Original scientific paper
UDC 628.112.033:[543.3:579.68]

SANITARY CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF DRINKING WATER IN KOCANI

Gordana Panova[1*], B. Panova[1], N. Panov[1]

[1]Faculty of Medical Sciences, University Goce Delcev, 2000, Stip, Krste Misirkov, 10A, Republic of Macedonia

[*]e-mail: gordana.panova@ugd.edu.mk

Abstract

Acute diseases occur as a result of contamination of drinking water with microorganisms (causes gastrointestinal disease) or contamination with nitrates causes methemoglobinemia in children), pesticides or other chemicals. The occurrence of water-borne infections due to inadequate sanitation, disposal of manure decomposition processing operating system or contamination during distribution. Harmful chemical pollution due to accidents or inadequate distribution system layout.

Purpose of these two year trials (2010 and 2011) was to: test how much water from wells used for drinking is contaminated, establish reasons and sources of water pollution and to enable the correction of possible mistakes/defects, in order to provide access to high-quality, chemicaly and bacteriologicaly safe water.

Drinking water physical properties as: turbidity, odor, color, chemical parameters as: presence of nitrates, iron and organochlorine compounds, and the presence of bacteria, were examined in laboratory and in field trials, by the methods described by Kocubovski [2].

Results showed that water quality and safety of regional drinking water supply in Kocani is satisfactory. However, there is a big problem with chemical and bacteriological contamination of other public water supply facilities like: water in the villages, weekend settlements and alternative public water supply facilities due to: Mistakes in water supply design and water supply piping; No protection from surface waters; and Contamination by the travelers/people. That emphasis an urgent need for establishment of legal procedures and responsibilities about alternative water supply in the areas of: design, maintenance and control.

***Keywords**: Drinking water, chemical and bacteriological contamination.*

1. Introduction

Water is of the essential importance for the entire living world. Drinking water has to possess good hygienic properties and all quality elements which are contributing in human wellbeing.

Sufficient quantities of safe and healthy drinking water improve living conditions, quality of life and environment at large. Sanitary (epidemiological and socially) or the medical aspect of drinking water is reflected in the following two aspects:

- Positive, when drinking water contributes to the health and general welfare and thus is used and/or is disposed in the way that poses no danger to human health and the environment;
- Negative, when due to physical, chemical or biological reasons water represents a source of infectious or noninfectious diseases in epidemic and endemic form [1].

The basic criteria for hygienic water supply are:

- Safe drinking water;
- Supply of sufficient quantities of wholesome water;
- Comfort in use;
- Continuity of supply.

Maintenance of these basic criteria is in close connection with proper sanitation and control of potential pollutants. For example, flow hygienic design of water facilities, piping system, bad maintenance etc, is one of the sources of water pollution. In many places water is seriously polluted with waste water and materials, including metals and waste from sewage. In rural areas, the use of pesticides and nitrates over many years represents a source of chemicals which are polluting groundwaters and rivers. People are also source of pollution.

Pollution of surface waters and ground waters can cause a decrease in the quality of the sources of drinking water and endanger public health. The most important issue is to protect the water use cycle in its entirety. Costs arising from poor control of water quality and safety and lack of proper maintenance are very high. It can lead to short term problems as for example, leaking water supply systems increases not only the lost in drinking waster quantity, but also the risk of water contamination [3], or it can lead to irreversible situations as permanent pollution of ground water, harmful contamination of water resources and even lost of human life's.

The goal of this examinations was to establish the quality and safety of drinking water in the Municipality of Kocani, or more precisely: to be determinate where and how much water is contaminated, what are the reasons for it and to enable the correction of possible mistakes/defects, in order to provide access to high-quality, chemicaly and bacteriologicaly safe water.

2. Materials and Methods

Drinking water physical properties as: turbidity, odor and color were examined by field trials [2].

Examinations of chemical and bacteriological parameters were performed in the laboratory, by the methods described by Kocubovski [2].

Examined chemical parameters were presence of: nitrates, iron and organochlorine compounds.

When speaking about the examined groups of bacteria we decided to test two groups of microorganisms, or more precisely - indicator organisms and if necessary pathogens. Usually there are two reasons for this:

1. Indicator organisms are bacteria such as non-specific coliforms (ex. *Escherichia coli* and *Pseudomonas aeruginosa*) that are present not only in the human or animal digestive system, but also in the sewage [5], so they can pinpoint several sources of contamination.
2. Their number is in much bigger quantity than pathogens. Therefore it is correct to assume that if the level of indicator organisms is low, then the level of pathogens will be much lower or absent [6]. That way it can be avoided further determination of types of pathogenic bacteria. In this paper are presented the results for indicator bacteria.

The contents of the substances found dissolved in the water that does not exceed the established norms (regulations) were not considered as pollution. Only in cases of exceeding the Maximum Contaminant Level Goal (MCLG) a given substance was considered as a contaminant.

3. Discussion and Results

Drinking water quality and safety is maintained if appropriate protective measures against pollution are implemented. Water supply sources protection from pollution is the responsibility of the sanitary authorities, and it is realized with the establishment of the so-called sanitary protection zones, as described by Panova [4], or more precisely:

- Strict sanitary supervision zone (first protection zone - narrow protection zone, water facilities protection) and is established around water intakes, reservoirs, and other parts of the water supply facilities exposed to possible harmful effects on the environment or people. This zone should be fenced, secured with guards and any activity performed inside the zone that is not a function of water supply is banned.
- Sanitary restriction zone (second protection zone/ wider zone) is established in the watershed area of the intakes. It may cover large areas that are mainly used as forest land, meadows, pastures, agricultural land, mountains and more. In this zone, application of some chemicals or disposal of industrial or municipal waste is limited. This zone should be considered as a major water source/intake for urban or rural settlements or food production factories, other economic and non-economic structures (schools, resorts, tourist and recreational facilities, etc), as well as major water source for so-called individual water supply facilities - wells and pumps that are often found in settlements and where exists a real possibility of contamination from neighboring toilet, dumps and other waste.
- Sanitary - epidemiological monitoring and surveillance zone (third protection zone/widest zone). This zone covers the land which is not part of the previous zone, but contains the watershed areas of the water sources which are used as drinking water.

Center for Public Health Kocani [7] monitors water quality and safety standards of the regional water supply - Kocani. Samples were taken on weekly base. The results from the samples from unprocessed water supplies are shown in Table 2.

Table 2. Comparative data from the physical, chemical and bacteriological tests from unprocessed water coming in the regional water Kocani, for 2010 and 2011

Place of sampling unprocessed water	Year					
	2010			2011		
	Examined samples	Defective chemically	Defective bacteria.	Examined samples	Defective chemically	Defective bacteria.
Water from wells	34	4 (11.7 %)	1 (2.9 %)	18	2 (11.1%)	1 (5.5%)
The entrance of water process. plant	50	2 (4%)	0	48	5 (10.4%)	0
Total	**84**	**6 (7.1 %)**	**1 (1.2 %)**	**66**	**7 (10.6%)**	**1 (1.5%)**

Unprocessed water analysis are showing tendency of slight increase in chemical and bacteriological contamination. More precisely, bacteriological contamination increased from 7.1% in 2010 to 10.6% in 2011 and this increase is direct result of human negligence in protection of water coming from wells. When speaking about chemical contamination it is noticeable that chemical contamination raised from 1.2% in 2010 to 1.5% in 2011 and the main reason is higher manganese content in certain wells.

Samples are taken on regular basis after processing. Usual sampling points are immediate exit from the water processing plant and 5 random points from the water network. The results from these analyses are shown in Table 3.

In both years water exiting processing plant was with high quality and safe, and without any trace of chemical or bacteriological contamination. However, in the 2010, 3 samples (1.06% of all samples) showed bacterial contamination and in 2011, 2 samples (0.8% of all samples) showed chemical contamination. The reasons for these findings were few defects in water piping system.

Generally speaking, the water quality and safety of regional drinking water supply in Kocani is satisfactory. On the basis of analysis results we can conclude that there are few types of action should be undertaken, or:

1. Improvement of Drinking Water Supply Source Protection Program and more frequent monitoring procedures, especially in the part of water from the wells.

2. Replacement of aging pipelines, which will not only prevent water contamination, but will also prevent water losses.

Beside regional water system supply of Kocani, Center for Public Health Kocani is the responsible for implementation of the program for general measures for protection of other public water supply facilities against infectious diseases, which means periodical monitoring of water in the villages, weekend settlements and alternative public water supply facilities which are used in emergencies. The results from these examinations are shown in Table 4.

Table 3. Comparative data from the physical, chemical and bacteriological examinations of water processed by the Regional Water Kocani, for 2010 and 2011

Place of sampling processed water	Year					
	2010			2011		
	Examined samples	Defective chemically	Defective bacteria.	Examined samples	Defective chemically	Defective bacteria.
Water output from the plant	**11**	**0**	**0**	**0**	**0**	**0**
Drinking water	**270**	**0**	**3 (1.1 %)**	**239**	**2**	**0**
Total	**281**	**0**	**3 (1.06 %)**	**239**	**2 (0.8 %)**	**0**

Table. 4 Comparative data from the physical, chemical and bacteriological findings from examination of other public water supply facilities

Water supply facilities	Year					
	2010			2011		
	Examined samples	Defective chemically	Defective bacteria.	Examined samples	Defective chemically	Defective bacteria.
1. Water supply in hilly and mountainous villages						
Water supply Leshi	2	0	2 (100%)	1	0	0
Village fountain Leshi	-	-	-	1	0	0
Water supply Nivichani	2	2 (100%)	2 (100%)	2	0	2 (100%)
Water supply Jastrebnik	1	0	0	-	-	-
Water supply Polaki	-	-	-	-	-	-
Water supply Pantelej Manastir	2	1 (50%)	2 (100%)	3	0	3 (100%)
Village fountain Pantelej	1	0	1 (100%)	3	2 (67%)	2 (67%)
Water supply Pantelej	-	-	-	1	0	1 (100%)
Village fountain Rajcani	2	2 (100%)	2 (100%)	4	3 (75%)	4 (100%)
Draw well Belsko	-	-	-	1	0	1 (100%)
Village fountain Dolna Preseka	-	-	-	3	2 (67%)	2 (67%)
Village fountain Gorna Preseka	-	-	-	1	1 (100%)	0
Total 1.	**10**	**5 (50%)**	**9 (90%)**	**20**	**8 (40%)**	**15 (75%)**
2. Water weekend settlements and roadside fountain						
Water supply Ponikva	1	0	1 (50%)	1	0	0
Village fountain - Sharena	2	1 (50%)	2 (100%)	1	1 (100%)	0
Village fountain - Forest house	No water	-	-	No water	-	-
Village fountain - Partizanska	1	0	1 (100%)	1	1 (100%)	0
Village fountain - Aramiska	1	0	0	2	0	0
Village fountain - Preslap	1	0	1 (100%)	1	0	1 (100%)
Total 2.	**6**	**1 (16.7%)**	**5 (83%)**	**6**	**2 (33%)**	**1 (16.7%)**
3. Water supply from alternative public water (wells, pumps) facilities in Kocani						
Pump Bavchalak	4	0	0	4	0	0
Village fountain - Usova	4	4 (100%)	0	4	3 (75%)	1 (25%)
Village fountain - B. Lovcija	4	0	4 (100%)	4	0	3 (75%)
Village fountain - Belska	4	4 (100%)	1 (25%)	4	4 (100%)	2 (50%)
Strishanska Water supply	1	0	0	1	0	0
Village fountain - Minova	4	4 (100%)	1 (25%)	4	3 (75%)	2 (50%)
Village fountain - Vojnicka	4	0	0	4	0	1 (25%)
Total 3.	**25**	**12 (48%)**	**6 (24%)**	**25**	**10 (40%)**	**9 (36%)**
Total (1, 2 , 3)	**41**	**18 (44%)**	**20 (48%)**	**49**	**19 (38.8%)**	**25 (51%)**

Results can be discussed according sub-type of other public water supply facilities.

1. In 2010 were tested 10 wells in hilly and mountainous villages. 5 of them (50%) were chemically polluted and 9 (90%) were bacteriologicaly contaminated. Next year (2011), from 20 monitored wells, 8 (40%) showed chemicall pollution and 15 (75%) bacterial contamination. Sources of this kind of problems are in general:
   - Mistakes in water supply design and water supply piping;
   - No protection from surface waters;
   - Contamination by the travelers/people
2. When speaking about the water weekend settlements roadside taps it was found that the water supply Ponikva in 2010 was bacteriologicaly contaminated. The reason for this was clogging of the drainage canal. The situation was corrected next year (2011) with installation of automatic chlorinating system and constant drainage canals monitoring. Almost half of the village fountains in 2010 showed bacteriological contamination and in 2011 chemical contamination. Main reasons for these were:
   - Mistakes in catchments design and water supply piping;
   - Contamination by the travelers/people goes on picnic;
   - Fountain inlet is not protected from surface waters.
3. In 2010, the water from alternative public water facilities in Kocani examined sources of which 12 (48%) were chemically defective and 6 (24%) bacteriologically contaminated. Situation was similar for 2011. Main reasons for this situation are:
   - Mistakes in catchments design and water supply piping;
   - Contamination by the travelers/people goes on picnic.

4. Conclusions

- Water quality and safety of regional drinking water supply in Kocani is satisfactory. On the basis of analysis results we can conclude that there are few types of action should be undertaken, or:
  1. Improvement of Drinking Water Supply Source Protection Program and more frequent monitoring procedures, especially in the part of water from the wells.
  2. Replacement of aging pipelines, which will not only prevent water contamination, but will also prevent water losses.
- When speaking about other public water supply facilities like: water in the villages, weekend settlements and alternative public water supply facilities which are used in emergencies it can be concluded that chemical and/or bacteriological contamination is due to:
  1. Mistakes in water supply design and water supply piping;
  2. No protection from surface waters;
  3. Contamination by the travelers/people.
- There is an urgent need for establishment of legal procedures and responsibilities about alternative water supply in the areas of: design, maintenance and control.

5. References

[1] *Law for Protection of the population from infectious diseases*. (2009). Official Gazette of the Republic of Macedonia., 99/2009.

[2] Kocubovski M. (2010). *Ekologija so higiena*. Kiril i Metodij, Skopje.

[3] J.Epidemiol (1998). *Community Helth*.

[4] Panova G. (2010). *Zdravstvena ekologija so higiena*. UGD, Stip.

[5] Branchman P. (1982). *Surveillance*, In: Bacterijal infections of humans, Plenum Medikal Book Company, New York-London.

[6] Lest M. (1983). *A Dictionary of Epidemiology*. Oxford University Press, Second Edition.

[7] JZU Centre for Public Health, archive, Kocani.