nd: Not determined
Ns: No standard
a: EEC maximum undesirable concentration limit (1980)

in the overall mean level from 4.56 in winter to 5.15 mg/l in summer (Fig. 5) is relatively small.

Unlike the springs, however, the Isinuka River is a freshwater source with a mean salinity of 2.47 mg/l in spring and 0.91 mg/l in summer. The river seemed to be slightly elevated downstream in summer where the salinity was found to be 1.80 mg/l compared to 0.02 mg/l upstream. This can be attributed to the impact of human activities in the pond by the edge of the river about 500 m upstream from the sampling site. The pond water is used by visitors to Isinuka springs to wash off the spring sediment applied to their faces and body.

Isinuka springs were characterised by high Cl⁻ concentrations throughout the sampling period. According to the classification of Dallas and Day (1993), Cl⁻ ions are non-cumulative toxins, an

excessive amount of which, if taken over a period of time can constitute a health hazard (WHO, 1984 and 1993). As can be seen in Tables 2 to 4, the Cl⁻ levels were almost four times greater than the maximum limits recommended by WHO and USEPA and about ten times the SABS guidelines. The concentration increased from a mean of 960.90 mg/l in winter to 986.60 mg/l in spring and 1188 mg/l in summer (Table 7, Fig. 4), which correlates with the variation of salinity with seasonal changes (Fig. 3). The salty taste experienced in the Isinuka spring waters might, therefore, be due to the high concentrations of the ions in the water.

Isinuka River water is low in Cl⁻ contents in spring (mean = 140.77 mg/l), but moderately high in summer with a mean of 270 mg/l. This difference (approximately twice more in summer than in spring) might be associated with the suggested elevation of the

TABLE 9
Water quality of Ferry Point Cottage spring compared with the limits recommended for drinking waters

Parameter	SABS (1984)	USEPA (1996)	WHO (1993)	Winter	Spring	Mean Value
Taste	-	-	-	Tasteless	Tasteless	
Colour	-	-	-	Colourless	Colourless	
Odour	-	-	-	Odourless	Odourless	
pH	6-9	6.5-8.5	6.5-8.5	4.73	5.5	7.27
Turbidity (NTU)	1.0	0.5-5	5	0.16	0.36	0.26
Conductivity (mS/cm)	70	Ns	400	44.10	45.50	44.80
Salinity (mg/l)	Ns	Ns	Ns	< Imt	< Imt	< Imt
Alkalinity (mg/l)	Ns	Ns	Ns	0.03	0.01	0.02
Hardness (mg/l)	300	Ns	500	0.01	0.03	0.02
TDS(mg/l)	450	500	1000	45.00	46.67	45.84
DO (mg/l)	Ns	Ns	Ns	14.40	14.40	14.40
NH ₄ ⁺ -N (mg/l)	1	0.10 ^a	1.50	0.11	0.10	0.11
NO ₃ ⁻ -N (mg/l)	6	10.0	50	0.01	0.06	0.04
NO ₂ ⁻ -N (mg/l)	Ns	1.0(0.1) ^a	3.0	0.02	0.01	0.02
Cl ⁻ (mg/l)	100	250	250	55.40	67.5	61.45
SO ₄ ²⁻ (mg/l)	200	250	250	11.30	10.30	10.80
SO ₃ ²⁻ (mg/l)	200	250	250	0.30	0.03	0.17
Phenol (mg/l)	Ns	0.005 ^a	Ns	0.01	0.48	0.25

< *Imt*: Below the instrument detection limit ;
Ns: No standard
a: EEC maximum undesirable concentration limit(1980)

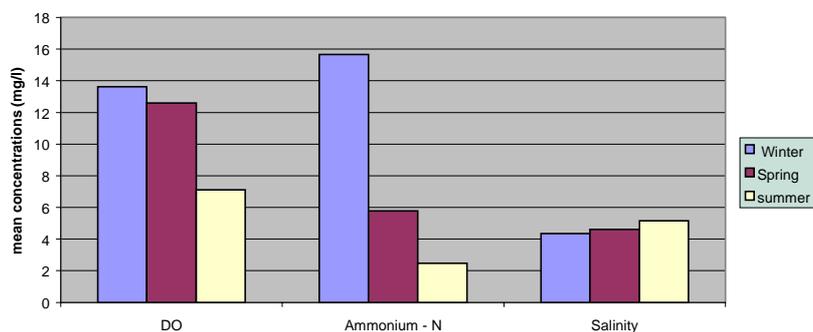


Figure 5

Seasonal variation of the mean concentrations (mg/l) of salinity, DO and NH₄⁺-N in Isinuka springs

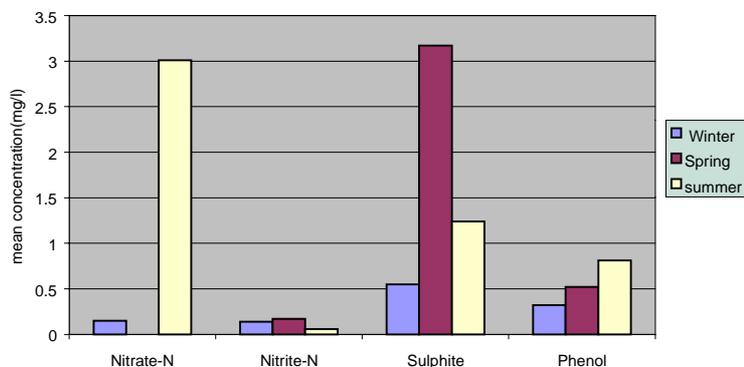


Figure 6

Seasonal variation of the mean concentrations (mg/l) of SO₃²⁻, NO₂⁻ and phenol in Isinuka springs

river water by human activities in the pond close to the sampling point downstream during the summer months. As indicated in Table 5, the Cl⁻ concentration upstream was 95.0 mg/l compared to 445.0 mg/l downstream.

Dissolved oxygen (DO), chemical oxygen demand (COD) and phenol

Water from the five spring sources had very high COD concentrations and low DO levels. The mean values were 4 170 mg/l in winter, 2469 mg/l in spring and 1 011 mg/l in summer. The mean values for DO during the same periods were 13.62, 10.59 and 7.11 mg/l respectively. Thus, both COD and DO are sensitive to seasonal changes (Figs. 4 and 5) as might be expected. Although the amount of phenol in the springs as shown in Tables 2 to 4 appears to be very low (0.02 to 2.66 mg/l), the levels are above the maximum limit of 0.005 mg/l recommended by the Ministry of Health and Welfare, Japan, for domestic waters. As observed earlier, spring Source 1 which is the most popular of all five sources, had the largest accumulation of phenol in each of the three seasons. While both COD and DO decreased from winter to summer (Figs. 4 and 5), the phenol concentrations increased by a factor of two from season to season between winter and summer (Fig.6).

In contrast, the Isinuka River water has low concentrations of COD and higher levels of DO compared to the spring sources during the same

period. This seems to confirm that the river is a freshwater body and will support aquatic life. The mean values of the phenol contents were 0.55 and 0.10 mg/l in spring and summer respectively.

The micronutrients

The amounts of nitrate, nitrite and ammonia present in natural waters in the form of nitrogen are of great interest because of their nutrient values. NH_4^+ -N, NO_3^- -N and NO_2^- -N are considered to be non-cumulative toxins (Dallas and Day, 1993). When present in high concentrations, NO_3^- -N and NO_2^- -N may give rise to potential health risks particularly in pregnant women and bottle-fed infants (Kempster et al., 1997; Kelter et al., 1997; Cotruvo, 1988; Bush and Mayer, 1982). NO_2^- -N poisoning causes the blue baby syndrome (methaemoglobinaemia). It has also been alleged that livestock can also be affected by nitrite poisoning (Kelter et al., 1997). At elevated concentrations NO_3^- -N is also known to result in cyanosis in infants (Comly, 1945). Ammonia is naturally present in surface water and groundwater and can be produced by the de-amination of organic nitrogen containing compounds and by the hydrolysis of urea. The problem of taste and odour may, however, arise when the NH_4^+ -N level is greater than 2 mg/l. Above 10 mg/l, appreciable amounts of NO_3^- -N may be produced from NH_4^+ -N under suitable anaerobic conditions (WHO, 1993; Kempster et al., 1997).

The mean concentrations of these micro-nutrients are listed in Tables 5 and 6 for the Isinuka River and springs respectively. These parameters are seen to be sensitive to seasonal changes (Figs. 5 and 6). Due to loss of some samples, the nitrate concentrations were not determined in the spring season. Water from the springs and river had very low concentrations of NO_3^- -N and NO_2^- -N which are within the recommended limits. However, the NH_4^+ -N level in the springs is above the permissible limits of 0.50 to 1.50 mg/l (Table 7). As shown in Fig. 5, it is highest in winter (mean = 15.99 mg/l) and lowest in summer (mean = 2.82 mg/l). In the river, the mean concentrations of NH_4^+ -N are fairly constant over the sampling period (0.34 and 0.30 mg/l) and are within the recommended guidelines (Tables 5 and 8).

Sulphate and sulphite contents

Water from Isinuka springs is believed to be a cure for constipation and other stomach problems when the water is taken in excess. Although it is within the maximum acceptable SABS recommended limits of 0 to 200 mg/l and classified as a non-toxin, intake of SO_4^{2-} ions at elevated concentrations can cause diarrhoea (Kempster et al., 1997). The springs have appreciable levels of SO_4^{2-} ion contents which range from 55 mg/l to 155 mg/l depending on the time of collection and the season (Table 6, Fig. 3). The mean concentrations in winter, spring and summer periods for example, were 98.93, 125.6 and 89.87 mg/l respectively.

The SO_3^{2-} ion concentrations in the springs ranged from 0.20 mg/l in winter from Source 4 to 14.50 mg/l in spring from source one. The available amount of SO_3^{2-} is lowest in winter (mean = 0.55 mg/l) and highest in spring (mean = 5.17 mg/l). These concentrations although relatively small, are very significant for drinking waters (EPA, 1994; Cotruvo, 1988; HWC, 1987). The mean values of SO_3^{2-} concentrations in the river were 1.02 mg/l and 0.30 mg/l in spring and summer respectively. The seasonal variations of the SO_4^{2-} and SO_3^{2-} concentrations are shown in Figs. 3 and 6.

Hardness and alkalinity

In both winter and summer seasons, the five springs exhibited a rather unusually high alkaline nature with means of 493.3 and 385.1 mg/l as CaCO_3 respectively. These dropped to 85.71 mg/l over a range of 3.30 to 165.00 mg/l in spring (Fig 4). On the other

hand, the mean value for the river was 557.0 mg/l in spring and 105.7 mg/l in the summer.

The results shown in Tables 5 and 6 indicate that Isinuka River water is soft in spring (mean hardness 30.60 mg/l) and becomes moderately hard in summer with a mean of 86.02 mg/l. (Fig. 3). Water from the spring sources is moderately hard in winter (mean = 111.64 mg/l), hard in spring (mean = 153.69 mg/l) and very hard in summer with a mean level of 259.76 mg/l (Fig. 3).

The socio-economic impact of Isinuka springs

Water is vital to life. It promotes the economic and the general well-being of the society through its diverse and beneficial uses. From the preliminary analysis of the structured socio-economic questionnaires and oral interviews, all the visitors to Isinuka springs have a strong belief that the spring water and the sediments are the answers to their ailments. They consider it to be an economically cheaper source, a faster and more effective way of treating all human diseases when compared to what it would cost to visit a regular health clinic (traditional or orthodox). The majority of them also believed that the efficacy of the spring water will be affected if protected or commercialised.

There is, therefore, a need to educate the general public about the enormous benefits to be derived from adequate management and conservation of the springs and their environment. The deleterious health effects that may result from prolonged intake of the spring water should also be emphasised without jeopardising the faith of the people. This will be consistent with the South Africa National Policy on water resource management (SWLR, 1995; DWAF, 1993; DWAF, 1997).

The Ferry Point Cottage spring

The Ferry Point Cottage spring water quality parameters are compared with the values recommended by SABS and other international bodies for drinking and domestic waters (see Table 9). The water is colourless and odourless. Except for the pH which is between 4.73 and 5.53, the measured spring's water quality values fall within the recommended drinking and domestic water guidelines for chemical variables.

The mean concentrations of turbidity, TDS and Cl⁻ ions were 0.26 NTU, 45.84 mg/l and 61.45 mg/l respectively over the two sampling seasons. These are below the maximum limits of 5 NTU, 500 mg/l and 100 mg/l recommended for drinking waters by SABS (1984). The mean value of the conductivity was 44.80 mS/cm which is a factor of five higher than the mean conductivity of Isinuka springs of 8.17 mS/cm during the same period. The mean pH of the spring was 5.13. This indicates that the water is acidic while the mean DO concentration of 14.4 mg/l is comparable to that of the Isinuka River.

Both the alkalinity and hardness of Ferry Cottage spring water had a mean concentration of 0.02 mg/l over the sampling period. The salinity was, however, below the detection limit of the instrument. The predominant anions during the same period were Cl⁻ (mean = 61.45 mg/l) and SO_4^{2-} (mean = 10.80 mg/l) while phenol was found to be concentrated at 0.25 mg/l mean levels. These concentrations are below the minimum toxic levels of the anions. Even though Ferry Point Cottage spring source adjoins the Indian Ocean, the generally low values obtained for conductivity, Cl⁻, SO_4^{2-} and salinity show that the cottage spring is a freshwater body and is unpolluted by salt-water intrusion from the sea.

Conclusions

The “wonder water” of Isinuka springs is not a freshwater body, generally hard and unsuitable for drinking in its present form without adequate treatment. The study indicates that most of the physical and chemical constituents of the five spring sources and in particular TDS, turbidity, NH_4^+ -N and Cl⁻, are above the maximum limits recommended for drinking water. These parameters are considered to be “hot spots” in Isinuka springs which should be monitored over a period of time because of possible threats to health at elevated concentrations.

The concentrations of SO_4^{2-} and phenol are at such elevated levels where serious health effects and risks might arise after prolonged and continuous intake. The results however, showed that NO_2^- -N poisoning should not be anticipated from the spring water sources as the concentration of both the NO_3^- -N and NO_2^- -N are below the critical value of 10 mg/l above which it may be dangerous for pregnant women and bottle-fed babies to drink water from Isinuka springs.

Isinuka River water and Ferry Point Cottage spring are freshwater bodies. In addition, Ferry Point Cottage spring showed no evidence of salt intrusion from the Indian Ocean as might be expected in view of its proximity to the sea. The water was unpolluted from a chemical perspective and may be safe for drinking and domestic use without treatment.

Visitors to Isinuka springs and others believe in the healing power of the spring water, its bottom sediment and the pungent gaseous emissions from the alleged abandoned and dried-up spring site in Isinuka Village. They use these to cure and to suppress their ailments and consider them to be more economical, safe and dependable than the orthodox and traditional medicines. It will, therefore, be of interest to investigate the effectiveness of the water and characteristics of the sediment and gaseous emission from the springs.

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