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BURDEN OF WATER-RELATED DISEASES IN DEVELOPING COUNTRIES. REVIEW

Alua O. Omarova [1*], http://orcid.org/0000-0002-2087-3824

Kamshat M. Tussupova [2], http://orcid.org/0000-0001-8005-0371

Ronny Berndtsson [2], http://orcid.org/0000-0003-1473-0138

Marat G. Kalishev [1], http://orcid.org/0000-0002-6693-8646

[1] Karaganda State Medical University, Department of Food Hygiene, General Hygiene, and Ecology, Karaganda, Kazakhstan;
[2] Lund University, Department of Water Resources Engineering & Center for Middle Eastern Studies, Lund, Sweden.

Summary

Introduction. The quality of drinking water is a serious problem in developing countries, where half the population is exposed to one or more diseases associated with water and sanitation.

The objective was a review of literature that deals with study of devastating burden of water-related diseases in developing countries.

Methods. The publications of findings of both foreign and domestic researchers were analyzed. Literature sources were searched in the PubMed, Scopus, GoogleScholar и eLibrary databases. Out of 166 literature sources, 77 were selected as the analytical material of the article. The depth of the search was from 1972 to 2016.

Criteria for the inclusion of publications in this review are the following: publications in Russian and English languages that are in open full-text access and bear statistically verified conclusions.

Exclusion criteria are as follows: summary reports, newspaper articles and personal messages.

Results. Review sources revealed that gastrointestinal diseases, intestinal helminth infestations and protozoan infections as well as the risk of carcinogenic and mutagenic effects on the human body are to a great extent attributed to poor-quality water consumption.

Conclusion. Based on the above, high-quality water supply exerts a considerable impact on reduction of water-related diseases and rise in the living standards of population. A significant number of cases can be prevented with a better access to safe water supply, adequate sanitation facilities and better hygienic practices.

Key words: drinking water, diarrhea, protozoan infections, intestinal helminth infections, chemicals.

Резюме

БРЕМЯ БОЛЕЗНЕЙ, СВЯЗАННЫХ С ВОДОЙ, В РАЗВИВАЮЩИХСЯ СТРАНАХ. ОБЗОР ЛИТЕРАТУРЫ

Алуа О. Омарова [1*], http://orcid.org/0000-0002-2087-3824

Камшат М. Тусупова [2], http://orcid.org/0000-0001-8005-0371

Ронни Берндтссон [2], http://orcid.org/0000-0003-1473-0138

Марат Г. Калишев [1], http://orcid.org/0000-0002-6693-8646

[1] Карагандинский государственный медицинский университет, Кафедра гигиены питания, общей гигиены и экологии, г. Караганда, Республика Казахстан;
[2] Лундский университет, Кафедра инженерии водных ресурсов и Центр Ближневосточных исследований, г. Лунд, Швеция.

Введение. Качество питьевой воды является серьезной проблемой развивающихся стран, где половина населения подвергаются одному или нескольким заболеваниям, связанным с водоснабжением и санитарией.

Целью был обзор литературных источников, посвященных изучению разрушительного бремени болезней, связанных с водой, в развивающихся странах.

Методы. Были проанализированы публикации результатов исследований зарубежных и отечественных исследователей. Поиск литературных источников проводился в базах данных PubMed, Scopus, GoogleScholar и eLibrary. Было найдено 166 источников, из которых 77 источников были отобраны в качестве аналитического материала статьи. Глубина исследования с 1972 по 2016 годы.

Критерии включения публикаций в обзор: публикации на русском и английском языках, находящиеся в открытом полнотекстовом доступе и несущие статистически выверенные выводы.

Критерии исключения: резюме докладов, газетные публикации, личные сообщения.

Результаты. Анализ источников показал, что желудочно-кишечные инфекции, кишечные гельминтозы, протозойные инфекции и риск воздействия на организм канцерогенных и мутагенных соединений во многом связаны с потреблением недоброкачественной питьевой воды.

Заключение. Качественное водоснабжение существенно влияет на сокращение бремени болезней, связанных с водой, повышение уровня и качества жизни населения. Значительное число случаев заболевания можно предотвратить, особенно в развивающихся странах, с помощью лучшего доступа к безопасному водоснабжению, адекватным санитарно-техническим средствам и лучшей гигиенической практике.

Ключевые слова: питьевая вода, диарея, протозойные инфекции, кишечные гельминтозы, химические вещества.

Түйіндеме

СУМЕН БАЙЛАНЫСТЫ СЫРҚАТТАРДЫҢ ДАМУШЫ ЕЛДЕРДЕГІ АУЫРТПАЛЫҒЫ. ӘДЕБИЕТКЕ ШОЛУ

Алуа О. Омарова [1*], http://orcid.org/0000-0002-2087-3824

Камшат М. Тусупова [2], http://orcid.org/0000-0001-8005-0371

Ронни Берндтссон [2], http://orcid.org/0000-0003-1473-0138

Марат Г. Калишев [1], http://orcid.org/0000-0002-6693-8646

[1] Қарағанды мемлекеттік медицина университеті, Тамақтану гигиенасы, жалпы гигиена және экология кафедрасы, Қарағанды қ., Қазақстан Республикасы;
[2] Лунд университеті, Су ресурстар инженериясы кафедрасы және Таяу Шығыс зерттеулері отралығы, Лунд қ., Швеция.

Кіріспе. Ауыз су сапасы дамушы елдердің аса маңызды мәселесі болып табылады, өйткені тұрғындардың жартысы сумен қамтамасыздандырумен және санитариямен байланысты сырқаттардың біреуіне немесе бірнешеуіне шалдыққан.

Мақсаты сумен байланысты сырқаттардың дамушы елдердегі талқандаушы ауыртпалығын меңгеруге арналған әдебиет көздерін шолу.

Әдістері. Шетелдік және отандық зерттеушілер жұмыстары нәтижелерінің жарияланымдары талданды. Әдебиет көздерін іздеу PubMed, Scopus, GoogleScholar және eLibrary мәліметтер базасында жүргізілді. Мақаланың талдау материалы ретінде 166 әдебиеттен 77 іріктелді. Зерттеу тереңдігі 1972 жылдан 2016 жылға дейін.

Шолуға жарияланымды енгізу критерийлері: ашық жағдайда толық мәтіні қол жетімді және статистикалық нақтыланған нәтижелері бар орыс және ағылшын тілдеріндегі жарияланымдар.

Алып тастау критерийлері: баяндамалардың тұжырымдары, газеттегі жарияланымдар, жеке хабарлар.

Нәтижелері. Әдебиет талдау көрсеткендей, асқазан-ішек инфекциялары, ішек гельминтоздары, протозойлы инфекциялар және ағзаға канцерогенді және мутагенді қосылыстардың әсер ету қаупі, көбінесе, сапасы нашар ауыз суды қолданумен байланысты.

Қорытынды. Сапалы ауыз сумен қамтамасыздандыру сумен байланысты сыртқаттар ауырпалығын қысқартуға, тұрғындардың өмір деңгейі мен сапасын көтеруге елеулі әсер етеді. Сырқат жағдайларының бірталайын, әсіресе дамушы елдерде, қауіпсіз сумен қамтамасыздандыруға жақсы қолжетімділік, адекватты санитарлық-техникалық құралдар және жақсы гигиеналық тәжірибе арқылы алдын алуға болады.

Негізгі сөздер: ауыз су, диарея, протозойлы инфекциялар, ішек гельминтоздары, химиялық заттар

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Introduction

The quality of drinking water is a serious problem in developing countries, where half the population is exposed to one or more diseases associated with water and sanitation [1,7,36,60]. In developing countries about 400 children per hour die from diseases that are transmitted by water [36]. The sources of drinking water pollution are agricultural chemicals, inappropriate operation of sewerage system, improper storage and disposal of domestic waste, spillage of industrial materials and natural substances [4,36].

The objective was a review of literature that deals with study of devastating burden of water-related diseases in developing countries.

Methods

The publications of findings of both foreign and domestic researchers were analyzed. Literature sources were searched in the PubMed, Scopus, GoogleScholar и eLibrary databases. Out of 166 literature sources, 77 were selected as the analytical material of the article. The depth of the search was from 1972 to 2016.

Criteria for the inclusion of publications in this review are the following: publications in Russian and English languages that are in open full-text access and bear statistically verified conclusions.

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Results and Discussion

1. Classification of Water-Related Diseases. Water-Related Infectious Diseases.

All over the world about 2.4 million deaths (4.2% of all deaths) [52] could have been prevented with a good and reliable sanitation and drinking water. Diarrhea is the cause of 3.3 million deaths per year, basically among children under five (and nearly a billion cases of diarrhea each year); about one-third of people in developing countries are infected with intestinal worms; 6-9 million people suffer from blindness after trachoma; 200 million people are infected with schistosoma [56].

Frequent bouts of diarrhea and intestinal parasitosis are important causes of malnutrition, which makes children more susceptible to other diseases. For example, when malnourished children recover from a diarrhea episode, they are susceptible to pneumonia. 26% of all cases of childhood pneumonia can be associated with susceptibility induced by diarrhea [63]. Similarly, 7% of the HSW-associated disease burden is directly related to malnutrition, and 29% accounts for diseases that are malnutrition consequences [20,57].

Lack of access to safe drinking water is also associated with several non-diarrheal diseases [42]. Chronic or acute influence of many organic and inorganic chemicals adversely affects the

consumers' health. The consequences vary from acute nausea, vomiting or skin rash to cancer and fetal abnormalities [8,11,42].

The first attempt to simplify the connection between water and public health in developing countries was made by David Bradley [27,72], who developed a classification of water-related diseases:

1. **Waterborne diseases** occur when people ingest water contaminated with faecal matter. Cholera and typhoid fever are classic examples of the waterborne diseases. It takes only a few microorganisms with high infectivity to cause severe diarrhea. Shigellosis, hepatitis A, amoebic dysentery and other gastrointestinal diseases can also be transmitted by water.
2. **Water-washed diseases** are due to the lack of quality water for washing, bathing and cleaning. Pathogenic organisms are transmitted from human to human or upon contact with contaminated surfaces. Under such conditions, there can be skin and eye infections, as well as diarrheal diseases. Bacteria, viruses, protozoa and helminths are transmitted through water.
3. **Water-based diseases** are caused by parasites, particularly helminths of various kinds, which spend a part of their life cycle in the different hosts. They spend one cycle of development in water shellfish, the other, as adult parasites, in the body of the host – an animal or a human. Since a favorite inhabitation for parasites is stagnant surface water, e.g. reservoirs, human activities significantly affect the occurrence of the diseases, such as dracunculiasis and schistosomiasis.
4. **Water-related insect vector routes diseases** are caused by stings of insects that breed in water. Transmitting insects, such as mosquitoes, carry malaria, chikungunya and other diseases.

However, as noted by a number of authors [33,41,47,62], there are some shortcomings in the classification, as follows:

- The classification has no chemically-mediated diseases, such as poisoning with arsenic and fluoride, which have a serious impact in some parts of the world [33,47].
- The classification does not consider that the need to collect and transport water affects the health of many people in the world. For example, a lot of children and women in developing countries have to carry heavy water containers for long distances every day. There have been no systematic studies on how this affects the locomotor apparatus [41].
- Long walks to collect water may also increase the spread of some other communicable diseases [62].
- Unpleasant tastes or odors of delivered water (e.g., arising from chlorination or iron content in the ground water), which is microbiologically safe, can serve as a deterrent to the use of safe sources, and therefore expose the users to the health risks associated with unprotected water sources [41].

According to the World Health Organization [6,28], water contains 13 thousand potentially toxic elements. Over the past few decades, the problem of contamination of water sources, such as lakes, rivers and ground water, has become very acute [10]. Harmful substances can accumulate in the body causing a variety of diseases up to malignant neoplasms [6,28,44,74,75,76].

Osman A. Dar and Mishal S. Khan [32] propose to amend the Bradley's classification by adding neoplasms caused by high concentrations of arsenic in drinking water and fluorosis caused by intake of water with a toxic dose of fluoride into the category "waterborne diseases".

Access to clean water is essential for the individual and public health, especially in reducing the burden of infectious gastrointestinal diseases [2,52].

According to the WHO [37], infectious diseases caused by pathogenic bacteria, viruses and protozoa or parasites are the most widespread, and they make a principal risk factor for the public health associated with drinking water. Ten major diseases transmitted through water are responsible for more than 28 billion cases of disease in developing countries each year. Gastrointestinal diseases among them have the highest mortality rates [36].

In addition, the main reason of growth retardation for millions of children in developing countries is poor nutrition as a result of frequent bouts of diarrhea. Repeated bouts of diarrhea inhibit the body's ability to assimilate food for a longer period than the actual duration of diarrhea. Thus, children who had diarrheal diseases are at risk of stunting from malnutrition [36].

One of the studies of diarrheal diseases in rural areas of Bolivia reports that only 30% of respondents associate diarrhea with dirty water, and that many people view diarrhea as a normal phenomenon at an early age [58]. This lack of knowledge about the possible cause-and-effect relationships and casual views of diarrhea in children are common in developing countries [36].

On the average, the minimum infectious dose (the smallest amount of ingested pathogens required to cause a disease) for healthy adult varies widely depending on different kinds of microorganisms. This dose ranges from several organisms for Salmonella Typhi, several hundred organisms for Shigella Flexneri, several million cells for Salmonella Enterica and up to one hundred million cells for Vibrio Cholerae. The minimum infectious dose also varies depending on the age, state of health, nutrition and immunological status of the person [36].

Over a year diarrhea kills more small children than the so-called 'big three' (HIV/AIDS, tuberculosis and malaria taken together) [25]. The key to its control is hygiene, sanitation and water [20]. 90% of all deaths from diarrhea diseases accrue to children under five, and 15 developing countries account for 73% of them [57].

Contamination of tap water remains a serious problem of health system in Turkey throughout the history of the country's existence. After contamination of drinking water by sewage in the Turkish cities for 2005 – 2008, 17,000 people were hospitalized due to acute intestinal infections [24].

2. Water-Related Parasite Invasion.

Good sanitation can prevent not only endemic diarrhea but parasitic diseases transmitted through water by protozoa, intestinal helminth infestations, as well as many other globally important diseases [20].

In the period of infancy parasitic diseases may result in immune system imbalance [23]. Helminthiases have an adverse effect on the nutritional status of infected individuals with subsequent impact on the growth process in young children and cause anemia, especially in pregnant women [49,68]. Helminthiases also reduce the effectiveness of some vaccines, e.g. against tuberculosis, HIV and malaria [6,50].

WHO expert judgment shows that helminth infections have the third highest number of patients in the world, and malaria is the fourth among the most important infectious and parasitic diseases: 1.4 billion and 600 million patients respectively. For comparison, the annual number of patients with influenza and other acute respiratory infections in the world is 395 million (the sixth place) [35]. Based on the damage for human health, intestinal helminth infections are included in the four leading causes of all diseases and injuries [5,12].

Adult helminths live in the gastrointestinal tract where they reproduce sexually. Their eggs are ejected from the infected host with faeces, and in such a way they are passed to other people, mainly, when defecating in the open air. Replacement of the open defecation for a good sanitation can reduce this transmission path completely, but the majority of modern helminth control programmes is based on drug treatment, the intake of which must be periodically repeated in the absence of sanitation [17,39].

Up to 10% of population in developing countries is infected with helminths, a large percentage of which is caused by ascarid. Severe forms of ascariasis are responsible for 60,000 deaths per year, mostly in children [48]. To a large extent, this is a disease of people exposed to raw wastewater or food products grown on it. Eighty-five thousand hectares in the Meskital valley in central Mexico is a classic example of using raw wastewater for irrigation of crops, which leads to a considerable increase in the incidence of diarrhea and ascariasis [18,29].

Worldwide, about 190 million people are infected with schistosomes, which can lead to chronic exhaustion, hematuria, dysplasia, urocyst diseases and colorectal cancer, as well as a significant malfunction in organs [39]. Adult schistosomes live in the portal vein, where they pass their eggs into the environment through the urine (Schistosoma haematobium) or faeces (other human schistosomiasis). After completing a part of their life cycle in aquatic snails, where they reproduce asexually, cercariae are discharged into the water, where they come into contact and infect humans through the skin. Thus, measures to improve sanitation and water are essential to any long-term control and elimination of Schistosomiaisis [17].

Trachoma is an endemic disease in many poor countries of the world. It is due to a clamidiosis

bacterium and is a leading cause of blindness in the world [59]. Trachoma control is conducted mainly on the basis of antibiotics, despite the existence of a management strategy SAFE (surgery, antibiotics, face washing and environmental protection measures, namely the strengthening of sanitation) [30,54]. However, in recent times a cluster randomized trial in Ghana [34] found that the provision of toilets reduced a significant number of flies Musca Sorbens (a vector for trachoma) and decreased the incidence of trachoma by 30%, thus confirming the role of improved sanitation in the control of trachoma.

For nearly a hundred years, between the past century and 2004, around the world it has been reported 325 protozoal parasitic outbreaks transmitted by water, whereas during a much shorter period of time, between 2004 and 2010, there were 199 reports of such outbreaks. [46]. Such essential difference in the number of reported outbreaks is caused by significant improvement in data reporting and establishment of surveillance systems in the developed countries. The highest prevalence of parasitic protozoa infections are known to occur in developing countries because of low sanitation and hygiene standards [19].

The etiologic agent in the reported outbreaks was Cryptosporidium spp. in 60.3% (120) of cases, Giardia lamblia in 35.1% (70) and other protozoa in 4.5% (9). Four outbreaks (2%) were caused by T. gondii, and three ones (1.5%) by C. cayetanensis. During two outbreaks (1%), Acanthamoeba was identified as the causative agent [38].

An overview of food-borne diseases and deaths made in the United States of America shows that 2.5 million diseases (7%) were caused by parasites (300,000 by Cryptosporidium parvum; 2,000,000 by Giardia lamblia; 225,000 by Toxoplasma and 52 by Trichinella spiralis) [53,70].

For 12 years, 39 documented outbreaks of waterborne cryptosporidiosis have occurred in the USA, Canada, UK, and Japan [61]. Activities related to livestock-breeding, in particular, the spread of faecal, as well as deposition and wash-out from contaminated pastures, have been proposed as the cause of many of these outbreaks [43,66-67].

Developments in the molecular genetic analyze of water-borne protozoan parasites including the determination of the identity of species and subtypes will help to understand their contribution to the environmental pollution. Significant research in this area is ongoing, and several methods of genotyping have been designed for Cryptosporidium, Giardia, Microsporidia spp. and Toxoplasma [16,40,51,55,69].

Spores of Microsporidia are persistent in the environment and remain infectious from a few days to a few weeks outside the host [64-65,71]. Their small size (5±1 mm) makes them difficult to remove using conventional filtration methods. It is also feared that they may have improved resistance to chlorine disinfection [70,73].

Two toxoplasmosis outbreaks associated with the consumption of water contaminated by oocysts were well documented [21,26]. The first outbreak occurred in the British army in Panama. Epidemiological data showed that the most likely means of transmission had been contaminated brook water. The second outbreak occurred in British Columbia, Canada, in 1995: 110 acute infections, 55 cases of which were related to infection of non-pregnant women, were determined. Forty-two cases included pregnant women and eleven ones were associated with children [26,70].

The latest advances in immunology and molecular biology allowed more sensitive and specific rapid tests that could replace the existing methods [70].

Among 1377 refugees and asylum seekers arrived in Sweden, intestinal parasites were more often identified in refugees from Southeast Asia, Africa and Latin America (infection rates of 48%, 43% and 42% respectively) than in those who had come from the Eastern Europe (22%) and Middle East (32%) [22,31].

The need to provide pure water and basic sanitation to everyone is a priority for the environmental health in Latin America because of the high rates of diarrheal and other water-borne diseases [31].

In the estimation of specialists, the annual number of people falling ill with parasitic diseases in Russia exceeds 20 million and tends to increase [9,13]. Thus, according to the number of

patients, parasitic diseases in Russia are second only to acute respiratory infections [12].

Investigations carried out in Medical Parasitology and Tropical Medicine named after E.I. Martsinovski [12] showed that water in open reservoirs near water intakes often contained lamblia cysts. This pathogen is also found in the tap water. Outbreaks of giardiasis associated with poor quality of tap water are regularly registered in the USA and other developed countries where the necessary investigations are conducted. In Russia, the only interpreted giardiasis outbreak has been registered in the city of Perm [12].

3. General concept of Non-Communicable Diseases Associated with Water.

Inorganic contaminants in drinking water, which are the causes of diseases, include arsenic, copper, fluorine, lead and nitrates. Organic compounds sparking concern include pesticides, chlordane, phenol and trihalomethanes [3,69].

Evaluation of possible links between drinking water and malignant neoplasms means identifying chemicals that are found in the water in concentrations sufficient to represent a significant risk of cancer [28].

Some chemicals matters such as arsenic, asbestos, radon, agricultural chemicals and hazardous waste are of the greatest interest to researchers of environmental risk of tumors [14-15,44]. Epidemiological studies in Taiwan [75-76] assumed that arsenic in drinking water posed a significant risk of canceration in liver, lungs, bladder, kidneys, pancreas [76], gullet [75], rectum [77] and breast [74]. Although the toxicological studies do not provide an unequivocal evidence of carcinogenicity of the given element, other epidemiological studies [44-45] also confirm the results of the Taiwan ones. Estimates of the risk of malignancy [45] show that the average arsenic level of 2.5 mg/l in drinking water in the United States is responsible for about 3,000 cases of cancer per year.

Lead: concerns about the potential impact of dissolved lead on the health led to significant efforts to reduce its concentrations in drinking water. Elevated lead levels are found in nature only in a few areas, such as the Debet River basin in Armenia. The usual sources of lead contamination are pipes used in plumbing, and their replacement is the only long-term strategy. Reduced water capacity of dissolving lead can be achieved by dosing orthophosphate or adjusting the pH from acid to alkaline, or both [13].

Arsenic is a known human carcinogen that causes various types of cancer diseases. In the estimation of specialists, in the south-eastern part of Hungary and along the border with Romania, 400,000 people were affected by this element in concentrations exceeding WHO standards in 1981 [35]. At the present time, in the areas with no alternative source for the removal of arsenic from drinking water, a chemical precipitation technology is used. In 1995, it was estimated that the number of people exposed to arsenic in Romania and south-eastern Hungary was reduced to 20,000 people [64]. High concentration of arsenic in the drinking water is an acute problem for Turkey [71].

Fluoride: excess concentration of fluoride in drinking water is the cause of fluorosis. Although the exact prevalence of the disease is unknown, according to WHO estimates, fluorosis affects millions of people worldwide. According to WHO guidelines, in most countries the concentration of fluoride is less than 1.5 mg/l. However, in Estonia 25%-35% of drinking water samples that have been analyzed since 1988 exceeded the standard, and 0.7% of population were subjected to high concentrations of this element [64]. In Sweden, where fluoride occurs naturally, according to experts, 2.4% of population is exposed to concentrations above the standard [64]. 35% of population in Moldova is also exposed to high concentrations of fluoride [64]. In India, 62 million people in 17 of the 32 states suffer from dental, skeletal and/or non-skeletal fluorosis [18].

Nitrates (and nitrite): a lot of European countries report the high concentrations of nitrates in drinking water. Nitrate can be reduced to nitrites in the body and may cause juvenile methemoglobinemia. Only a few countries keep records of the disease, and the majority of reported cases are associated with well water, which often comes from shallow wells affected by agricultural activities. Indicators of the reported cases of methemoglobinemia per 100,000 people is 0.26 in Hungary, 0.56 in Slovakia, 0.74 in Romania and 1.26 in Albania [64]. It is estimated that one third of the European population is exposed to nitrates in concentrations above the WHO standard.

Conclusion

Review sources revealed that gastrointestinal diseases, intestinal helminth infestations and protozoan infections as well as the risk of carcinogenic and mutagenic effects on the human body are to a great extent attributed to poor-quality water consumption.

In the literature the pathogenic water pollutants have been given more attention than the chemical ones. The classification of water-related diseases traditionally focuses on diseases caused by infectious microorganisms. However ingestion of toxic chemicals from contaminated water sources is becoming more and more recognized as a source of morbidity and mortality of population in recent decades. These diseases can also be classified as water-related ones.

Based on the above, high-quality water supply exerts a considerable impact on reduction of water-related diseases and rise in the living standards of population**.** A significant number of cases can be prevented with a better access to safe water supply, adequate sanitation facilities and better hygienic practices, especially in the developing countries.

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Литература:

1. *Борзунова Е.А., Кузьмин С.В., Акрамов Р.Л., Киямова Е.Л.* Оценка влияния качества воды на здоровье населения // Гигиена и санитария. 2007. №3. С. 32-34.

2. *Васильева М.В., Натарова А.А., Мелихова Е.П.* Гигиеническое значение питьевой воды в жизнедеятельности человека // Символ науки. 2016. №3. С. 180-181.

3. *Горбачев А.Л., Добродеева Л.К., Теддер Ю.Р., Шацова Е.Н.* Биогеохимическая характеристика северных регионов. Микроэлементный статус населения архангельской области и прогноз развития эндемических заболеваний // Экология человека. 2007. №1. С. 4-11.

4. *Иванов А.В., Тафеева Е.А., Давлетова Н.Х., Вавашкин К.В.* Современные представления о влиянии качества питьевой воды на состояние здоровья населения // Химия и экология. 2012. №3. С. 48-53.

5. Инвестиции в здравоохранение. Отчет о мировом развитии. Вашингтон: Всемирный банк, 1993. 240 с.

6. *Ключников Д.А.* Оценка риска для здоровья населения при употреблении питьевой воды // Сборник тезисов Международной научно-практической конференции «Экология и защита окружающей среды», Минск, 19 – 20 марта, 2014. С. 135-137.

7. *Коваленко Л.М., Рыспаева А.Б., Александрова А.И.* Водообеспечение населения Карагандинской области в рамках программы «Питьевая вода» // Медицина и экология. 2011. № 3. С. 15-19.

8. *Кутлыева А.Г.* Влияние минерального состава питьевой воды на состояние здоровья человека // Сборник статей Международной научно-практической конференции «Современная наука: теоретический и практический взгляд», 28 ноября, 2015. С. 34-37.

9. *Онищенко Г.Г.* О мерах по усилению профилактики паразитарных болезней в России // Медицинская паразитология. 2003. №3. С. 3-7.

10. О санитарно-эпидемиологической обстановке в Российской Федерации в 2010 году // Государственный доклад. М.: Федеральный центр гигиены и эпидемиологии Роспотребнадзора. 2011. 431 с.

11. *Сангаджиев М.М., Онкаев В.А.* Вода Калмыкии – экология и современное состояние // Вестник Калмыцкого университета. 2012. №3. С. 18-25.

12. *Сергеев В.П.* Паразитарные болезни сегодня и завтра // Паразитарные болезни. 2005. №1. С. 13-16.

13. *Сергеев В.П.* Регистрируемая и истинная распространенность паразитарных болезней // Медицинская паразитология. 1992. №2. С. 3-5.

14. *Турбинский В.В., Маслюк А.И.* Риск для здоровья населения химического состава питьевой воды // Гигиена и санитария. 2011. №2. С. 23-27.

15. *Унгуряну Т.Н., Новиков С.М.* Результаты оценки риска здоровью населения России при воздействии химических веществ питьевой воды (обзор литературы) // Гигиена и санитария. 2012. №1. С. 19-24.

16. *Adam R.D.* The Giardia lamblia genome // International Journal for Parasitology. 2000. No.30. P.475-484.

17. *Albonico M., Montresor A., Crompton D.W.T., Savioli L.* Intervention for the control of soil-transmitted helminthiasis in the community // Trends in Parasitology. 2006. No.61. P. 311-348.

18. *Ashbolt N.J.* Microbial contamination of drinking water and disease outcomes in developing regions // Toxicology. 2004. No.198. P. 229-238.

19. *Baldursson S., Karanis P.* Waterborne transmission of protozoan parasites: Review of worldwide outbreaks – An update 2004 – 2010 // Water Research. 2011. No.45. P. 6603-6614.

20. *Bartram J., Cairncross S.* Hygiene, Sanitation, and Water: Forgotten Foundations of Health // PLOS Medicine. 2010. No.7(11). e1000367.

21. *Benenson M.W., Takafuji E.T., Lemon S.M., Greenup R.L., Sulzer A.J.* Oocyst-transmitted toxoplasmosis associated with the ingestion of contaminated water // New England Journal of Medicine. 1982. No. 307. P. 666-669.

22. *Benzeguir A.K., Capraru T., Aust-Kettis A., Bjorkman A.* High frequency of gastrointestinal parasites in refugees and asylum seekers upon arrival in Sweden // Scandinavian journal of infectious diseases. 1999. No.31(1). P. 79-82.

23. *Berkman D.S., Lescano A.G., Gilman R.H., Lopez S.L., Black M.M.* Effects of stunting, diarrheal disease, and parasitic infection during infancy on cognition in late childhood: a follow up study // Lancet. 2002. No.359. P. 564-571.

24. *Bilgic A.* Measuring willingness to pay to improve municipal water in southeast Anatolia, Turkey // Water Resources Research. 2010. No.46. W12545, doi: 10.1029/2009WR009010.

25. *Boschi-Pinto C., Velebit L., Shibuya K.* Estimating child mortality due to diarrhea in developing countries // Bull World Health Organ. 2008. No.86. P. 710-717.

26. *Bowie W.R., King A.E., Werker D.H., Isaac-Renton J.L., Bell A., Eng S.B., Marion S.A.* Outbreak of toxoplasmosis associated with municipal drinking water // Lancet. 1997. No.350. P. 173-177.

27. *Cairncross S., Valdmanis V.* Water Supply, Sanitation, and Hygiene Promotion. Disease Control Priorities in Developing Countries. Chapter 41. Oxford University Press, 2006.

28. Calcium and Magnesium in Drinking Water: Public Health Significance. Geneva: World Health Organization, 2009.

29. *Cifuentes E., Blumenthal U., Ruizpalacios G., Bennett S., Quigley M., Peasey A., Toerozlvarez H.* Health problems related to irrigation with wastewater in Mexico // Salud Publica de Mexico. 1993. No.35(6). P. 614-619.

30. *Cook J.A.* Eliminating blinding trachoma // The New England Journal of Medicine. 2008. No.358. P. 1777-1799.

31. *Cotruva J.A., Durfour A., Rees G., Bartram J., Carr R., Cliver D.O., Craun G.F., Fayer R., Gannon V.P.J.* Waterborne zoonoses: identification causes and control. World Health Organisation, IWA Publishing, 2004.

32. *Dar O.A., Khan M.S.* Millennium development goals and the water target: details, definitions and debate // Tropical Medicine and International Health. 2011. No.16(5). P. 540-544.

33. *Edmunds W.M., Smedley P.L.* Fluoride in natural waters. In: Essentials of medical geology: the impacts of natural environment on public health. London: Elsevier Academic Press, 2005. P. 301-329.

34. *Emerson P.M., Lindsay S.W., Alexander N., Bah M., Dibba S.M., Faal H.B., Lowe K.O., McAdaam K.P., Ratcliffe A.A., Walraven G.E., Bailey R.L.* Role of flies and provision of latrines in trachoma control: cluster-randomised controlled trial // Lancet. 2004. No.363. P. 1093-1098.

35. Fighting disease, fostering development. The World Health Report. Geneva: World Health Organization, 1996.137 p.

36. *Gadgil A.* Drinking water in developing countries // Annual Review of Energy and the Environment. 1998. No.23. P. 253-286.

37. Guidelines for drinking water quality: recommendations. 2nd edition. Geneva: World Health Organization, 1993. P. 41-42.

38. *Hakim S., Gan C., Malkit K., Azian M., Chong C., Shaari N., Zainuddin W., Chin C., Sara Y., Lye M.* Parasitic infections among Orang Asli (Aborigine) in the Cameron Highlands, Malaysia //

Southeast Asian Journal of Tropical Medicine and Public Health. 2007. No.38. P. 415-419.

39. *Hotez P.J., Bundy D.A.P., Beegle K., Brooker S., Drake L., de Silva N., Montresor A., Engels D., Jukes M., Chitsulo L., Chow J., Laxminarayan R., Michaud C., Bethony J., Correa-Oliveira R., Shuhua X., Fenwick A., Savioli L.* Helminth infections: soil–transmitted helminth infections and schistosomiasis. Disease control priorities in developing countries, 2nd edition. Washington, D.C.: World Bank, 2006. P. 467-482.

40. *Howe D.K., Honore S., Derouin F., Sibley L.D.* Determination of genotypes of Toxoplasma gondii strains isolated from patients with toxoplasmosis // Journal of Clinical Microbiology. 1997. No.35. P. 1411-1414.

41. *Hunter P.R., MacDonald A.M., Carter R.C.* Water Supply and Health // PLOS Medicine. 2010. No.7(11). e1000361. doi:10.1371/journal.pmed.1000361.

42. *Hunter P.R.* Waterborne disease: epidemiology and ecology. Chichester: Wiley, 1997. 372 p.

43. *Jakubowski W., Boutros S., Faber W., Fayer R., Ghiorse W., LeChevallier M., Rose J., Schaub S., Singh A., Stewart M.* Environmental methods for Cryptosporidium // Journal of the American Water Works Association. 1996. No.87(9). P. 107-121.

44. *Janna H., Abbas M.D., Mojid M.H.* Demineralized Drinking Water in Local Reverse Osmosis Water Treatment Stations and the Potential Effect on Human Health // Journal of Geoscience and Environment Protection. 2016. No.4. P. 104-110.

45. *Jonathan E.M., Rose H.G.* Arsenic and skin cancer in the USA: the current evidence regarding arsenic-contaminated drinking water // International Journal of Dermatology. 2016. doi:10.1111/ijd.13318.

46. *Karanis P., Kourenti C., Smith H.* Waterborne transmission of protozoan parasites: a worldwide review of outbreaks and lessons learnt // Journal of Water and Health. 2007. No.5. P. 1-38.

47. *Karim M.M.* Arsenic in groundwater and health problems in Bangladesh // Water Research. 2000. No.34. P. 304-310.

48. *Kindhauser M.K.* Communicable Diseases 2002: Global defence against the infectious disease threat. Geneva: World Health Organization, 2003.

49. *Li J.W., Xin Z.T., Wang X.W., Zheng J.L., Chao F.H.* Mechanisms of inactivation of hepatitis A virus by chlorine // Applied and Environmental Microbiology. 2002. No.68(10). P. 4951-4955.

50. *Markus M.B.* Helminthiasis: new medical significance // Trends in Parasitology. 2002. No.18. P. 205.

51. *Mathis A.* Microsporidia: emerging advances in understanding the basic biology of these unique organisms // International Journal for Parasitology. 2000. No.30. P. 795-804.

52. *Mc Kee M., Balabanova D., Akingbade K., Pomerleau J., Stickley A., Rose R., Haerpfer C.* Access to water in the countries of the former Soviet Union // Public Health. 2006. No.120. P. 364-372.

53. *Mead P.S., Slutsker L., Dietz V., Mc Caig L.F., Bresee J.S., Shapiro C., Griffin P.M., Tauxe R.V.* Food-related illness and death in the United States // Emerging Infectious Diseases. 1999. No.5. P. 607-625.

54. *Melese M., Alemayehu W., Lakew T., Yi I., House J., Chidambaram J.D., Zhou Z., Cevellos V., Ray K., Hong K.C., Porco T.C., Phan I., Zaidi A., Gaynor B.D., Whitcher J.P., Lietman T.M.* Comparison of annual and biannual mass antibiotic administration for elimination of infectious trachoma // The Journal of the American Medical Association. 2008. No.299. P. 778-784.

55. *Orlandi P.A., Lampel K.A.* Extraction free, filter based template preparation for rapid and sensitive PCR detection of pathogenic protozoa // Journal of Clinical Microbiology. 2000. No.38. P. 2271-2277.

56. *Parry-Jones S., Kolsky P, Smith L., Cairncross S.* Some global statistics for water and sanitation related diseases. WEDC: Loughborough University, UK, 2005.

57. *Pruss-Ustun A., Bos R., Gore F., Bartram J.* Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health. Geneva: World Health Organization, 2008. 60 p.

58. *Quick R.* A new strategy for waterborne disease prevention. 23rd WEDC Conference. Durban, South Africa, 1997.

59. *Resnikoff S., Pascolini D., Etya'ale D., Kocur I., Pararajasegaram R., Pokharel G.P., Mariotti S.P.* Global data on visual impairment in

the year 2002 // Bull World Health Organ. 2004. No.82(11). P. 844-851.

60. *Rosado M.A., Cunha-E-SA M.A., Ducla-Soares M.M., Nunes L.C.* Combining averting behavior and contingent valuation data: An application to drinking water treatment in Brazil // Environment and Development Economics. 2006. No.11: 729-746.

61. *Rose J.B.* Environmental ecology of Cryptosporidium and public health implications // Annual Review of Public Health. 1997. No.18. P. 135-161.

62. *Santaniello-Newton A., Hunter P.R.* Management of an outbreak of meningococcal meningitis in a Sudanese refugee camp in northern Uganda // Epidemiology an Infection. 2000. No.124. P. 75-81.

63. *Schmidt W.P., Cairncross S., Barreto M.L., Clasen T., Genser B.* Recent diarrheal illness and risk of lower respiratory infections in children under the age of 5 years // International Journal of Epidemiology. 2009. No.38(3). P. 766-772.

64. *Shadduck J.A.* Human microsporidiosis and AIDS // Reviews of Infectious Diseases. 1989. No.11. P. 203-207.

65. *Shadduck J.A., Polley M.B.* Some factors influencing the in vitro infectivity and replication of Encephalitozoon cuniculi // Journal of Protozoology. 1978. No.25. P. 491-496.

66. *Smith H.V.* Detection of parasites in the environment // Parasitology. 1998. No.117. P. S113-S141.

67. *Smith H.V., Rose J.B.* Waterborne cryptosporidiosis: current status // Parasitology Today. 1998. No.14. P. 14-22.

68. *Stanwell-Smith R., Andersson Y., Levy D.A.* National surveillance systems. In: Drinking Water and Infectious Diseases Establishing the Links. London: CRC Press, 2003.

69. *Suliaman I.M., Xiao L., Lal A.* Evaluation of Cryptosporidium parvum genotyping techniques // Applied and Environmental Microbiology. 1999. No.65. P. 4431-4435.

70. *Slifko T.R., Smith H.V., Rose J.B.* Emerging parasite zoonoses associated with water and food // International Journal for Parasitology. 2000. No.30. P. 1379-1393.

71. *Waller T.* Sensitivity of Encephalitozoon cuniculi to various temperatures, disinfectants and drugs // Lab Animal. 1979. No.13. P. 227-230.

72. *White G., Bradley D., White A.* Drawers of Water: Domestic Water Use in East Africa. Chicago: University of Chicago Press, 1972.

73. *Wolk D.M., Johnson C.H., Rice E.W., Marshall M.M., Grahn K.F., Plummer C.B., Sterling C.R.* A spore counting method and cell culture model for chlorine disinfection studies of Encephalitozoon syn. Septata intestinalis // Applied and Environmental Microbiology. 2000. No.66. P. 1266-1273.

74. *Yang C.Y., Chiu H.F., Cheng M.F., Hsu T.Y., Cheng M.F., Wu T.N.* Calcium and Magnesium in Drinking Water and the Risk of Death from Breast Cancer // Journal of Toxicology and Environmental Health, Part A. 2000. No.60. P. 231-241.

75. *Yang C.Y., Chiu H.F., Cheng M.F., Tsai S.S., Hung C.F., Lin M.C.* Esophageal Cancer Mortality and Total Hardness Levels in Taiwan's Drinking Water // Environmental Research. 1999. No.81. P. 302-308.

76. *Yang C.Y., Chiu H.F., Cheng M.F., Tsai S.S., Hung C.F., Tseng Y.T.* Pancreatic Cancer Mortality and Total Hardness Levels in Taiwan's Drinking Water // Journal of Toxicology and Environmental Health, Part A. 1999. No.56. P. 361-369.

77. *Yang C.Y., Tsai S.S., Lai T.C., Hung C.F., Chiu H.F.* Rectal Cancer Mortality and Total Hardness Levels in Taiwan's Drinking Water // Environmental Research. 1999. No.80. P. 311-316.

References:

1. Borzunova E.A., Kuzmin S.V., Akramov R.L., Kiyamova E.L. Otsenka vliyaniya kachestva vody na zdorovye naseleniya [Assessment of the impact of water quality on public health]. *Gigiyena i sanitariya* [Hygiene and sanitation]. 2007. No.3. P. 32-34. [in Russian]

2. Vasilyeva M.V., Natarova A.A., Melikhova Y.P. Gigiyenicheskoye znacheniye pityevoy vody v zhiznedeyatelnosti cheloveka [Hygienic significance of drinking water in human life]. *Simvol nauki* [Symbol of Science]. 2016. No.3. P. 180-181. [in Russian]

3. Gorbachev A.L., Dobrodeyeva L.K., Tedder Y.R., Shatsova Y.N. *Biogeokhimicheskaya kharakteristika severnykh regionov. Mikroelementnyy status naseleniya arkhangelskoy oblasti i prognoz razvitiya*

endemicheskikh zabolevaniy [Biogeochemical characteristics of the northern regions. Microelement status of the population of the Arkhangelsk region and the forecast of development of endemic diseases]. *Ekologiya cheloveka* [Human ecology]. 2007. No.1. P. 4-11. [in Russian]

4. Ivanov A.V., Tafeyeva Ye.A., Davletova N.Kh., Vavashkin K.V. Sovremennye predstavleniya o vliyanii kachestva pityevoy vody na sostoyaniye zdorovya naseleniya [Modern ideas about the impact of drinking water quality on public health]. *Khimiya i ekologiya* [Chemistry and Ecology]. 2012. No.3. P. 48-53. [in Russian]

5. *Investitsii v zdravookhraneniye* [Investments in health care]. *Otchet o mirovom razvitii* [World Development Report]: Washington, *Vsemirnyi Bank* [The World Bank], 1993. P. 240. [in Russian]

6. Klyuchnikov D.A. Otsenka riska dlya zdorovya naseleniya pri upotreblenii pityevoy vody [Assessment of the risk of drinking water use to public health. *Sbornik tezisov Mezhdunarodnoy nauchno-prakticheskoy konferentsii «Ekologiya i zashchita okruzhayushchey sredy»* [Collection of Abstracts of the International Research and Practice Conference "Ecology and Environmental Protection"], Minsk, 19 – 20th of March, 2014. P. 135-137. [in Russian]

7. Kovalenko L.M., Ryspayeva A.B., Aleksandrova A.I. Vodoobespecheniye naseleniya Karagandinskoy oblasti v ramkakh programmy «Pityevaya voda» [Water supply of the population of the Karaganda region in the framework of "Drinking Water" Program]. *Meditsina i ekologiya*. [Medicine and ecology]. 2011. No. 3. P. 15-19. [in Russian]

8. Kutlyyeva A.G. *Vliyaniye mineralnogo sostava pityevoy vody na sostoyaniye zdorovya cheloveka* [Health effect of the mineral composition of drinking water] // *Sbornik statey Mezhdunarodnoy nauchno-prakticheskoy konferentsii «Sovremennaya nauka: teoreticheskiy i prakticheskiy vzglyad»* [Collection of articles of the International Research and Practice Conference "Modern Science: Theoretical and Practical View"]. 28th November, 2015. P. 34-37. [in Russian]

9. Onishchenko G.G. O merakh po usileniyu profilaktiki parazitarnykh bolezney v Rossii [On measures to strengthen the prevention of parasitic diseases in Russia]. *Meditsinskaya parazitologiya* [Medical parasitology]. 2003. No.3. P. 3-7. [in Russian]

10. O sanitarno-epidemiologicheskoy obstanovke v Rossiyskoy Federatsii v 2010 godu [The sanitary and epidemiological situation in the Russian Federation in 2010]. *Gosudarstvennyy doklad. M.: Federalnyy tsentr gigiyeny i epidemiologii Rospotrebnadzora* [State report. M: Federal Center for Hygiene and Epidemiology of Federal Service on Customers' Rights Protection and Human Well-being Surveillance]. 2011. P. 431. [in Russian]

11. Sangadzhiyev M.M., Onkayev V.A. Voda Kalmykii – ekologiya i sovremennoye sostoyaniye [Water of Kalmykia – ecology and current state]. *Vestnik Kalmytskogo universiteta* [Bulletin of Kalmyk University], 2012. No.3. P.18-25. [in Russian]

12. Sergeyev V.P. Parazitarnyye bolezni segodnya i zavtra [Parasitic diseases today and tomorrow]. *Parazitarnyye bolezni* [Parasitic diseases]. 2005. No.1. P. 13-16. [in Russian]

13. Sergiyev V.P. Registriruyemaya i istinnaya rasprostranennost parazitarnykh bolezney [The registered and true prevalence of parasitic diseases]. *Meditsinskaya parazitologiya* [Medical parasitology]. 1992. No.2. P. 3-5. [in Russian]

14. Turbinskiy V.V., Maslyuk A.I. Risk dlya zdorovya naseleniya khimicheskogo sostava pityevoy vody [The health effect of chemical composition of drinking water. *Gigiyena i sanitariya* [Hygiene and Sanitation]. 2011. No.2 P. 23-27. [in Russian]

15. Unguryanu T.N., Novikov S.M. Rezultaty otsenki riska zdorovyu naseleniya Rossii pri vozdeystvii khimicheskikh veshchestv pityevoy vody (obzor literatury) [Results of an assessment of the health risk to the Russian population under the influence of drinking water chemicals (literature review)]. *Gigiyena i sanitariya* [Hygiene and Sanitation]. 2012. No.1. P. 19-24. [in Russian]

16. Adam R.D. The Giardia lamblia genome. *International Journal* for *Parasitology*. 2000. No.30. P.475-484.

17. Albonico M., Montresor A., Crompton D.W.T., Savioli L. Intervention for the control of soil-transmitted helminthiasis in the community. *Trends in Parasitology*. 2006. No.61. P. 311-348.

18. Ashbolt N.J.. Microbial contamination of drinking water and disease outcomes in developing regions. *Toxicology.* 2004. No.198. P. 229-238.

19. Baldursson S., Karanis P. Waterborne transmission of protozoan parasites: Review of worldwide outbreaks – An update 2004 – 2010. *Water Research.* 2011. No.45. P. 6603-6614.

20. Bartram J., Cairncross S. Hygiene, Sanitation, and Water: Forgotten Foundations of Health. *PLOS Medicine.* 2010. No.7(11). e1000367.

21. Benenson M.W., Takafuji E.T., Lemon S.M., Greenup R.L., Sulzer A.J. Oocyst-transmitted toxoplasmosis associated with the ingestion of contaminated water. *New England Journal of Medicine.* 1982. No. 307. P. 666-669.

22. Benzeguir A.K., Capraru T., Aust-Kettis A., Bjorkman A. High frequency of gastrointestinal parasites in refugees and asylum seekers upon arrival in Sweden. *Scandinavian journal of infectious diseases.* 1999. No.31(1). P. 79-82.

23. Berkman D.S., Lescano A.G., Gilman R.H., Lopez S.L., Black M.M. Effects of stunting, diarrheal disease, and parasitic infection during infancy on cognition in late childhood: a follow up study. *Lancet.* 2002. No.359. P. 564-571.

24. Bilgic, A. Measuring willingness to pay to improve municipal water in southeast Anatolia, Turkey. *Water Resources Research*. 2010. No.46. W12545, doi: 10.1029/2009WR009010.

25. Boschi-Pinto C., Velebit L., Shibuya K. Estimating child mortality due to diarrhea in developing countries. *Bull World Health Organ.* 2008. No.86. P. 710-717.

26. Bowie W.R., King A.E., Werker D.H., Isaac-Renton J.L., Bell A., Eng S.B., Marion S.A. Outbreak of toxoplasmosis associated with municipal drinking water. *Lancet.* 1997. No.350. P. 173-177.

27. Cairncross S., Valdmanis V. Water Supply, Sanitation, and Hygiene Promotion. Disease Control Priorities in Developing Countries. Chapter 41. Oxford University Press, 2006.

28. *Calcium and Magnesium in Drinking Water: Public Health Significance.* Geneva: World Health Organization, 2009.

29. Cifuentes E., Blumenthal U., Ruizpalacios G., Bennett S., Quigley M., Peasey A., Toerozlvarez H. Health problems related to irrigation with wastewater in Mexico. *Salud Publica de Mexico.* 1993. No.35(6). P. 614-619.

30. Cook J.A. Eliminating blinding trachoma. *The New England Journal of Medicine.* 2008. No.358. P. 1777-1799.

31. Cotruva J.A., Durfour A., Rees G., Bartram J., Carr R., Cliver D.O., Craun G.F., Fayer R., Gannon V.P.J. *Waterborne zoonoses: identification causes and control.* World Health Organisation, IWA Publishing, 2004.

32. Dar O.A., Khan M.S. Millennium development goals and the water target: details, definitions and debate. *Tropical Medicine and International Health.* 2011. No.16(5). P. 540-544.

33. Edmunds W.M., Smedley P.L. Fluoride in natural waters. In: Essentials of medical geology: the impacts of natural environment on public health. *London: Elsevier Academic Press*, 2005. P. 301-329.

34. Emerson P.M., Lindsay S.W., Alexander N., Bah M., Dibba S.M., Faal H.B., Lowe K.O., McAdaam K.P., Ratcliffe A.A., Walraven G.E., Bailey R.L. Role of flies and provision of latrines in trachoma control: cluster-randomised controlled trial. *Lancet.* 2004. No.363. P. 1093-1098.

35. *Fighting disease, fostering development.* The World Health Report. Geneva: World Health Organization, 1996.137 p.

36. Gadgil A. Drinking water in developing countries. *Annual Review of Energy and the Environment.* 1998. No.23. P. 253-286.

37. *Guidelines for drinking water quality: recommendations.* 2nd edition. Geneva: World Health Organization, 1993. P. 41-42.

38. Hakim S., Gan C., Malkit K., Azian M., Chong C., Shaari N., Zainuddin W., Chin C., Sara Y., Lye M. Parasitic infections among Orang Asli (Aborigine) in the Cameron Highlands, Malaysia. *Southeast Asian Journal of Tropical Medicine and Public Health.* 2007. No.38. P. 415-419.

39. Hotez P.J., Bundy D.A.P., Beegle K., Brooker S., Drake L., de Silva N., Montresor A., Engels D., Jukes M., Chitsulo L., Chow J., Laxminarayan R., Michaud C., Bethony J., Correa-Oliveira R., Shuhua X., Fenwick A., Savioli L. *Helminth infections: soil–transmitted helminth infections and schistosomiasis. Disease control priorities in developing countries, 2nd edition.* Washington, D.C.: World Bank, 2006. P. 467-482.

40. Howe D.K., Honore S., Derouin F., Sibley L.D. Determination of genotypes of Toxoplasma gondii strains isolated from patients with toxoplasmosis. *Journal of Clinical Microbiology.* 1997. No.35. P. 1411-1414.

41. Hunter P.R., Mac Donald A.M., Carter R.C. Water Supply and Health. *PLOS Medicine*. 2010. No.7(11). e1000361. doi:10.1371/journal.pmed.1000361.

42. Hunter P.R. *Waterborne disease: epidemiology and ecology.* Chichester: Wiley, 1997. 372 p.

43. Jakubowski W., Boutros S., Faber W., Fayer R., Ghiorse W., LeChevallier M., Rose J., Schaub S., Singh A., Stewart M. Environmental methods for Cryptosporidium. *Journal of the* American Water Works Association. 1996. No.87(9). P. 107-121.

44. Janna H., Abbas M.D., Mojid M.H. Demineralized Drinking Water in Local Reverse Osmosis Water Treatment Stations and the Potential Effect on Human Health. *Journal of Geoscience and Environment Protection*. 2016. No.4. P. 104-110.

45. Jonathan E.M., Rose H.G. Arsenic and skin cancer in the USA: the current evidence regarding arsenic-contaminated drinking water. *International Journal of Dermatology.* 2016. doi:10.1111/ijd.13318.

46. Karanis P., Kourenti C., Smith H. Waterborne transmission of protozoan parasites: a worldwide review of outbreaks and lessons learnt. *Journal of Water and Health.* 2007. No.5. P. 1-38.

47. Karim M.M. Arsenic in groundwater and health problems in Bangladesh. *Water Research.* 2000. No.34. P. 304-310.

48. Kindhauser M.K. *Communicable Diseases 2002: Global defence against the infectious disease threat.* Geneva: World Health Organization, 2003.

49. Li J.W., Xin Z.T., Wang X.W., Zheng J.L., Chao F.H. Mechanisms of inactivation of hepatitis A virus by chlorine. *Applied and Environmental Microbiology.* 2002. No.68(10). P. 4951-4955.

50. Markus M.B. Helminthiasis: new medical significance. *Trends* in *Parasitology*. 2002. No.18. P. 205.

51. Mathis A. Microsporidia: emerging advances in understanding the basic biology of these unique organisms. *International Journal* for *Parasitology*. 2000. No.30. P. 795-804.

52. Mc Kee M., Balabanova D., Akingbade K., Pomerleau J., Stickley A., Rose R., Haerpfer C. Access to water in the countries of the former Soviet Union. *Public Health.* 2006. No.120. P. 364-372.

53. Mead P.S., Slutsker L., Dietz V., McCaig L.F., Bresee J.S., Shapiro C., Griffin P.M., Tauxe R.V. Food-related illness and death in the United States. *Emerging Infectious Diseases*. 1999. No.5. P. 607-625.

54. Melese M., Alemayehu W., Lakew T., Yi I., House J., Chidambaram J.D., Zhou Z., Cevellos V., Ray K., Hong K.C., Porco T.C., Phan I., Zaidi A., Gaynor B.D., Whitcher J.P., Lietman T.M. Comparison of annual and biannual mass antibiotic administration for elimination of infectious trachoma. *The Journal of the American Medical Association.* 2008. No.299. P. 778-784.

55. Orlandi P.A., Lampel K.A. Extraction free, filter based template preparation for rapid and sensitive PCR detection of pathogenic protozoa. *Journal of Clinical Microbiology.* 2000. No.38. P. 2271-2277.

56. Parry-Jones S., Kolsky P, Smith L., Cairncross S. *Some global statistics for water and sanitation related diseases.* WEDC: Loughborough University, UK, 2005.

57. Pruss-Ustun A., Bos R., Gore F., Bartram J. *Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health.* Geneva: World Health Organization, 2008. 60 p.

58. Quick R. *A new strategy for waterborne disease prevention. 23rd WEDC Conference*. Durban, South Africa, 1997.

59. Resnikoff S., Pascolini D., Etya'ale D., Kocur I., Pararajasegaram R., Pokharel G.P., Mariotti S.P. Global data on visual impairment in the year 2002. *Bull World Health Organ.* 2004. No.82(11). P. 844-851.

60. Rosado M.A., Cunha-E-SA M.A., Ducla-Soares M.M., Nunes L.C. Combining averting behavior and contingent valuation data: An application to drinking water treatment in Brazil. *Environment and Development Economics*. 2006. No.11: 729-746.

61. Rose J.B. Environmental ecology of Cryptosporidium and public health implications.

Annual Review of Public Health. 1997. No.18. P. 135-161.

62. Santaniello-Newton A., Hunter P.R. Management of an outbreak of meningococcal meningitis in a Sudanese refugee camp in northern Uganda. *Epidemiology an Infection.* 2000. No.124. P. 75-81.

63. Schmidt W.P., Cairncross S., Barreto M.L., Clasen T., Genser B. Recent diarrheal illness and risk of lower respiratory infections in children under the age of 5 years. *International Journal of Epidemiology*. 2009. No.38(3). P. 766-772.

64. Shadduck J.A. Human microsporidiosis and AIDS. *Reviews of Infectious Diseases*. 1989. No.11. P. 203-207.

65. Shadduck J.A., Polley M.B. Some factors influencing the in vitro infectivity and replication of Encephalitozoon cuniculi. *Journal of Protozoology.* 1978. No.25. P. 491-496.

66. Smith H.V. Detection of parasites in the environment. *Parasitology.* 1998. No.117. P. S113-S141.

67. Smith H.V., Rose J.B. Waterborne cryptosporidiosis: current status. *Parasitology Today*. 1998. No.14. P. 14-22.

68. Stanwell-Smith R., Andersson Y., Levy D.A. *National surveillance systems. In: Drinking Water and Infectious Diseases Establishing the Links.* London: CRC Press, 2003.

69. Suliaman I.M., Xiao L., Lal A. Evaluation of Cryptosporidium parvum genotyping techniques. *Applied and Environmental Microbiology.* 1999. No.65. P. 4431-4435.

70. Slifko T.R., Smith H.V., Rose J.B. Emerging parasite zoonoses associated with water and food. *International Journal for Parasitology.* 2000. No.30. P. 1379-1393.

71. Waller T. Sensitivity of Encephalitozoon cuniculi to various temperatures, disinfectants and drugs. *Lab Animal.* 1979. No.13. P. 227-230.

72. White G., Bradley D., White A. *Drawers of Water: Domestic Water Use in East Africa.* Chicago: University of Chicago Press, 1972.

73. Wolk D.M., Johnson C.H., Rice E.W., Marshall M.M., Grahn K.F., Plummer C.B., Sterling C.R. A spore counting method and cell culture model for chlorine disinfection studies of Encephalitozoon syn. Septata intestinalis. *Applied and Environmental Microbiology.* 2000. No.66. P. 1266-1273.

74. Yang C.Y., Chiu H.F., Cheng M.F., Hsu T.Y., Cheng M.F., Wu T.N. Calcium and Magnesium in Drinking Water and the Risk of Death from Breast Cancer. *Journal of Toxicology and Environmental Health, Part A.* 2000. No.60. P. 231-241.

75. Yang C.Y., Chiu H.F., Cheng M.F., Tsai S.S., Hung C.F., Lin M.C. Esophageal Cancer Mortality and Total Hardness Levels in Taiwan's Drinking Water. *Environmental Research.* 1999. No.81. P. 302-308.

76. Yang C.Y., Chiu H.F., Cheng M.F., Tsai S.S., Hung C.F., Tseng Y.T. Pancreatic Cancer Mortality and Total Hardness Levels in Taiwan's Drinking Water. *Journal of Toxicology and Environmental Health, Part A.* 1999. No.56. P. 361-369.

77. Yang C.Y., Tsai S.S., Lai T.C., Hung C.F., Chiu H.F. Rectal Cancer Mortality and Total Hardness Levels in Taiwan's Drinking Water. *Environmental Research.* 1999. No.80. P. 311-316.

Контактная информация:

***Омарова Алуа Ораловна** - докторант PhD 1 года обучения по специальности "Общественное здравоохранение" Карагандинского Государственного медицинский университета, г. Караганда, Республика Казахстан.

Почтовый адрес: Республика Казахстан, 100008, г. Караганда, ул. Гоголя, 40

E-mail: alua_1912@mail.ru

Телефон: 7 778 867 66 00