JOURNAL OF AGRICULTURE & SOCIAL SCIENCES
1813–2235/2007/03–1–31–33
http://www.fspublishers.org

Microbiological Quality Assessment of Rural Drinking Water Supplies in Iran

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ABSTRACT

The rural drinking water resources in Zanjan, Iran were characterized by using microbiological methods to investigate the quality of water and the influence of kind and location of sources, supervision of Rural Water and Wastewater Company (RWWC) and turbidity on microbiology of water resources. For microbiological analysis, total and thermo-tolerant coliforms were assessed. The water quality parameters of concern were microbiological contamination and turbidity. Data showed that 30.2% of the villages under study had contaminated water resources. The turbidity values for 23.3% of resources were greater than recommended limits. There was a linear relationship between turbidity and microbiological quality of resources ($P < 0.023$). The villages supervised by RWWC were in better condition than those without any supervision ($P < 0.07$). Data suggests that all rural water resources should be supervised by RWWC. Furthermore, water resources should be comprehensively planned and monitored keeping in view the WHO recommended parameters.

Key Words: Microbiological quality; Rural drinking water sources; Turbidity; Zanjan; Iran

INTRODUCTION

Many developing regions suffer from either chronic shortages of freshwater or the pollution of readily accessible water resources (Lehloesa & Muyima, 2000). According to a recent UNICEF report, about 800 million people in Asia and Africa are living without access to safe drinking water. Consequently, this has caused many people to suffer from various diseases (Tanwir *et al*., 2003). The quality of drinking water is of vital concern to mankind, since it is directly associated with human life. Fecal pollution of drinking water causes water-borne diseases, which wiped out entire population of cities (Farah *et al*., 2002). According to the special report of United Nations on Iran, the population is exposed to higher risks of enteritis, diarrhea and contagious diseases, due to non-availability of drinking water in rural areas (OCHA, 2001).

Drinking water supplies have a long history of being infected by a wide spectrum of microbes. Therefore, the primary goal of water quality management from health perspective is to ensure that consumers are not exposed to pathogens that cause disease. Protection of water sources and treatment of water supplies have greatly reduced the incidence of these diseases in developed countries. Therefore, testing the source of water is necessary, especially when there is no water treatment. This is useful as result of the failure of treatment process or as a part of an investigation of serious water-borne disease outbreak (WHO, 2003).

The parameters recommended by WHO for the minimum monitoring of community supplies are those that ensure the hygienic state of water and reduce the risk of water-borne pathogens. The essential parameters of water quality are: (a) *Escherichia coli* and thermo-tolerant coliforms accepted as suitable substitutes, (b) chlorine residual (if chlorination is practiced), (c) pH and (d) turbidity (WHO, 2003). The coliform groups of bacteria principally infect water used for domestic, industrial or other purposes (Zamaxaka *et al*., 2004). High levels of coliform counts indicate a contaminated source, inadequate treatment or post treatment deficiencies. Besides poor water quality in rural areas, few data exist on the bacterial quality of water supply in these settings, since most studies are available from urban communities.

Based on previous research regarding microbiological quality of drinking water, we propose that a relationship exists between the turbidity and the microbial population of drinking water. The supervision of Rural Water and Wastewater Company (RWWC) would profoundly affect the microbiological quality of drinking water. Moreover, the location (in rural or urban area) and kinds of drinking water resources may also influence the quality of water. In this study, we included the indicators of pollution such as total and thermo-tolerant coliforms to determine and ascertain the hygienic quality of water sources in of rural communities of Zanjan Province in line with the laid down guidelines of WHO (2003) and as described by Obi *et al*. (2002).

MATERIALS AND METHODS

This descriptive-analytic study was conducted on main drinking water supplies in 116 villages were selected in

Zanjan rural community, Northwest Province, Iran. The selection of villages was based on the information gathered from The RWWC, Zanjan. Thus the samples comprised all villages equipped with active drinking water distribution system.

With respect to a great importance of microbiological method for sampling and to protect the samples from contamination, we took microbiological samples in closed sterilized glass containers (300 mL capacity) aseptically, transported to the laboratory on ice, kept at 4ºC and analyzed within 2 h. The samples were drawn for two months (September to October, 2003). A total of 116 samples of different drinking water resources, including deep well, shallow well, springs and subterranean canal were taken (Table I) and tested for microbiological quality and turbidity. In all assessed villages, 11 water resources were located within the studied villages and the rest were from out of the surveyed areas.

Microbiological analyses of water samples were performed as described in Standard Methods for the Examination of Water and Wastewater. Total coliform and thermo-tolerant bacteria were determined by means of Standard Total Coliform Fermentation Technique as per method 9221, including presumptive, confirmed and completed phases (APHA - AWWA, 1998). Statistical approaches such as frequency distribution, student t- test, ANOVA, and linear regression were used to analyze the data ($P < 0.05$) using SPSS package.

RESULTS

The studied villages were divided in two groups. The first included villages, where the drinking water resources were under the supervision of RWWC (74.1%) and the second group comprised rest of the water resources under no supervision (25.9%). The distribution of rural drinking water resources according to microbiological quality and turbidity are presented in Table II and III. To analyze the relationship between turbidity and microbiological quality, we used simple regression test and found linear relationship between these two variables, nephelometric turbidity unit (NTU) and most probable number (MPN), were assessed as quantitative variables (Table IV), which was $r = 0.212$. Student t-test showed significant ($P < 0.05$) differences in microbiological quality but not the turbidity between RWWC-supervised and un-supervised water resources ($P < 0.07$). For microbiological quality, analysis of variance showed non-significant ($P > 0.05$) difference between different kinds of drinking water resources. Student t-test showed non-significant ($P > 0.05$) difference between the villages in which the drinking water resources were located within and outside the studied region.

DISCUSSION

Data suggested that 30.2% of the studied villages had primarily microbiological contaminated drinking water resources when assessed according to WHO guidelines (Table II). This indicated that people from these areas might be prone to water-borne diseases and suitable disinfection units must be established. It is noteworthy however that some fecal pathogens, including many viruses and protozoa, may be more resistant to treatment by chlorine than the indicator bacteria. This implied that even a very low level of contamination measured by bacteriological analysis may be a risk, especially during an outbreak of disease like cholera (WHO, 2003). Therefore the chlorination of drinking water must be considered and monitored more carefully. Chlorination is considered to be highly effective for virus inactivation if the water has a turbidity (NTU < 1; a free chlorine residual of 1 mg L^{-1} or greater for at least 30 minutes) and pH < 8 (Dufour *et al*., 2003).

Bacterial contamination indicates that water resources were contaminated by wastewater. Therefore, parameters such as nitrate and nitrite should be necessarily assessed. Since these parameters can not be removed or eliminated by means of water disinfection and can bring about a lot of health hazards, a complementary unit must be added to

Table I. Distribution of Rural Drinking Water Resources (Zanjan, 2003)

Kind of Resource	No	Percent
Deep Well	15	12.9
Shallow Well	26	22.4
Spring	65	56.0
Subterranean Canal	9	7.8
Compound	1	0.9
Total	116	100.0

Table II. Distribution of Rural Drinking Water Resources According to Microbiological Pollution (Zanjan, 2003)

Condition	No	Percent	Indicator
Safe	81	69.8	MPN /100 ml <2.2
contaminated	35	30.2	MPN /100 ml ≥2.2
Total	116	100	

Table III. Distribution of Rural Drinking Water Resources According to Turbidity

Condition	No	Percent	Turbidity (NTU)
Safe	89	76.7	<1
Acceptable	22	19.0	1-5
Poor	5	4.3	>5
Total	116	100.0	

Table IV. Distribution of Drinking Water Resources according to MPN values

MPN	Frequency	Valid Percent
0-9	83	71.6
>10	33	28.4
Total	116	100.0

water treatment processes or these resources should be considered as undrinkable water resources (Chapman, 1996).

Data revealed turbidity values above 1 NTU for 23.3% of drinking water resources (Table III). The maximum national standard for drinking water is 5 NTU (ISIRI, 1997). This point must be considered in water chlorination and sanitation issues. A significant relationship between turbidity and microbiological quality of water resources implied that turbidity can be viewed as a supporting factor for microbiological contamination in drinking water (Table III). This finding is consistent with earlier reports indicating that disinfection efficiency was negatively correlated with turbidity and was influenced by season, chlorine demands of the samples and the initial Coliform level (Le Chevallier *et al*., 1981). Findings of this study showed that the supervision of the RWWC and measures such as different kinds of sanitations had a significant impact on the quality of water resources by controlling the water microbiological contamination. Therefore, all governmental and non-governmental organizations should be involved for effective implementation of a large scale sanitation program.

According to guideline values for bacteriological parameters the total and fecal coliform bacteria should be less than 10/100 mL in un-treated water intended for drinking. Moreover, greater than 75% of samples should be in proper situation (Busari, 1999). These data indicated that less than 72% water resources qualities were fit for potable purposes (Table IV). This implied that the methods the microbiological quality of water resources must be monitored. Furthermore, microbiological contamination of water resources in Zanjan rural areas was considerably higher than that of Sahelian region of Burkina Faso (30.2% versus 7.7%) as reported by Guillemin *et al*. (1991).

As the location of water resources can potentially be viewed as a modulating factor for microbiological quality, we decided to assess relationship between them. We did not find a significant difference between the villages located within and out of the studied region. Furthermore, the kind of resources had no relationship with microbiological quality of drinking water. It seemed that proper disposal of wastewater, geological situations, low density of population and the use of sanitized springs and deep wells protected the quality of water resources in these villages. This necessitated that all rural water resources should be monitored by RWWC.

Comprehensive planning should be made for continuous monitoring of water resources, especially the contaminated ones. At least those parameters emphasized in different guidelines such as thermo-tolerant bacteria, turbidity, nitrate and nitrite and chloride, should be necessarily assessed.

Acknowledgment. The authors thank Zanjan University of Medical Sciences and Organization of Management and Planning for sponsoring this study.

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(Received 30 October 2006; Accepted 12 December 2006)