WATER SUPPLY SYSTEM AND WATER QUALITY ASSESSMENT OF LIQVAN VILLAGE USING WATER SAFETY PLAN

MOSAFERI M.[1], POURAKBAR M.[2] and LAK S.[3]

[1] Tabriz Health Services Management Research Center, Tabriz University of Medical Sciences, Tabriz, Iran (mmosaferi@yahoo.com), [2] Department of Environmental Health Engineering, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran, [3] Department of Environmental Health Engineering, Ardabil University of Medical Sciences, Ardabil, Iran

ABSTRACT

The aim of this study was to identify probable risks and threatening hazards to drinking water quality of the Liqvan village, Tabriz County, along with assessment of river bank filtration of the village.

In the present study all risks and probable hazards were identified and ranked and finally for each of these cases, practical suggestions for removing or controlling of them were given. To assess potable water quality in Liqvan village, samplings were done from different parts of the village and physicochemical parameters were measured. To assess efficiency of bank filtration system of the village, independent T-test was used to compare average values of parameters in river and treated water.

One of the probable sources of pollution in this study was domestic wastewater which is threatening water quality. The results of this study show that bank filtration efficiency in water supply of the village is acceptable.

Although Bank filtration imposes fewer expenses on governments, it provides suitable water for drinking and other uses. However, it should be noted that these systems application should be done after a thorough study of water pollution level, types of water pollutants, soil properties of the area, soil percolation and system distance from pollutant sources.

Keywords: Bank filtration, Liqvan, risk ranking, Water safety plan, water pollution

1. Introduction

Safe drinking water is one of the necessities in sustaining life and a satisfactory (adequate, safe and accessible) supply of water must be available for all people. Qualitative assessment of water leads to the water quality improve and is an important factor in water treatment (1).

Although two thirds of the earth is covered with water, the available fresh water is rare. Along with water scarcity, water pollution is the other issue threatening fresh water resources (2).

Industrialization without considering sustainable developments principles, population increase, modern and mechanized agriculture etc. has contributed to the pollution of water resources in recent years. This is much more significant especially in the case of developing countries (3, 4) Over time and with increased attention to the quality of drinking water during the last few years, different methods have been used to assess the quality of drinking water resources. Such measure over the last few years in relation to drinking water in the world is the implementation of Water Safety Plans. Given the importance of access to safe water, WSP since 2004 has been on the agenda of the World Health Organization (3, 5, 6).

The primary objectives of a WSP in ensuring good drinking-water supply practice are the prevention or minimization of contamination of source waters, the reduction or removal of contamination through treatment processes and the prevention of contamination during storage, distribution and handling of drinking-water. A WSP has three key components including system assessment, operational monitoring, and management and communication plans (6).

Liqvan is a village in Meydan Chay Rural District, in the Central District of Tabriz County, East Azerbaijan Province, Iran. At the 2011 census, its population was 5524, in 1553 families (7).

It is famous for slight weather during summer time and cold weather in winter. The main occupation of the people is agriculture, dairy and gardening. Liqvan's traditional feta cheese is the most famous cheese all around Iran.

Since no study on the quality of drinking water supply of Liqvan village and assessment of the system performance of the village has not been reported thus, identifying risks and hazards threatening water quality and health of the villagers and the prioritization and monitoring of risks and hazards is necessary.

2. Methods

Liqvan village drinking water before 2004 was provided only from the spring. This spring has been sanitized since 20 years ago. The source of the water to this spring is provided from riverbank filtration. In recent years, the riverbank filtration system alone could not provide water for the village due to population increase in the village. In 2004, a well has been drilled to a depth of 160 meters on the south side of the village. Water well after disinfection with chlorine along with riverbank filtration water is pumped to storage tank on top of a mountain overlooking the village. Then the water is injected to the water distribution network of the village.

In this study, the first step was to identify the hazards and potential risks in different parts of the water distribution network to identify threatening hazards and prioritize them. A variety of different semiquantitative and qualitative approaches have been proposed for ranking risks. In this study the ranking proposed by the World Health Organization was used. Semiquantitative approach which was used in the present study is given in table 1 (7).

The study will also identify and prioritize the risks in accordance with the above matrix, then strategies to modify or reduce the risks has been presented.

Table 1: Scoring matrix for ranking risks

Likelihood	**Severity of consequences**				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	5	10	15	20	25
Likely	4	8	12	16	20
Moderately likely	3	6	9	12	15
Unlikely	2	4	6	8	10
Rare	1	2	3	4	5

Risk score	< 6	6–9	10–15	>15
Risk rating	Low	Medium	High	Very high

Liqvan River originates from the northern slopes of Sahand mountain. Several springs and rivers join to form the Liqvan river. The river flows from south to north and irrigates downstream lands. This river flows in relatively deep valley in downside of the village. Thus sanitary wastewater and agricultural drainages could be released to the river and therefore threatening potable water resources of the village.

In this study, 3 samples from different parts of the river through the village were taken. The samples were taken from entrance, middle (next to riverbank filtration system), and the end point of the river in village. Parameters including pH, electric conductivity (EC), hardness, major cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and major anions ($HCO_3^{\,-}$, SO_4^{2-}, Cl^{-}, F^{-} and $NO_3^{\,2-}$) were considered to be measured All the analyses were according to standard methods for examination of water and wastewater (8).

Since the water to the village is supplied from two separate sources (well and riverbank filtration system), sampling was also done from these points. The samples were collected in acid-washed PET bottles after 5 min discharge of the current and 3 times washing of the bottles. To evaluate the water quality at the point of use, 3 samples were taken from different parts of the network. Figure 1 is illustrating the sampling points.

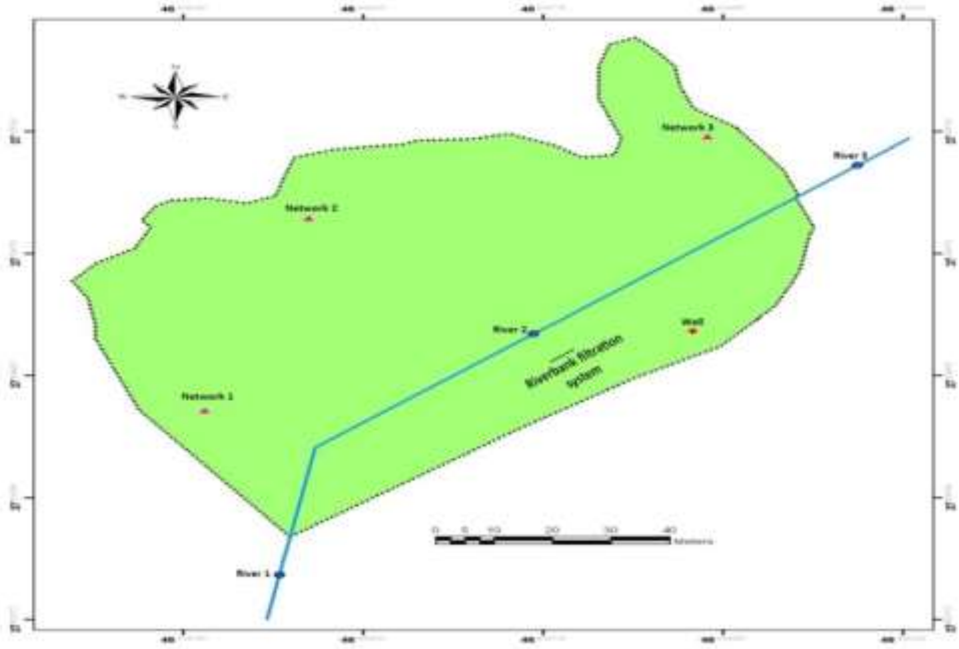

Figure 1: Sampling points and riverbank filtration system of the village

In the next step in order to study the performance of the filtration system of the village and impact of the river water on the treated water by riverbank filtration, statistical analysis was used. To assess the normality of the variables in spring and summer seasons, KS test was used and confirmed. For the comparison of the mean values of the indices, independent t-test was used. $P<0.05$ was considered significant.

3. Results

All potential risks of water quality of Lighvan village is shown in Table 2. Likelihood and severity of each of the risks was determined by 2 public health experts and finally The extent of these risks were ranked.

Table 2: Potential pollution risks ranking

event	Likelihood	severity	Risk ranking
Contamination of drinking water by sanitary wastewater discharged to river	5	4	20
Drinking water contamination by sewage from dairy products canters, especially in the months of January through the end of July	3	3	9
Drinking water contamination by animal waste	4	2	8
Drinking water contamination by agricultural drainage	3	2	6
The risk of secondary contamination due to lack of residual chlorine in the network	2	2	4
Contamination of drinking water by the wastewater from nearby school	2	1	2

As indicated In the table the sanitary wastewater of the village is one of the main potential pollution of the water. This is particularly important in the case of riverbank filtration.

3.1. Physicochemical analysis

Results of the hydrochemical analysis are presented in table 3. In terms of hardness, water is grouped as soft water (<75 mg/L $CaCO_3$), medium hard (75–150 mg/L $CaCO_3$), hard water (150–300 mg/L $CaCO_3$) and very hard water (>300 mg/L $CaCO_3$). As specified in the table the Range and of total hardness in the network water samples were 124-136 mg/L as $CaCO_3$, representing that the studied water samples could be grouped as medium hard water. The electrical conductivity is almost same in different parts of the water distribution network, indicating that there is not any change in dissolved solids.
As shown in table 3 the dissolved solids of the riverbank filtration is less than the well.

Table 3: hydrochemical analysis of water samples

sample	pH	EC µs/cm	TDS mg/l	Turbidity NTU	F mg/l	Cl mg/l	SO_4 mg/l	NO_3 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Hardness mg/l	Alkalinity mg/l
Network1	7.20	320	208.0	0.21	0.6	36	23.8	9.4	35.2	9.7	30.0	4.2	128	112
Network2	7.02	315	204.8	0.34	0.6	36	25.5	7.4	41.6	7.8	28.9	4.1	136	112
Network3	7.12	318	206.7	0.39	0.6	36	26.1	7.2	36.8	7.8	31.2	4.2	124	112
Riverbank	7.03	310	201.5	0.26	0.6	32	32.5	8.5	35.2	8.7	31.2	3.9	124	116
Well	7.02	340	221.0	1.16	0.6	36	35.2	7.3	36.8	10.7	35.8	4.1	136	128
River 3	7.35	360	234.0	20.40	0.6	44	41.1	6.9	30.4	11.7	47.3	4.2	124	112
River 2	7.60	335	217.8	12.60	0.6	42	38.9	4.2	27.2	12.6	41.5	3.5	120	108
River 1	7.90	326	211.9	4.10	0.6	40	33.9	3.1	24.0	12.6	31.2	3.3	112	96

3.2. Evaluation of river bank filtration system performance

Schematic diagram of Liqvan village river bank filtration is illustrated in figure 2. After passing of the river water through the riverbank filtration, reduction was observed in pH, turbidity, TDS, Magnesium, Sodium, Sulfate and chloride. However, there was an increasing trend in bicarbonate, potassium, nitrate, calcium and hardness.

The results of p-value between the mean values of the physicochemical parameters of river and riverbank filtration system shows that there is only significant correlation between chloride ($p=0.049$) and magnesium ($p=0.032$).

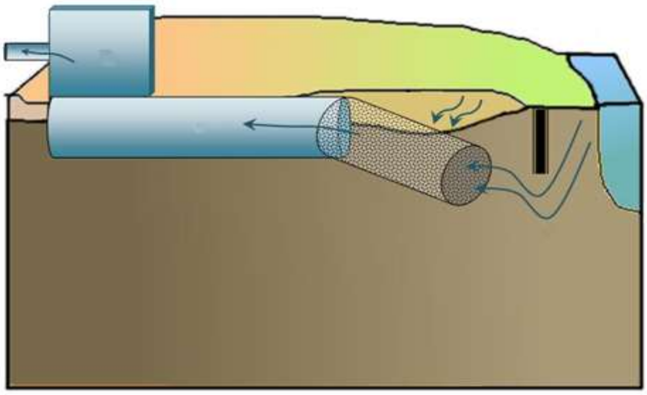

Figure 2: Schematic of riverbank filtration system

4. Discussion

One of the main problems that threaten the safety of the village water is sanitary wastewater and the wastewater which is discharged to the river from dairy products centers. Considering that a large population inhabits the village so a large amount of wastewater is produced. The intrusion of wastewater to the river and passing of that through the riverbank filtration could threaten the public health in the village. It is strongly suggested to modify the wastewater collection network of the village and to conduct the collected wastewater to the downstream of the village. Then it could be treated by natural wastewater treatment systems, and after being polished up to an accepted level it could be discharged to the river. Minimal corrective action which could be given is that, discharge of the wastewater to the river from the upstream of the riverbank filtration should be stopped.

About the case of animal wastes, which could be the main reason for an increase in nitrate concentration of the riverbank filtration effluent, is to assigning some sites out of the village for waste storage.

It is suggested to construct especial canals for collecting agricultural drainage particularly near the well and riverbank filtration system.

Subsurface water storage systems take the advantages of natural capacity of water and soil therefore, Imposing little cost to governments in addition it is generating high quality water (9-11).

In this study some chemical parameters such as hardness, alkalinity, nitrate, potassium and calcium increased after treatment which is similar to the findings of a study conducted in Egypt on the Nile River filtration system. However, the amounts of magnesium, sodium, sulfate and chloride decreased which is contrasting with the findings of Nile river study. In addition similar to the study took place in Egypt the amount of turbidity and suspended solids are reduced significantly.(12)

Although nitrate is low but increased after passing through the filtration system, it is increased. It could be due to accumulation of animal waste near the riverbank filtration system which led to the inclusion of nitrogen in animal waste to treated water.

In general, in the construction of these kinds of systems water pollution, type of the pollutant, soil type, soil permeability, and the distance of system from pollution sources should be paid much attention. Hence, while this method is recommended for use in different parts of Iran, comprehensive studies in this field is also proposed and accurate and continuous monitoring of water from the standpoint of chemical and biological parameters, before and after construction of the system and during its operation is recommended.

5. Conclusions

A lot of risks and hazards of pollution could be controlled by implementation of rural Water Safety Plan. Therefore, implementation of these kinds of programs, especially in rural communities is recommended.

Although Bank filtration imposes fewer expenses on governments, it provides suitable water for drinking and other uses. However, it should be noted that these systems application should be done after a thorough study of water pollution level, types of water pollutants, soil properties of the area, soil percolation and system distance from pollutant sources.

ACKNOWLEDGMENT

This article was a report resulted from the data set of M.Sc. thesis, registered in Tabriz University of Medical Sciences (TBZMED). We also appreciate Environmental Chemistry Laboratory of Faculty of Health, especially Mr. Mohammad Abedpour

REFERENCES

1. Nowshadi M, Azarpeikan A, Nohegar A. Investigation of water quality in Bandar Abbas drinking water using cluster and factor analysis Iran Water research Journal. 1388;3(5):79-82. Farsi.
2. Quevauviller PP, Fouillac AM, Grath J, Ward R. water quality measurement series, Groundwater Monitoring: Wiley; 2009.
3. Kathuria V. Controlling water pollution in developing and transition countries—lessons from three successful cases. Journal of Environmental Management. 2006;78(4):405-26.
4. Kathuria V. Informal regulation of pollution in a developing country: Evidence from India. Ecological Economics. 2007;63(2–3):403-17.
5. Summerill C, Pollard SJT, Smith JA. The role of organizational culture and leadership in water safety plan implementation for improved risk management. Science of The Total Environment. 2010;408(20):4319-27.
6. WHO. Guidelines for Drinking Water Quality. 4rd ed: Geneva: World Health Organization; 2011.
7. Census of the Islamic Republic of Iran, 1390 (2011.(
8. APHA-AWWA-WPCF. Standard Methods for Examination of Water and Wastewater. 21st ed2005.
9. Hubbes SA. Riverbank Filtration Hydrology (Nato Science Series: IV: Earth and Environmental Sciences) (Nato Science Series: IV: (closed)): Kluwer Academic Publishers; 2002.
10. Ray C. Riverbank Filtration: Understanding Contaminant Biogeochemistry and Pathogen Removal (Nato Science Series: IV: (closed)): Springer; 2002.
11. vet WWJMd, Genuchten CCAv, Loosdrecht MCMv, Dijk Cv. Water quality and treatment of river bank filtrate. Drinking Water Engineering and Science. 2010;1(3):79-90.
12. Shamrukh M, Abdel-Wahab A. Riverbank filtration for sustainable water supply: application to a large-scale facility on the Nile River. Clean Technologies and Environmental Policy. 2008;10:351-8.