Reappraisal of Drinking Water in Thecho Village of Nepal
—Precise Measurement of Arsenic and Fluorine and Simplified Measurement of Remaining Chloride—

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Abstract

The quality of the water for living in Thecho village of Nepal was reappraised for arsenic, fluorine and remaining chloride. In this inspection, we measured exact concentration of arsenic by using an atomic absorption spectrophotometer. Arsenic was not detected in any samples, although in the previous inspection using the simplified method arsenic was indicated be contained in all samples. This result indicated that water in the village was safe as for arsenic. In addition, we measured remaining chloride which was not examined in the previous inspection. Remaining chloride was not detected in city water which was treated by bleaching powder. This means that bacteria might grow easily and is a problem for which corrective steps should be taken. Furthermore fluorine was also measured exactly using an ion meter. Concentrations of fluorine in all samples were less than 0.2 mg/l. This result confirmed the previous inspection and gave the base to significance of mouth rinsing with fluoride.

Key words: Water analysis / Arsenic / Fluorine / Chloride / Nepal

Introduction

The Kingdom of Nepal is one of the poorest countries in the world and the level of her health care is also one of the lowest. In the case of dental care, the number of dentists is only about 100 to 23,400,000 population of Nepal¹⁰. Therefore, in 1989 we started international
cooperation on dental health care in Nepal and since that time we have continued to carry out projects for dental care and scientific investigation\(^\text{2-6}\). The main field of our activity has been Thecho village which is a farm village with a population of 11,000 in the suburbs of the capital Kathmandu of Nepal. In the early stage of dental health care cooperation, the treatment of dental decay, such as tooth cavity filling, tooth extraction etc., was our predominant activity. Later, projects for health education including a nutrition survey and construction of toilets\(^\text{6}\) have been added as another main activity, corresponding to the situation of fields and the needs of the resident. This means that not only dental care but also total health care is included in our current activity\(^\text{7}\).

For total health care, in addition to understanding of the resident's health states, it is necessary to obtain scientific data on environmental factors which affect the resident's health. Water is one such factor. In Thecho, village residents can get city water from water supply facilities for one hour each in the morning and evening. However, city water is insufficient for living because of the limited time of water supply and the small number of supply facilities, so people in the village are still using pond water or gushing water for living. Therefore, in 1997, as a part of our project for health care, we attempted to evaluate the quality of the water used in Thecho village\(^\text{8}\). Samples collected from the various places were examined for items such as general bacteria, coliform group, cadmium, mercury, lead, arsenic, chromium, calcium, cyanide, nitrate, nitrite, calcium and pH, by using simplified methods\(^\text{8}\). These items were selected from 'items relating to human health' ordained by Japanese Water Works Law. Except for the coliform group and arsenic, values of materials examined were lower than prohibitive or detectable levels.

The existence of the coliform group was a problem, but the problem can be solved basically by boiling of drinking water. On the other hand, detection of arsenic in all samples was a serious problem. At that time, the real concentration of arsenic was not determined, because arsenic concentration with lower than 0.2 mg/l could not be determined in the simplified method we used. For drinking water, the standard level of arsenic is not more than 0.01 mg/l. This result led us to the present study. In this study we attempted to measure the concentration of arsenic more exactly by using an atomic absorption spectrophotometer. In addition, we measured the remaining chloride which was not examined in the previous inspection although city water was treated by bleaching powder. Furthermore fluorine, which was once measured by the simplified method before we carried out the mouth rinsing with fluoride in the field\(^\text{9}\), was also determined exactly using an ion meter.

**Materials and methods**

This inspection was carried out from Dec. 26, 1998 to Jan. 7, 1999. Samples were collected at the same places as in the previous survey\(^\text{6}\). City water samples were obtained from 6 out of 8 water supply facilities along the main street in the center of the village. The origin of city water was mountain water, to which sodium hypochloride was added. Samples were also
obtained from 5 ponds, which were used as water sources, along the main street. At the lower land level away from the main street water gushed out and 3 samples were collected. In addition, 5 drinking water samples from Aekhot village, which is a mountain village with a population of 800 and about 4 hours away from Kathmandu by car, were analyzed.

Samples for arsenic analysis were collected immediately before our return to Japan. Arsenic concentration was determined by injecting a 20μl sample into a graphic cuvette (Model 180-7400) using a simultaneous multielement atomic absorption spectrophotometer (model Z-9000, Hitachi Ltd., Tokyo, Japan) at Kyushu Dental College in Japan. For calibration, a arsenic standard solution (Wako Pure Chemical Industries, Ltd., Osaka, Japan) diluted with 0.1 N HNO₃ was used. Remaining chloride and fluoride were examined within a few hours after collection. Chloride was determined as ClO⁻ Chlorine by pack test-ClO⁻ (Kyoritu Chemical–Check Lab., Corp, Tokyo, Japan); samples were mixed with reagents and the colors of the mixture were compared with the standard colors. Fluorine was determined by an ion meter (model 290A, Orion Research Inc., Beverly, MA, U.S.A.) using a fluoride standard solution (Orion Research Inc., Beverly, MA, U.S.A.) for calibration.

Results

The results of analyses are summarized in Tables 1, 2 and 3. Arsenic can be detected in level of 1μg/l by using an atomic absorption spectrophotometer, but arsenic was not detected in any samples. In the examination of remaining chloride, all mixtures of samples and reagents were colorless, indicating that they did not contain remaining chloride. Concentrations of fluoride were less than 0.2 mg/l in all samples.

Discussion

Prior to carrying out the primary health care plan, it is necessary to have scientific data of the living environment. Therefore, in 1997 we evaluated the quality of water which is a very important factor for life8. In that inspection, simplified methods were used for water analysis because of the easy operating at any places, poor equipment at the fields and our small budget.

From the results of that inspection, a serious problem was indicated that all the samples contained arsenic, especially with high concentration in pond and gushing water. In the present examination using an atomic absorption spectrophotometer, however, arsenic was not detected in any samples. The reason that arsenic was detected in the previous inspection was not clear, although dirty water such as pond water tended to show high value of arsenic concentration. It was suggested that the simplified measuring method of arsenic might have a limit to the application as compared to those of other items and that it should be carried out carefully. In any case, this result indicated that water in the village was safe as for arsenic.

Remaining chloride was not detected in city water which was treated by bleaching powder. As concentration of more than 0.1 mg/l is required for sterilization, this means that bacteria
Table 1  Analysis of city water in Thecho village

<table>
<thead>
<tr>
<th>Samples</th>
<th>City water</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Arsenic</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
</tr>
<tr>
<td>Chloride</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
</tr>
<tr>
<td>Fluorine</td>
<td>0.034</td>
<td>0.032</td>
<td>0.031</td>
<td>0.032</td>
<td>0.053</td>
<td>0.046</td>
</tr>
<tr>
<td></td>
<td>0.037</td>
<td>0.047</td>
<td>0.042</td>
<td>0.044</td>
<td>0.059</td>
<td>0.054</td>
</tr>
<tr>
<td></td>
<td>0.028</td>
<td>0.031</td>
<td>0.030</td>
<td>0.030</td>
<td>0.039</td>
<td>0.039</td>
</tr>
<tr>
<td></td>
<td>(0.033)</td>
<td>(0.037)</td>
<td>(0.035)</td>
<td>(0.035)</td>
<td>(0.051)</td>
<td>(0.046)</td>
</tr>
</tbody>
</table>

N. D.: Not detected
Data represent each value of 3-time measurement and mean in parentheses.

Table 2  Analysis of pond water and gushing water in Thecho village

<table>
<thead>
<tr>
<th>Samples</th>
<th>Pond</th>
<th>Gushing water</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
</tr>
<tr>
<td>Chloride</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
</tr>
<tr>
<td>Fluorine</td>
<td>0.056</td>
<td>0.070</td>
<td>0.057</td>
<td>0.104</td>
<td>0.072</td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td>0.056</td>
<td>0.087</td>
<td>0.076</td>
<td>0.129</td>
<td>0.085</td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td>0.055</td>
<td>0.067</td>
<td>0.055</td>
<td>0.101</td>
<td>0.068</td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td>(0.056)</td>
<td>(0.075)</td>
<td>(0.063)</td>
<td>(0.111)</td>
<td>(0.075)</td>
<td>(0.059)</td>
</tr>
</tbody>
</table>

N. D.: Not detected
Data represent each value of 3-time measurement and mean in parentheses.

Table 3  Analysis of drinking water in Anekhott village

<table>
<thead>
<tr>
<th>Samples</th>
<th>Swamp</th>
<th>Well</th>
<th>Gushing water</th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Arsenic</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
</tr>
<tr>
<td>Chloride</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
<td>N. D.</td>
</tr>
<tr>
<td>Fluorine</td>
<td>0.072</td>
<td>0.183</td>
<td>0.016</td>
<td>0.188</td>
<td>0.229</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.057</td>
<td>0.135</td>
<td>0.120</td>
<td>0.136</td>
<td>0.173</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.070</td>
<td>0.144</td>
<td>0.140</td>
<td>0.150</td>
<td>0.179</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.066)</td>
<td>(0.154)</td>
<td>(0.092)</td>
<td>(0.158)</td>
<td>(0.194)</td>
<td></td>
</tr>
</tbody>
</table>

N. D.: Not detected
Data represent each value of 3-time measurement and mean in parentheses.
might grow easily and is a problem for which corrective steps should be taken.

Fluorine was once examined using simplified method before the performance of mouth rinsing with fluoride. The result in this study confirmed the previous analysis and gave the base of the necessity for mouth rinsing with fluoride.

Further inspection in the rainy season, for comparison with this study that we did in the dry season, will be done in the future.

Conclusions

Previously, as a part of international health care cooperation, we examined the quality of the water for living in Thecho village of Nepal, using the simplified method. In that inspection, it was indicated that all the samples collected from the various places including city water supply facilities contained arsenic, especially with high concentration in ponds and gushing water, but the real concentration of arsenic was not determined. In the present study we attempted to measure exact concentration of arsenic by using an atomic absorption spectrophotometer, but arsenic was not detected in any samples. This result indicated that water in the village was safe as for arsenic. It was suggested that the simplified measuring method of arsenic might have a limit to the application as compared to those of other items and that it should be carried out carefully.

In addition, we measured remaining chloride which was not examined in the previous inspection. Remaining chloride was not detected in city water which was treated by bleaching powder. This means that bacteria might grow easily and is a problem for which corrective steps should be taken.

Furthermore fluorine, which was once measured by the simplified method before we carried out the mouth rinsing by fluoride in the field, was also measured exactly using an ion meter. Concentrations of fluorine in all samples were less than 0.2 mg/l. This result confirmed the previous inspection and the significance of mouth rinsing with fluoride.

Acknowledgment

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References


ネパール王国テチョー村における生活用水の水質再評価
—砒素とフッ素の精密測定と残留塩素の簡易測定—

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ネパール王国テチョー村における国際保健医療協力の一環として、1997年に村人の健康に直結する生活用水の水質調査を実施した。村では水道水不足のため、溜め池の水や湧き水も生活用水として利用されている。このため、水道の水源、水道施設、溜め池、湧き水などから採取した試料について、一般細菌など健康に関わる基本的な12項目について検査を実施した。

この調査で明らかになった問題点の一つは、全ての試料で砒素が検出され、特に湧き水と溜め池の水ではさらに高い値を示したことである。しかし、この調査では簡易測定法で実施されたため正確な砒素濃度は不明であった。そこでこの度、原子吸光法を用いて砒素の精密測定を実施した。試料は水道施設、溜め池、湧き水について前回と同じ場所で採取した。砒素の精密分析は現地では不可能なため、帰国直前に採水し、九州歯科大学で行った。その結果、簡易法と異なり、原子吸光法ではいずれの試料にも砒素は検出されなかった。砒素の簡易測定法は、他の測定項目に比べて適用範囲が狭く、測定は慎重に行うべきことが示唆される。いずれにせよ、この結果は水の水は砒素に関しては安全であることを示す。

また、前回検査しなかった残留塩素についても、簡易法により測定した。水道水は一応さらし粉処理されていたが、残留塩素は検出されなかった。これはこの水には容易に細菌が繁殖しやすい可能性がある事を示し、早急な対策が必要である。

さらに、我々は以前フッ素洗口の実験に先立ち簡易法でフッ素の測定を行っていたが、今回精密測定を実施した。全ての試料でフッ素濃度は0.2 mg/l以下であった。これは以前の結果を確認し、フッ素洗口の意義の根拠を与えるものである。