Original article

Sanitary chemical analysis of protected springs in Jimma zone, Southwestern Ethiopia

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Abstract: Sanitary chemical analysis is one of the methods used to evaluate the safety of water. Water samples were collected from sixteen protected springs located in and around Jimma, Agaro, Shebe, and Asendabo towns from April to May 1997. After making three determinations in three samples taken from each protected spring, average analytical data of sanitary chemicals, namely, chloride (Cl^-), ammonia (NH_3^+), nitrite (NO_2^-), and nitrate (NO_3^-), were compiled.

Although concentrations of ammonia and nitrite were low, nitrate concentration which exceeded the safe level (50 mg/l) was recorded at three sites in Agaro and in one in Shebe area. The four springs with the highest nitrate concentrations were also noted to have the highest chloride concentration. This finding indicates the presence of organic pollution and, therefore, the microbiological safety of the protected springs is questionable. Moreover, the presence of excess nitrate in drinking water supply may present a potential health hazard as it is known to cause methemoglobinemia, especially in young infants. [*Ethiop. J. Health Dev.* 1999;13(1):45-48]

Introduction

Water of good chemical and physical quality is necessary from the points of view of its acceptability by the people and the protection of the health of the consumer (1). A World Health Organization report states that about 80% of all human illnesses in developing countries is associated with polluted water (2). In Ethiopia the national per capita consumption of water (10 L/day) is among the lowest in the world and access to safe water supply is estimated to be 12% and 70% to the rural and urban populations respectively (3). Similarly, the sanitation coverage which is only 7% (3) may have far reaching health effects on the population.

Measurements of physico-chemical parameters is useful in order to establish whether or not chemical contamination of water supply exists (4) and it may provide a clue to the presence of organic pollution. When laboratory chemical analysis indicates a potential hazard to health, sanitary survey should be undertaken on a regular basis by the water authority (5). Chloride (Cl-) concentrations in unpolluted water are often below 10 mg/L and are indicators of sewage pollution because of the chloride content of urine (6). The natural levels of ammonia (NH_3), which are generated largely by deamination of organic nitrogen compounds and hydrolysis of urea (7) in ground water are usually below 0.2 mg/L, and, when this value is exceeded, it is an important indicator of fecal pollution (8). Nitrates are products of oxidation of organic nitrogen by bacteria present in soils and water where sufficient oxygen is present while nitrites are formed by incomplete oxidation of organic nitrogen (5). Excess levels of nitrogenous compounds, including nitrates (NO_3) and nitrites (NO_2), in a protected water supply system are used as an indication of pollution by organic wastes (1,6).

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A significant number of very serious health problems may occur as a result of chemical contamination of water sources (4). Dissolved nitrate (NO_3) is known to be a health hazard when present in water in excess of 50 mg/L (5,6,9). Water supplies containing high levels of nitrate have been responsible for cases of infantile methemoglobinemia (8, 10-12). In Ethiopia, ground water concentration of nitrate measuring up to 195 mg/L was reported from Dire Dawa (9). No such information is available for Jimma Zone.

The current study was, therefore, designed to assess the safety of water from selected protected springs in Jimma Zone using sanitary chemical analysis.

Methods

Sixteen protected springs in four towns in Southwest Ethiopia namely, Jimma (population about 88, 867), Agaro (population about 23, 246), Shebe (population about 4,076) and Asendabo (population about 5241) (13) - were studied from April 1 to May 1, 1997. A protected spring in this study is defined as one in which the water is collected where it rises by enclosing the "eye" of the spring in a covered chamber with an outlet near the bottom to allow water to flow away from the original site (4).

The springs were located within the towns or in accessible areas around the towns. Springs that were not protected were excluded. In Agaro, Shebe, and Asendabo towns entire communities depend mainly on the springs studied for their water supply whereas springs studied in and around Jimma serve as alternatives to other sources.

The water samples were collected in polyethylene bottles washed several times with tap water and finally rinsed with deionized water. Samples were stored at 4^{0}C until analysis was carried out. Three samples were taken from each spring at intervals of about a week and the average values of sanitary chemicals were recorded for each protected spring. pH was measured by wag-tech pH meter at 25^{0}C. Concentrations of chemicals were determined in accordance with the procedure described in the "Standard Methods for the Examination of Water and Waste water" (14). The concentration of ammonia was determined by Nesselerization and that for chloride by argentometric methods. Nitrate and nitrite concentrations were determined by nitrogen phenoldisulphonic acid (220 and 275 nm) and diazotization methods (543 nm), respectively. The U-2000 Hitachi spectrophotometer used in this study has been calibrated by the manufacturer which is programmed to signal whenever calibration is needed. Series of standards were prepared to draw calibration curve and samples were measured using blank as a control.

Results

Sanitary chemicals were determined in samples taken from 16 protected springs in Jimma Zone, Southwest Ethiopia. The levels of ammonia and nitrite were low in most of the springs studied. The concentration of nitrate, on the other hand, has far exceeded the safe level of 50 mg/L in three springs in Agaro and in one in Shebe. The four springs with the highest nitrate concentration were also observed to have the highest chloride concentration (Table 1).

Table 1: **Sanitary chemical analysis of protected springs in Jimma Zone, Southwest Ethiopia, 1997**

Sample sorce	Average values for 3 determinations*1				
	PH*2	Cl$^-$	NH_{4+}	NO_2*3	NO_{3-}
Agaro town*4					
- Abagelan	5.1	59.9	0.02	0.0	1947
- Municipal	5.6	65.8	0.08	0.01	271.1
- Suse	5.3	2.9	0.02	0.0	4.2
- Tije	4.9	22.6	0.04	0.0	1142
Asendabo town*4					
- Bisso	5.1	1.0	0.17	0.0	1.9
- Doyo	4.4	2.9	0.22	0.0	3.4
- Nada	4.4	11.8	0.22	0.0	25.3
- Seyo	4.9	5.9	0.18	0.0	16.4
Jemma town*4					

- Geruke	4.5	4.9	0.10	0.0	18.8
- Merewa	4.5	3.7	0.18	0.0	6.6
- Saredo	4.9	3.3	0.18	0.0	3.1
- Wellege	5.5	3.9	0.24	0.0	6.0
Shebe town*4					
- Bomba	5.3	21.6	0.06	0.0	12.3
- Digo	6.6	45.2	0.07	0.0	56.0
- Keymeskal	5.2	17.7	0.31	0.0	3.9
- Melka Sheki	5.7	17.7	0.16	0.0	7.3

*1 Except for pH, the unit is mg/L *2 pH determined at 25^0c
*3 Applicable range of method 10-1000 microgram; 0 value indicates values below the limit of detection. *4 Names of protected springs in and/or around the town.

Discussion

The presence of nitrogenous compounds in a protected water supply system is used as an indication of pollution by organic wastes (1). In our study the concentration of nitrate was higher than the accepted safe level (50 mg/l) in four protected springs. Although the presence of nitrate and nitrite in water may result from excessive application of fertilizers or from leaching of wastewater or other organic wastes into surface water and ground water (4), the parallel increase of chloride concentration with nitrate in our study provided a clue that the probable origin of the organic pollutant might be waste products of animals or humans (6,8). Moreover, the sanitary survey made by the investigators (result not shown) gives further evidence that the probable source of contamination is of human origin.

Another major concern related to excessive nitrate level in drinking water is associated with its toxicity which is related the extent of its reduction to nitrite (8,11). Nitrites are strong oxidizing agents leading to the oxidation of hemoglobin to methemoglobin which is unable to transport oxygen to the tissues and results in the development of methemoglobinemia (8,10,11). Young infants below three months of age are most affected as they do not yet have normal gastric acid production and, therefore, harbor nitrate-reducing bacteria in the upper part of the gastrointestinal tract. Furthermore, the Hemoglobin F present in young infants is more susceptible to oxidation by nitrite as compared to Hemoglobin A, also contributing to the increased susceptibility of infants to nitrate-induced illness (11,12). Breastfed infants have a low nitrate intake whereas those fed on infant formula feeds receive nitrate from the water used in its preparation (15). Therefore, excess levels of nitrate concentrations recorded in Shebe and Agaro areas may represent a serious potential health problem to infants, particularly if mothers in the area introduce supplementary food or water early in the first three months of life. Adults, especially pregnant women and individuals deficient in glucose 6-phosphate dehydrogenase or methemoglobin reductase, could also be affected (8).

In conclusion, our findings suggest the possibility of organic pollution in some of the protected springs and, hence, the safety of the water from these sources is questionable. We recommend that inspection of the entire water -shed drainage area, appropriate site selection, and proper construction of springs to prevent water contamination should be implemented in protecting community water supplies.

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