COMPARATIVE ANALYSIS OF DRINKING WATER MONITORING DURING FLOODS IN BULGARIA

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Abstract: The floods are disaster situations, which bring about risk - to the highest extent - for the life and health of Bulgarian population. Intensified control over the possible unfavorable factors of floods is necessary for prevention of appearance and development of infectious diseases. The basic factor of contagion transmission is the water contaminated with pathogenic microorganisms, which results in development of heavy hygienic and epidemiological situation. The **aim** of the study is to analyze drinking water monitoring after flood. **Material and methods:** Data were collected from references in literature on the subject, as well as from a personal study on two floods, which affected the second and the third largest cities of Republic of Bulgaria - Plovdiv (2005) and Varna (2014). The parameters from the ongoing health control in the period of time without flood (2015) were also studied. Descriptive and comparative methods were used in the study. **Results:** The comparative analysis of drinking water monitoring in Plovdiv in the period with flood (2005), and period without flood (2015), showed that - when floods occurred - changes in the normal parameters of drinking water were established, which increased the risk from development of intestinal infectious diseases with water as a transmission factor. After the flood in the district of "Asparuhovo", samples of drinking water were also collected from objects with public significance. After cleaning up territories affected by the flood, and multiple collection of drinking water samples in norm, the water supply was resumed. **Discussion:** The results from drinking water monitoring are indicative for the effectiveness of hygienic and antiepidemiological undertakings in the periods before and during flood. **Conclusions:** Intensified monitoring of drinking water quality is also necessary, and it is implemented according to organoleptic, chemical, and microbiological parameters in the towns and villages affected by the flood. **Final statement:** The frequent monitoring of drinking water after those and other floods, the intensified regimen of cleaning, disinfection, subsequent healthcare expert opinion, as well as the purposeful healthcare education, are priorities for the respective institutions in Bulgaria, regarding the prevention of infectious diseases appearance after flood.
Keywords: flood, monitoring, drinking water.

1. INTRODUCTION

Floods are disaster situations, which give rise to risk of unfavorable influence on the population and affected territory. They exercise influence on human health by means of action of different factors, including by increase of intestinal infectious morbidity. The basic factor of contagion transmission is the water contaminated with pathogenic microorganisms, which results in development of heavy hygienic and epidemiological situation. Change of hygienic and epidemiological situation is registered days, weeks, and even months after the risen waters had receded [¹]. It is a result of destruction or damages of the sewer network and water supply network. There is also impossibility of effective water purifying in the purification plants due to their pollution and/or destruction [²]. Not less significance has also the pollution of floodplains with slob, corpses of humans and animals, decay of waste, etc.

The above-mentioned factors increase the risk of development of epidemies after water receding - the following infectious diseases are most frequently registered: enterocolitis, dysenteries, salmonelloses, shigelloses, viral hepatitis A, etc. [³]. The changes of living conditions of population have also significance for their development. The number of risk factors, which contribute to activization of transmission mechanism of intestinal infectious diseases (poor sanitary and hygienic conditions), also increases. Based on literature data, the basic mechanism of transmission is the fecal-oral one due to the limited access to water suitable for drinking and everyday needs. The pathogenic microorganisms are transmitted by means of dirty hands, contact with polluted objects and contaminated food [⁴] [⁵]. The characteristics of water (soft water, hard water, mineral water, spring water, table water, groundwater), the temperature of environment, as well as the atmospheric conditions of drying (fast or slow) have

all significance for development of pathogenic microorganisms [6]. The data from the indicated and other sources confirm that, when floods take place, favorable conditions occur for development of bacterial agents, which requires realization of the necessary and timely organization for implementation of a complex of prophylactic undertakings and liquidation of the biological contamination focus, which has come into being [7].

That is achieved - in Bulgaria - by implementation of a complex of measures, including by intensification of the State Healthcare Control (SHC) after floods. The SHC is a main element of hygienic and antiepidemiological insurance of the population, and it comprises a series of sanitary and hygienic undertakings. The intensified SHC is continuation of the ongoing control, which is carried out in the flood-free periods. The timely organization and implementation of SHC on the objects with public purpose, foodstuffs, objects from the everyday life, as well as other activities with significance for the population and environment, are decisive for prevention of heavy epidemiological situations [8]. The activities connected with implementation of SHC are described in the respective regulations: Regulation No. 36/2009 for the conditions and order of SHC implementation, and Regulation No. 9/2001 for the quality of water intended for drinking and everyday needs [9][10]. After introduction of the requirements of Regulation No. 9/2001 - for the quality of water intended for drinking and everyday activities - other obligatory tests (Escherichia coli, Clostridium perfringens, Pseudomonas aeruginosa) are added to the routine tests of "coli-titer" and "microbic number" [11].

The undertaking of timely measures for prevention of development of gastric and intestinal diseases is in direct dependence from the results of qualitative microbial assessment of drinking water [12]. Those measures include providing of access to suitable sources of pure drinking water; sufficient quantity of cleaning agents; timely disposal of waste; effectively implemented disinfection, disinsection, deratization, etc. [13]. The timely realization of those measures is achieved by means of fast and coordinated reatcions of the institutions, engaged with reduction of the consequences after floods [14]. The institutions - in Republic of Bulgaria - which govern, implement, and control the undertakings connected with hygienic and antiepidemiological insurance, when disaster situations (including such after floods) occur, are the Regional Healthcare Inspectorates (RHI), which extend the range of activities, performed until 2011 by the Regional Inspectorates for Protection and Control of Public Health (RIPCPH) [15].

The **aim** of the study is to analyze the need and significance of drinking water monitoring after flood.

2. MATERIAL AND METHODS

Data from two floods were collected; the floods have heavily affected the second and the third largest cities of the Republic of Bulgaria - Plovdiv (2005) and Varna (2014). By means of the potentials of descriptive and comparative methods, the significance of intensified and extended monitoring of drinking water after flood was proved. For accomplishment of the aim, data - from the archive of RIPCPH Plovdiv (after the flood in the latter city, in August 2005), regarding the taken samples of drinking water from objects with public significance - were gathered and analyzed. Data - based on electronic sites, regarding the flood in the district of "Asparuhovo" in Varna (in June 2014) - were collected and analyzed. The data received, regarding the flood in Plovdiv (in August 2005), were compared with data from monitoring in the period of time without flood in the same city (Plovdiv - in August, September 2015), as well as with data from the flood in Varna (in June 2014).

3. RESULTS FROM A PERSONAL STUDY

The information gathered can be summarized in the following way: A series of towns and villages in Plovdiv Province were flooded in consequence of pouring rains on August 5, 2005, which resulted in heavy general, and hygienic and epidemiological situation. The losses for Plovdiv Province were more than 67,926,821 levs, the flood, however, did not cause any loss of human lives [16]. As a result of the combination of climatic (pouring rains), landscape (terrain, soil, vegetation, rocks), and anthropogenic (illegal cutting of trees, disposed waste, illegally built houses) factors in the district of "Asparuhovo" in Varna, a tidal wave formed - on June 19, 2014 - with a height of two meters and a half. 13 persons lost their lives subsequently and dozens of houses were destroyed [17]. The heavy general consequences, which occurred as a result of both floods, required monitoring of drinking water, foodstuffs, objects of public significance, etc., to be simultaneously performed with the urgent and pressing undertakings of break-down and recovery, in order to be avoided serious hygienic and epidemiological situation.

Because of the risk from infectious diseases after the flood in August 2005, RIPCPH Plovdiv put under intensified monitoring the drinking water in the city. Samples of drinking water were collected from objects with public significance, including private homes. Several basic parameters were followed up - turbidity, coli forms, Escherichia coli, ammonium ion, residium chloride, etc. The data from water monitoring after the flood are presented on Table 1.

Table 1. Drinking water monitoring from August 8, 2005 to August 10, 2005 in Plovdiv.

Date of sample collection	Plovdiv	Parameter	Value	Norm
August 8, 2005	Second Medical Center district of "Iztochen"	coli forms E. coli	more than 24/100 16/100	0/100 colony-forming units per ml 0/100 colony-forming units per ml
August 8, 2005	district of "Komatevo" school pavilion	coli forms E. coli turbidity	more than 24/100 16/100 not acceptable	0/100 colony-forming units per ml 0/100 colony-forming units per ml Acceptable
August 10, 2005	district of "Komatevo" private home	ammonium ion	0.62 mg/l	0.50 mg/l
August 10, 2005	water-carrier of Pulmonary Care Hospital	turbidity residual chloride	not acceptable 1.0 mg/l	acceptable 0.3-0.4 mg/l
August 10, 2005	water-carrier in front of General Hospital for Active Treatment "St. Panteleymon" (Second City Hospital)	turbidity	not acceptable	acceptable
August 10, 2005	water-carrier in front of Psychiatric Dispensary	turbidity residual chloride	not acceptable 0.8 mg/l	acceptable 0.3-0.4 mg/l

The following information was found from the data collected:
1. According to the parameter turbidity - water is undrinkable (not acceptible);
2. According to the parameter pathogenic microorganisms - increased values of coli forms and Escherichia coli;
3. According to the parameter ammonium ion - increased content, which is a sign of recent fecal contamination;
4. According to the parameter residual chloride - hyperchlorination of water. According to the requirements of Regulation No. 9/2001 for the quality of water intended for drinking and everyday needs, the residual chloride in drinking water must be 0.3-0.4 mg/l. The parameter is determined in the first and all intermediate sites of chlorination after a realized 30-minute contact with the water. The amount of residual chloride in the samples of drinking water collected is 0.8 mg/l and 1.0 mg/l, which is an index for hyperchlorination of water.

For accomplishment of the aim of our study, regarding the need of intensified drinking water monitoring after flood, we compared the data with samples of drinking water collected during the ongoing (permanent and/or periodical) healthcare control implemented by RHI Plovdiv in the period without flood (in 2015). The data from the ongoing monitoring of water without flood are presented on Table 2.

Table 2. Monitoring of drinking waters from August 31, 2015 to September 30, 2015 in Plovdiv.

Date of sample collecting	Plovdiv central water source	Parameter	Value	Norm
August 31, 2015	petrol station "Petrol" at General Hospital for Active Treatment Plovdiv	coli forms E. coli color turbidity	0/100 0/100 acceptable acceptable	0/100 colony-forming units per ml 0/100 colony-forming units per ml acceptable acceptable
August 31, 2015	Diagnostics and Consultancy Center "Iztok" district of "Izgrev"	coli forms E. coli color turbidity	0/100 0/100 acceptable acceptable	0/100 colony-forming units per ml 0/100 colony-forming units per ml acceptable acceptable
August 31, 2015	fountain - market-place district of "Gagarin"	ammonium ion residual chloride coli forms	<0.05 0.2 mg/l 0/100	0.50 mg/l 0.3-0.4 mg/l 0/100 colony-forming units per ml
September 30, 2015	petrol station "Petrol" at General Hospital for Active Treatment Plovdiv	coli forms E. coli color turbidity	0/100 0/100 acceptable acceptable	0/100 colony-forming units per ml 0/100 colony-forming units per ml acceptable acceptable
September 30, 2015	Diagnostics and Consultancy Center "Iztok" district of "Izgrev"	coli forms E. coli color turbidity	0/100 0/100 acceptable acceptable	0/100 colony-forming units per ml 0/100 colony-forming units per ml acceptable acceptable
September 30, 2015	fountain - market-place district of "Gagarin"	ammonium ion residual chloride coli forms	<0.05 0.15 mg/l 0/100	0.50 mg/l 0.3-0.4 mg/l 0/100 colony-forming units per ml

The monitoring of drinking waters (Table 2) - in the period without flood in Plovdiv - demonstrated that all parameters were in norm. Water was well chlorinated, with acceptable color and turbidity, without presence of pathogenic microorganisms or ammonium ion.

The comparative analysis of the monitoring of drinking waters in Plovdiv in period with flood 2005 (table 1), and period without flood 2015 (table 2), demonstrated that, when floods occur, conditions for changes in the normal parameters of drinking water are brought into existence, which increases the risk from development of intestinal infectious diseases with water as factor of transmission.

The other flood, the consequences of which were subject to the comparative analysis, was the one in the district of "Asparuhovo", in Varna, which occurred in June 2014. Immediately after the flood with a resolution of the respective institutions, the water supply was stopped. The use of water from local water sources (foutains, wells, soundings, etc.) was forbidden until receiving of information for their use by the respective institutions. Intensified control on the water-carriers was assured in the districts with discontinued water supply. Inspectors from section State Healthcare Control at RHI Varna implemented additional sample collection of water in hazardous objects with public purpose - day nurseries, kindergartens, schools, medical centers, public institutions, etc. Water samples were collected several times from seven sites on the territory of the affected district for implementing of organoleptic, chemical, and microbiological water analysis [18].

It was found that there was a deviation from the standard parameters for drinking water quality, but no salmonellosis or hepatitis. Because of the presence of risk, the frequent monitoring of water continued not only in the affected territories, but also in the neighbouring districts. The population was timely informed of the studies' results [19].

Other measures were carried out at the same time with the latter ones in order to be prevented worsening of the hygienic and epidemiological situation. The healthcare education in the affected territories is intensified, by which the undertaken measures are assisted. The use of bottled water or water from water-carriers is recommended for meeting of the drinking and everyday needs. After cleaning of the territories affected by the flood, disinfection of the streets and public buildings, and after multiple collections of samples from drinking water for implementation of microbiological and chemical analysis - which was in norm - the water supply was resumed [20].

4. DISCUSSION

The results from drinking water monitoring are indicative for the effectiveness of the hygienic and antiepidemiological undertakings in the periods before and after flood.

5. CONCLUSIONS

The analysis of data, collected from the scientific sources, and from the personal study, gives grounds for the following conclusions:

- The institutions carry out intensified monitoring for the quality of drinking water based on organoleptic, chemical, and microbiological parameters in the affected by the flood towns and villages.
- The working dose of chloride is increased in order to be decontaminated the water intended for drinking and everyday needs, when need for that is established.
- The cleaning, washing, and disinfection of the flooded water suppliers and Water Supply and Sewage facilities - facilities for intake of surface water and groundwater, pump and chlorinating stations, reservoirs, shafts with open water level, etc.
- The population was informed in time for the results from laboratory tests, both about the limitations and cancellation of water use prohibition.

The results from the performed analyses demonstrated that after floods the risk for the population health increased due to the contamination of the drinking water. The frequent monitoring of drinking water after floods, the enhanced regimen of cleaning, washing and disinfection (including the increased working dose of chloride for decontamination of water), the subsequent healthcare expert opinion, as well as the purposeful healthcare education, are priorities for the respective institutions in Bulgaria, regarding prevention of occurrence of infectious diseases after flood.

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