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ОЦЕНКА РИСКА И УЩЕРБА ЗДОРОВЬЮ НАСЕЛЕНИЯ ПРИ УПОТРЕБЛЕНИИ ВОДЫ И ПРОДОВОЛЬСТВИЯ, СОДЕРЖАЩИХ ХИМИЧЕСКИЕ ЗАГРЯЗНЕНИЯ

С.А. Буймова, А.Г. Бубнов, Ю.В. Царев, А.О. Семенов

Светлана Александровна Буймова*, Андрей Германович Бубнов

Кафедра промышленной экологии, Ивановский государственный химико- технологический университет, Шереметевский пр-т, 7, Иваново, Российская Федерация, 153000
E-mail: byumova@mail.ru *, bubag@mail.ru

Юрий Валерьевич Царев

Кафедра информационных систем и технологий, Ярославский государственный технический университет, Московский пр-т, 88, Ярославль, Российская Федерация, 150023
E-mail: czarev.66@mail.ru

Алексей Олегович Семенов

Кафедра пожарной тактики и основ аварийно-спасательных и других неотложных работ (в составе УНК «Пожаротушение»), Ивановская пожарно-спасательная академия государственной противопожарной службы МЧС России, Строителей пр-т, 33, Иваново, Российская Федерация, 153040
E-mail: ao-semenov@mail.ru

В настоящей статье рассматривается возможность адаптации известных методов оценки риска и расчёта потенциального ущерба для различных групп населения России от потребления питьевой воды и продуктов питания, содержащих различные виды загрязняющих веществ. Были рассмотрены параметры: внешний вид, цвет, вкус, запах, текстура (для всех образцов), а также форма, поверхность, вид трещин (для сухих печенья), запах, аромат, цвет, мутность (для воды в бутылках); pH; содержание минеральных веществ (Na^+, Ca^{2+}, Mg^{2+}, Cu^{2+}, Zn^{2+}, $Fe_{общ}$); содержание токсичных элементов (As^{2+}, Cd^{2+}, Pb^{2+}, Hg^{2+}); содержание хлор-органических пестицидов (ДДТ, α-, β-, γ-ГХГ, гептахлор); содержание влаги, каротиноидов; содержание жира и Cl^- (для консервированного мяса); содержание сухого вещества, примесей растительного происхождения, а также титруемая кислотность (для фруктовых и овощных пюре); толщина, влажность, щелочность, кислотность, водопоглощение, содержание жира и золы (для печенья). В целом были проанализированы 52 показателя качества для каждого из отобранных образцов воды. Согласно выполненной оценке значительным ущербом для здоровья населения является потребление мяса и молока, вырабатываемых в совхозах Ивановской и Костромской области (16000 - 280000 долларов США в год), а также при потреблении бутилированной воды (15000 долл. США до 24540 долл. США в год). Для питьевой родниковой воды ущерб составляет от 270 до 9200 долларов в год. Минимальный ущерб оценивается при потреблении водопроводной воды (2220- 2050 долл. США в год), и фруктовых и овощных пюре (7520 долл. США в год). Предлагаемая методология может быть использована для обоснования стоимости мер по охране окружающей среды, а также мер безопасности, принимаемых органами здравоохранения и социальной защиты.

Ключевые слова: индивидуальный риск, риск для населения, ущерб здоровью, экономический ущерб, безопасность, качество, питание, вода, родники

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ASSESSMENT OF POTENTIAL RISK AND DAMAGE TO POPULATION HEALTH FROM WATER AND FOOD CHEMICAL CONTAMINATION

S.A. Buymova, A.G. Bubnov, Yu.V. Tsarev, A.O. Semenov

Svetlana A. Buymova *, Andrei G. Bubnov

Department of Industrial Ecology, Ivanovo State University of Chemistry and Technology, Sheremetevskiy ave., 7, Ivanovo, 153000, Russia
E-mail: byumova@mail.ru *, bubag@mail.ru

Yuri V. Tsarev

Department of Information Systems and Technologies, Yaroslavl State Technical University, Moskovsky ave., 88, Yaroslavl, 150023, Russia
E-mail: czarev.66@mail.ru

Aleksey O. Semenov

Department of Fire Tactics and Basics of Emergency Rescue and Other Urgent Works (as part of UNK "Firefighting"), Ivanovo Fire and Rescue Academy of the State Fire Service of EMERCOM of Russia, Stroiteley ave., 33, Ivanovo, 153040, Russia
E-mail: ao-semenov@mail.ru

This paper examines the possibility of adapting known methods of risk assessment and calculation of potential damage to various groups of Russian population from consuming drinking water and food containing different types of pollutants. Parameters were considered: appearance, color, taste, smell, texture (for all samples), as well as shape, surface, type of cracks (for dry cookies), odor, aroma, color, turbidity (for bottled water); pH; the content of mineral substances (Na^+, Ca^{2+}, Mg^{2+}, Cu^{2+}, Zn^{2+}, Fe_{gen}); the content of toxic elements (As^{2+}, Cd^{2+}, Pb^{2+}, Hg^{2+}); the content of chlorine-organic pesticides (DDT, α-, β-, γ-HCH, heptachlor); moisture content, carotenoids; fat content and Cl^- (for canned meat); the content of dry matter, vegetable admixtures, and titrated acidity (for fruit and vegetable purees); thickness, humidity, alkalinity, acidity, water absorption, fat and ash content (for biscuits). In total, 52 quality indicators for each of the selected water samples were analyzed. According to the assessment, the significant damage to the health of the population is the consumption of meat and milk produced in the state farms of Ivanovo and the Kostroma region (16000 - 280000 dollars per year), as well as consumption of bottled water ($ 15000 to $ 24540 per year). For drinking spring water, the damage ranges from 270 to 9,200 dollars per year. The minimum damage is estimated with the use of tap water ($ 2,220- $ 2050 per year), and fruit and vegetable purees ($ 7,520 per year). The proposed methodology can be used to justify the cost of environmental protection measures as well as safety measures taken by health protection and welfare authorities.

Key words: individual risk, population risk, damage to health, economic losses, safety, quality, food, water, springs

INTRODUCTION

Analysis, assessment and management of ecological risks are objectives of current importance that prevail while elaborating trends of regional development and technology development [1]. The particularity of this type of risks lays in their close interrelations with other risks, in particular with population health risks, since different pollutants can enter a human body through water and food [2, 3]. In particular, among them are metallic compounds (including heavy metal-containing compounds having toxic effect on the human organism), organochlorine pesticides (DDT, α-, β-, γ- hexachlorocyclohexane, heptachlor) that have carcinogenic effect, and other components whose content exceeds the set standards [4].

The novelty and topicality of the study lie in adapting the known approaches to risk assessment and calculation of potential damage caused to different population groups of the Central Russia by drinking water and food consumption [2, 3]. This paper integrates the information contained herein and the data presented previously. Besides, we carry out continuous multiple control of the presence of hazardous substances in the tested samples of food and drinking water people consume given that their quality is not stable and can change since it is dependent on many factors and parameters such as raw materials quality (in case of food products), negative effects of environmental pollution, seasonality (for natural waters), etc. [5].

For instance, the paper [6] examines approaches and methods used for the economical assessment of health and life risks and statistical value of human life. The author proposes a range of values of health and life risk unit which is recommended for use in Russia when carrying out economic assessment, estimation of efficiency, and optimization of risk reduction costs.

It should be noted that so far in Russia the regulatory documents for assessment of potential risk and damage to population (including children) health caused by the consumption of food and drinking water (containing a number of pollutants) have not been developed. Therefore, additional information that allows to confirm the possibilities of the previously proposed [7, 8] theoretical and methodical approaches to assessment of potential damage to population health, is quite useful. Moreover, the collection of data related to determining qualitative and quantitative values of the level of water and food contamination with different pollutants and assessing risks to population, always has indisputable practical significance due to the fact that it allows decision-makers to develop corrective action plans aimed at reducing (if necessary) the revealed risk values and/or maintaining its acceptable level [9].

In paper [10] has been estimated exposure of chemical contaminants in samples of poultry of regional producers sold in one of the largest hypermarkets in Ivanovo. Food consumption was studied in a cross-sectional study using the method of 24-hour food reproduction. Priority pollutants of the samples of poultry meat forming the risk of development of non-carcinogenic and carcinogenic effects in the population were nitrates, compounds of lead, cadmium, arsenic and mercury. A total of 138 samples of canned tuna, sardines and mackerel from the Serbian market were analyzed in work [11] for toxic (As, Cd, Pb, Hg) element levels [12]. A risk assessment based on the measured levels of examined elements indicated that consumption of canned fish according to current eating habits in Serbia presents little risk to human health since the carcinogenic risk is within the acceptable range, 10^{-4}-10^{-6}. Green and sustainable remediation (GSR) has emerged as one of the most important pioneering directions in the environmental remediation field. The GSR concept calls for maximizing the 'net environmental benefit (NEB)' by taking into account not only the environmental benefit, but also the life cycle environmental cost of remediation operations. However, existing literature to date has not examined how cleanup levels may affect the NEB. In paper [13] proposed a framework that combines life cycle assessment with health risk assessment to derive cleanup levels for remediating contaminated land. This method goes beyond the traditional approach, which focuses on acceptable risk levels to site users. It takes into account the number of potential receptors, as well as life cycle secondary environmental impacts, in order to select the 'greenest' cleanup level which maximizes the NEB. The study [14] monitored the human health risks through dermal exposure, hazardous risks to ecological integrity, contamination levels, spatio-temporal distribution, and congener specific analysis of organochlorine pesticides (OCPs) across River Ravi and its three northern tributaries (Nullah Bein, Nullah Basanter and Nullah Deg). the calculated carcinogenic risk possessed by OCPs through dermal exposure ranged from 1.39 10^{-10} to 1.98 10^{-5} that highlighted the considerable carcinogenic risk associated to aldrin, dieldrin, p,p′-DDT and β-endosulfan at certain studied sites. Therefore, the high levels of ecological risk and carcinogenic human health risk had emphasized an immediate elimination of ongoing OCPs addition in the studied area.

Therefore, *the aim* of this research paper is to examine the possibility of adapting the known methods of risk assessment and calculation of potential damage to various groups of Russian population from consuming drinking water and food containing different types of pollutants. For this very reason, this paper integrates the data contained herein and the data presented previously in [7, 15, 16].

The objects of the research are drinking spring water, bottled water for adults and children, a number of nutritional products, as well as meat and whole raw milk produced by cattle farms in Ivanovo and Kostroma regions (Central Federal District of the Russian Federation). It should be noted that meat and milk are included in the consumer basket, along with water, since they are fundamental components of food consumed by the majority of population.

Samples of spring water were collected from 51 springs surrounding the Volga river basin (Central Federal District of the Russian Federation). During the last 11 years (2003-2013) water samples wear collected on monthly bases from most usable springs surrounding the Volga river. In addition to this, water samples from other springs have been collected 1-4 times per year.

For the enrichment of the research, the following samples were collected:

1. Dry instant milk oatmeal porridges for babies from 5 months and above (hereinafter – oatmeal porridges) produced by 6 different brands:
- 1st brand is Nutricia (the Netherlands), a part of Danone (France);
- 2nd brand is Nutritek (Russia);
- 3rd and 4th brands are Russian companies producing infant food;
- 5th brand is Droga Kolinska (Slovenia);
- 6th brand is Heinz (Italy).

2. Canned sterilized pureed meat «Beef» for babies, produced by 6 brands:
- 1st brand is OAO «Vimm-Bill-Dann» (Russia), which is a part of PepsiCo (USA);
- 2nd, 3rd, and 4th brands are Russian companies producing infant food;
- 5th brand is Danone (France);
- 6th brand is Nestle (Switzerland).

3. Lever pate produced by 6 brands:
- 1st brand is Tulip Food Company (Denmark);
- 2nd brand is a Russian manufacturer, partner of Grand-Mere (Belgium);
- 3rd, 4th, 5th, and 6th brands are Russian.

4. Baby homogenized apple-apricot puree in glass jars, produced by 6 brands:
- 1st brand is OAO «Vimm-Bill-Dann» (Russia), which is a part of PepsiCo (USA);
- 2nd brand is Nutricia (the Netherlands), which is a part of Danone (France);
- 3rd, 4th, 5th, and 6th brands are Russian companies producing infant food.

5. Dry biscuits from 1st grade flour by 5 brands:
- 1st brand is a Russian manufacturer «United Bakers», which is a part of Kellogg Company (USA);
- 2nd and 3rd brands are Russian manufacturers;
- 4th brand is Galletas Gullon S.A. (Spain);
- 5th brand is Vaasan (Finland).

6. Similar products (porridges, canned meat, lever pate, vegetable purees (courgette/eggplant), dry biscuits) for individual meal packs (MRE package № 2) of the officer of the Russian Ministry of Emergencies.

7. Bottled water for children produced by 5 brands. All 5 brands are Russian companies producing infant food.

8. Bottled water for adults produced by 10 brands:
- two brands are OAO «Vimm-Bill-Dann» (Russia), which is a part of PepsiCo (USA);
- third brand is The Coca-Cola Company (USA);
- the other seven brands are Russian companies.

9. Tap water before and after cleansing through absorption water filter pitcher (the filter's manufacturer recommends such water for children of 2 years old and above).

The chosen samples of food and drinking water allow comparing products of various price ranges produced by different manufacturers and supplied by different trademarks owners.

It should be emphasized that the majority of the food and bottled water samples are manufactured in Russia by companies whose trademark is owned by foreign partner companies. At the same time, a number of the analyzed food products is produced by European manufacturers such as oatmeal porridges «Bebi» (Slovenia) and «Heinz» (Italy); canned meat «Gerber» (Switzerland); lever pate «Grand-Mere» (Belgium) and «Tulip» (Denmark); fruit puree «Nutricia» (the Czech Republic); dry biscuits «Maria Ligera» (Spain) and «FinnCrisp» (Finland).

The chemical compositions of the following potable water samples of one Russian brand was analyzed and compared:

- bottled water;
- water passed through a water cooler;
- mineral water used for curative purposes.

It is important to note that currently in Russia there is no methodology of the uniform integral quality assessment for the above mentioned products. As such their negative influence upon human organism and subsequent potential health risk and damage [17] (for instance, that is the case for spring waters [15]). The quality assessment for food, including potable water, is limited to determining specific primary and secondary quality parameters specified in Russian national standards.

METHODS OF RESEARCH

Samples collection, preparation and analysis were performed in accordance with Russian applicable guideline documents.

Spring water sampling was performed according to GOST 31861-2012 «Water. General requirements for sampling», bottled water sampling – according to GOST 32220-2013 «Drinking bottled water. General specifications», food products – in accordance with methodical recommendations MosMR 2.3.2.006-03 «Food sampling for laboratory tests and studies». The single samples were bought in stores of the big supermarket chains in Ivanovo. Then, these samples were combined and an average sample was formed (for each item of the product line of a certain brand) which was sent to the laboratory for testing. The weight (volume) of a product sample was determined in accordance with the reference documentation for a particular type of product so that the weight (volume) was sufficient for testing.

In order to obtain an initial sample of preserved food products packed in tin cans, glass or polymer containers, not less than 5 packaged items were collected since a homogeneous lot of products contained up to 1000 pieces.

Spring water samples for physical and chemical tests were collected in containers made from chemical-resistant glass with friction-fitted lids or from polymer materials allowed for use as water contact materials.

The delivery of samples to the laboratory was performed under conditions that excluded the possibility of change of sample characteristics able to influence the quality of test results (temperature conditions, delivery time, etc).

The selected samples were marked, and the accompanying documents containing the sample name, the weight (volume), the collection place, date, and time, collection and transportation conditions, were filled out.

It should be noted that baby food is subject to stricter control and requirement compared with food made for adults. The product samples collected for this research should meet the standards of hygiene, safety and nutritional value of baby food, as well as sanitary-epidemiological regulations and norms. Therefore, first of all, *the chemical composition of selected products* wear analyzed. The following quality control parameters were examined:

Organoleptic parameters: appearance, color, taste, odor, texture (for all samples), as well as form, surface, fracture view (for dry biscuits), odor, flavor, color, turbidity (for bottled water);

- safety: pH value; content of mineral substances (Na^+, Ca^{2+}, Mg^{2+}, Cu^{2+}, Zn^{2+}, Fe_{gen}); content of toxic elements (As^{2+}, Cd^{2+}, Pb^{2+}, Hg^{2+}); content of chlor-organic pesticides (DDT, α-, β-, γ-HCH, heptachlor);

- use: moisture content and content of carotenoids, i.e. organic pigments found in plants (for porridge samples); content of fat and Cl^- (for canned meat and lever pate); dry matter content, content of impurities of plant origin as well as titratable acidity (for fruit and vegetable purees); thickness, moisture, alkalinity, acidity, water absorptivity, content of fat and ash (for dry biscuits).

52 Quality parameters were analyzed for each of the selected water samples (for compliance with hygiene standards).

Thermo-gravimetric, photometric (in particular, photoelectric colorimetry (PHC)), titrimetric, and potentiometric methods, as well as methods of gas-liquid chromatography and atomic absorption spectroscopy (AAS) were used for the determination of the above mentioned parameters. The obtained results were presented with the consideration of the combined uncertainty, including its systematic and random components. The uncertainty of the applied method was estimated. Also, the uncertainty estimated using the Student's method was taken into account based on five parallel experiments.

The choice of the quality parameters is determined by:

1) hygienic requirements for potable water and food quality;

2) need of a number of elements for the proper growth and development of infant and adult organisms;

3) safety requirements for potable water and food quality.

The amount of risk was calculated based on basic data of quantitative analysis. The applied methodology of assessment of population health potential damage and risk provoked by consuming drinking water and food was partly described in [6, 7].

The average daily doses are calculated for the monitored metals compounds (that are not carcinogenic) which enter a human body through regular consumption of the analyzed samples of water and food *(CDI)*, mg/kg $_{weight}$ per day):

$$CDI = \frac{Q \cdot IR \cdot EF \cdot ED}{BW \cdot AT} \quad (1)$$

Q – the concentration of heavy metals in drinking water sample (mg/ml) or in food sample (mg/kg) calculated by means of chemical analysis; *IR* – the average daily consumption of drinking water (ml/day) or food (kg/day). For purposes of the calculation, it is assumed that IR is 2000 ml/day for drinking water, 0.16 kg/day for meat, 0.62 for milk (the average density of raw milk is 1.065 t/m^3), 0.135 for baby porridge, 0.075 for canned meat, 0.16 for lever pate, 0.045 for fruit and vegetable purees, and 0.1 for dry biscuits; *EF* – exposure frequency (days per year). For purposes of the calculation, it is assumed that the analyzed potable water and food are included in daily ration. Therefore, EF is 365 days per year.

ED – exposure duration (year), calculated as the difference between the average life expectancy in the region ($T_{average}$) and the average age of customers. The calculations are based on the data from the Russian Federal State Statistics Service official web-site. The duration of meat and milk as well as lever pate and dry biscuits consumption by adults was assumed to be

20 years; the duration of baby food (oatmeal porridges, canned meat, fruit and vegetable purees) and drinking water consumption was assumed to be 1.5 years;

BW – the average human weight (kg). BW for adults is 70 kg, for children – 11.32 kg through 13.35 kg.

AT – averaging time, days. This value is calculated as $T_{average}$ 365 days.

These standards are recommended by Deutsche Gesselschaft fur Ernahrung (DGE), the Food and Nutrition Board (FNB) of the Institute of Medicine (USA) and the European Union Scientific Committee on Food (SCF) [13].

The lifetime individual risk of death (LR) caused by consuming drinking water and food is calculated for carcinogenic substances (such as compounds of Cd, Pb, As, etc.) using the following formula:

$$LR = CDI \cdot SF, \quad (2)$$

SF – carcinogenic potential factor, $(mg/(kg_{human\ weight}\ per\ day))^{-1}$, that serves as the basis for the recalculation of contribution of the average daily intake (.i.e. dose) to the value of the lifetime individual risk of death. SF_{Cd} = 0,38, SF_{Pb} = 0,047, SF_{As} = 1,5 $(mg/(kg\cdot per\ day))^{-1}$.

Along with the value of the individual risk of death, the value of population risk (R_{popul}) – possible number of deaths – can be used when evaluating the probability of occurrence of negative effects.

This value can be calculated on the basis of experimental data concerning the chemical composition of the analyzed samples of potable water and food using the method elaborated by B. Cohen [6]:

$$R_{popul} = LR \cdot N, \quad (3)$$

N – number of persons inhabiting the region. However, accurate and precise statistics concerning mortality in different age groups are required for its evaluation. Statistics from Rosstatistika official website were used for ED evaluation.

The approach proposed in [6] is applied to determine the amount of damage to human health caused by various adverse factors. This approach includes the calculation of life expectancy decrease due to the deterioration in life quality (LLE per year):

$$LLE = LR \cdot L, \quad (4)$$

L – remaining life expectancy (year). It is calculated as the difference between the average life expectancy and the average age of consumers. L is considered to be 63.5 years in the calculation for baby drinking water and food.

Knowing the value of LLE, the population health damage can be evaluated in monetary terms (Russian rubles) (damage caused by LLE):

$$Y = LLE \cdot VSL, \quad (5)$$

VSL – value of statistical life (Russian rubles).

The *VSL* for one inhabitant of Ivanovo and Kostroma regions in 2003-2013 used in our calculations is given by the Russian insurance company (Rosgosstrah). For example, in 2012 the average value of life in Russia was 4.5 mln Russian rubles. Besides, the *VSL* can be calculated using the following formula:

$$VSL = \frac{GDP \cdot T_{cp}}{N} \quad (6)$$

GDP (RDP) – Gross Domestic Product (Regional Domestic Product), Russian rubles; $T_{average}$ – average life expectancy in the country (region), year; *N* – number of persons inhabiting the region, person. The disadvantage of such *VSL* evaluation is that the obtained values are not permanent and vary from year to year.

It should be noted that it is rather difficult to evaluate the risk of development of negative consequences for a child's organism since the weight range of young children varies widely and their average weight is rather low (compared to an adult's weight). Therefore, only potential approximate values of risk rating are given in this paper.

RESULTS AND DISCUSSION

Chemical and microbiological analysis of spring water samples showed that 76% of samples contained various kinds of pollutants. The sources located in the area of low anthropogenic influence (rural areas) are much less susceptible to contamination than springs situated on the urbanized territories. The more detailed results of the chemical analysis of spring water samples are given in [15, 16, 18].

One of the samples of ground waters had a higher concentration of hardness salts (SO_4^{2-}, Na^+) as well as higher rate of general mineralization. However, it should be noted that the mentioned waters are curative mineral waters which are used in curative and preventive purposes for the treatment of digestive tract and kidney diseases.

The organoleptic analysis of the samples of food, meat, milk and potable bottled water showed that all the samples met the normative standards. The content of pesticides in all of the analyzed samples was inferior to the detection limit. The parameters of the analyzed products purpose met the requirements of guideline documentation.

The analysis showed that all the sample of the analyzed samples of food, meat, milk, and potable bottled water meet the safety normative standards since the obtained results do not exceed the normative values. The normative value of monitored elements content in potable water is maximum allowable concentration (MAC), in meat and milk – allowable level (AL), in food – daily requirement (DR) for adults and children (through to 3 years old) in accordance with the Russian applicable national standards.

Carcinogenic risks due to spring water and tap water consumption were calculated. Increased population morbidity risks (risks of negative organoleptic effects, chronic intoxication, and general toxicity) were revealed in 2003 – 2013. More detailed results of risk calculation are shown in [15, 19].

Table 1

Lifetime individual health risk for adult people and children at the analyzed products consumption1 ($\times 10^{-5}$)

***Таблица 1*. Индивидуальный риск для здоровья взрослых и детей при потреблении анализируемых продуктов1 ($\times 10^{-5}$)**

<table>
<tr><td rowspan="2">Sample No</td><td rowspan="2" colspan="2">Country – owner of the brand producing the analyzed samples of food and potable water</td><td colspan="3">Metal compounds</td></tr>
<tr><td>Pb</td><td>As</td><td>Cd</td></tr>
<tr><td>1</td><td colspan="2">2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6">Oatmeal porridges</td></tr>
<tr><td>1</td><td colspan="2">France</td><td>3,4</td><td>45,0</td><td>6,5</td></tr>
<tr><td>2</td><td colspan="2">Slovenia</td><td>10,0</td><td>68,0</td><td>4,2</td></tr>
<tr><td>3</td><td colspan="2">Italy</td><td>6,8</td><td>68,0</td><td>4,2</td></tr>
<tr><td>4</td><td colspan="2">Russia</td><td>6,8</td><td>68,0</td><td>10,0</td></tr>
<tr><td>5</td><td colspan="2">Russia</td><td>10,0</td><td>45,0</td><td>10,0</td></tr>
<tr><td>6</td><td colspan="2">Russia</td><td>9,3</td><td>23,0</td><td>8,6</td></tr>
<tr><td>7</td><td colspan="2">Russia – MRE package</td><td>8,7</td><td>45,0</td><td>10,0</td></tr>
<tr><td colspan="6">Canned meat «Beef»</td></tr>
<tr><td>1</td><td colspan="2">France</td><td>0,8</td><td>2,0</td><td>0,5</td></tr>
<tr><td>2</td><td colspan="2">Switzerland</td><td>10,0</td><td>2,0</td><td>1,0</td></tr>
<tr><td>3</td><td colspan="2">USA</td><td>10,0</td><td>1,5</td><td>0,4</td></tr>
<tr><td>4</td><td colspan="2">Russia</td><td>0,5</td><td>2,0</td><td>0,8</td></tr>
<tr><td>5</td><td colspan="2">Russia</td><td>0,8</td><td>2,0</td><td>0,5</td></tr>
<tr><td>6</td><td colspan="2">Russia</td><td>10,0</td><td>2,5</td><td>1,0</td></tr>
<tr><td>7</td><td colspan="2">Russia – MRE package</td><td>0,8</td><td>1,0</td><td>1,0</td></tr>
<tr><td colspan="6">Lever pate</td></tr>
<tr><td>1</td><td colspan="2">Denmark</td><td rowspan="4">0,28
(0,04)</td><td rowspan="4">0,0038
(0,0006)[2]</td><td rowspan="4">0,023 (0,0033)</td></tr>
<tr><td>2</td><td colspan="2">Belgium</td></tr>
<tr><td>3 – 6</td><td colspan="2">Russia</td></tr>
<tr><td>7</td><td colspan="2">Russia – MRE package</td></tr>
<tr><td colspan="6">Fruit and vegetable purees</td></tr>
<tr><td>1</td><td colspan="2">France</td><td rowspan="4">0,05[2]</td><td rowspan="4">0,001[2]</td><td rowspan="4">0,004[2]</td></tr>
<tr><td>2</td><td colspan="2">USA</td></tr>
<tr><td>3 – 6</td><td colspan="2">Russia</td></tr>
<tr><td>7</td><td colspan="2">Russia – MRE package</td></tr>
<tr><td colspan="6">Dry biscuits</td></tr>
<tr><td>1</td><td colspan="2">Spain</td><td rowspan="5">1,74
(0,28)</td><td rowspan="5">0,0024
(0,0004)[2]</td><td rowspan="5">0,14 (0,023)</td></tr>
<tr><td>2</td><td colspan="2">Finland</td></tr>
<tr><td>3</td><td colspan="2">USA</td></tr>
<tr><td>4, 5</td><td colspan="2">Russia</td></tr>
<tr><td>6</td><td colspan="2">Russia – MRE package</td></tr>
<tr><td colspan="6">Meat[3]</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Ivanovo region</td><td>winter</td><td>(0,2 – 1,0)</td><td rowspan="4">(0,0006)[2]</td><td>(0,2 – 1,0)</td></tr>
<tr><td>summer</td><td>(0,3 – 2,0)</td><td>(0,2 – 5,0)</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Kostroma region</td><td>winter</td><td>(0,6 – 2,0)</td><td>(0,6)</td></tr>
<tr><td>summer</td><td>(2,0 – 3,0)</td><td>(0,2 – 4,0)</td></tr>
<tr><td colspan="6">Milk[3]</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Ivanovo region</td><td>winter</td><td>(0,6 – 1,2)</td><td rowspan="4">(0,0026)[2]</td><td>(0,7 – 3,3)</td></tr>
<tr><td>summer</td><td>(0,7 – 3,2)</td><td>(1,0 – 11,2)</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Kostroma region</td><td>winter</td><td>(0,8 – 2,0)</td><td>(0,8)</td></tr>
<tr><td>summer</td><td>(1,1 – 2,0)</td><td>(2,0 – 8,2)</td></tr>
<tr><td colspan="6">Bottled water for children</td></tr>
<tr><td>1-5</td><td colspan="2">Russia</td><td>0,05[2]</td><td>4,8[2]</td><td>0,03[2]</td></tr>
</table>

Bottled water for adults				
1-3	USA	(0,33 – 0,37)	(2,0)[2]	(0,005)[2]
4-10	Russia	(0,32 – 0,42)		
Potable water produced by a Russian brand				
1	Bottled	0,04	(2,0)[2]	0,02
2	Water run through a water cooler	0,04		0,02
3	Mineral	0,08		0,07
1-51	Spring water	(0,07 – 1,0)	(2,0)[2]	(0,005)[2]
1-3	Tap water[3]	(0,016– 0,045)	(2,0)[2]	(0,005)[2]

[1]the brackets indicate the LR value for the health of the adult consumer, the remaining values are given for young children, i.e. up to three years

[2]these components were not detected in the samples, so the risk calculation was carried out on the basis of the detection limit of each of the controlled metals by atomic absorption spectroscopy

[3]the table shows the averaged LR values, for spring and tap water the observation period was 2003–2013, for meat and milk – 2006-2010

[1] в скобках указана величина LR для здоровья взрослого потребителя, остальные значения приведены для детей раннего возраста, т.е. до 3 лет

[2] данные компоненты не были обнаружены в пробах, поэтому расчет риска был проведен исходя из предела обнаружения каждого из контролируемых металлов методом атомно-абсорбционной спектроскопии

[3] в таблице приведены усредненные значения LR, для родниковой и водопроводной воды период наблюдений составлял 2003-2013 гг., для мяса и молока – 2006 - 2010 гг.

The average daily dose and lifetime individual mortality risk are calculated on the basis of chemical analysis results. The calculated CDI values of metals (Cu, Zn, Fe, Na, Ca, Mg) entry in an adult's or child's body through meat and milk, some food and bottled water are allowable since they do not exceed the value of maximum allowable dose and average daily requirement. For Cd, Pb compounds and as there is no value of maximum allowable dose and average daily requirement since the presence of these metals in a human body is intolerable, because they are carcinogenic and toxic for a human organism. Therefore, the lifetime individual mortality risk (LR) due to the analyzed products consumption was calculated. The obtained values of LR are shown in Table 1.

Table 2

Scale for ranking the risk of death

***Таблица 2*. Шкала для ранжирования риска смерти**

Scale of risks of death							
Low		Moderate			High		
< 10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	>
Insig-nifi-cant	Low	Rela-tively low	Mod-erate	Rela-tively high	High	Very high	Extreme
Danger scale							
8	7	6	5	4	3	2	1

According to the classification of levels of risk acceptability [6], the level of individual risk for young children (Table 1) when consuming food (containing Cu, Zn, As, Fe, Cd, Pb) can be considered as:

- moderate, relatively high and high risks – for baby porridges (different samples);
- moderate and relatively high – for canned meat;
- relatively low and moderate – for dry biscuits and natural spring water;
- insignificant and low – for fruit and vegetable purees, lever pate, as well as bottled water for adults and children;
- insignificant and moderate – for meat and milk.

The following scale is used for rating risks of death (Table 2).

Although *the monitored quality parameters values for all analyzed samples corresponded to the normative values*, some samples could be determined as high risk since the method of LR assessment take into account all potential *negative* effects (carcinogenic, mutagenic, teratogenic, embryogenic, etc.) effects of pollutants on child's organism. Thus, risk value is a complex (integral) index compared to the evaluation of the substance content in a product based on the correlation between the maximum allowable concentration and the allowable level. Therefore, the estimation of the lifetime risk from consuming food can become a justification for management decision making when carrying out activities aimed at reducing health risk and improvement of population life quality [20].

The calculated value of population risk R_{popul} (number of potential deaths per year) due to daily consumption of: drinking water (spring and tap water) is approximately 0.004-3.0; baby bottled water – 0.09-0.3; bottled water for adults – approximately 3.4-4.4; food – 0.1-3.2. The values of R_{popul} (potential death of persons inhabiting the mentioned Russian regions), provided that only meat and milk produced in the mentioned regions were consumed, are 1-14 and 6-56 respectively [21, 22].

According to the classification presented in [6], the values of LLE calculated and shown in Table 3 for tap water, bottled water and spring water, meat and milk and other food correspond to the risks caused by earthquake and flood (i.e. insignificant risks).

Table 3

Decrease in an individual's life expectancy and corresponding damage caused by regular consumption of drinking water and food containing Pb and Cd

***Таблица 3*. Снижение ожидаемой продолжительности жизни человека и оценка ущерба, вызванного регулярным потреблением питьевой воды и продуктов питания, содержащих Pb и Cd**

Food or drinking water samples		*LLE*. year		Y. $	Y^1. RUB
		Cd	Pb		
Food					
Oatmeal porridge: France		$4.1\cdot10^{-3}$	$2.1\cdot10^{-3}$	1381.14	88392.96
Slovenia		$2.6\cdot10^{-3}$	$6.3\cdot10^{-3}$	1981.55	126819.20
Italy		$2.6\cdot10^{-3}$	$4.3\cdot10^{-3}$	1535.10	98246.40
Russia		$6.3\cdot10^{-3}$	$4.3\cdot10^{-3}$	2346.63	150184.32
Russia		$6.3\cdot10^{-3}$	$6.3\cdot10^{-3}$	2793.08	178757.12
Russia		$5.4\cdot10^{-3}$	$6.0\cdot10^{-3}$	2520.40	161305.60
Россия ИРП		$6.3\cdot10^{-3}$	$5.5\cdot10^{-3}$	2610.54	167074.56
Canned meat: France		$3.1\cdot10^{-4}$	$5.0\cdot10^{-4}$	181.44	11612.16
Switzerland		$6.3\cdot10^{-4}$	$6.3\cdot10^{-3}$	1536.20	98316.80
USA		$2.5\cdot10^{-4}$	$6.3\cdot10^{-3}$	1451.52	92897.28
Russia		$5.0\cdot10^{-4}$	$3.1\cdot10^{-4}$	181.44	11612.16
Russia		$3.1\cdot10^{-4}$	$5.0\cdot10^{-4}$	181.44	11612.16
Russia		$6.3\cdot10^{-4}$	$6.3\cdot10^{-3}$	1536.20	98316.80
Russia – MRE package		$6.3\cdot10^{-4}$	$5.0\cdot10^{-4}$	251.38	16088.32
Fruit and vegetable purees: France		$2.5\cdot10^{-6}$	$3.1\cdot10^{-5}$	7.52	481.28
USA					
Russia					
Russia – MRE package					
Lever pate: Denmark		For young children (under 3 y.o.)			
Belgium		$1.5\cdot10^{-5}$	$2.0\cdot10^{-4}$	42.35	2710.40
Russia		For adults (18 y.o. and above)			
Russia – MRE package		$1.3\cdot10^{-6}$	$1.5\cdot10^{-5}$	3.67	234.88
Dry biscuits: Spain		For young children (under 3 y.o.)			
Finland		$1.0\cdot10^{-3}$	$1.2\cdot10^{-3}$	217.40	13913.60
USA		For adults (18 y.o. and above)			
Russia		$0.9\cdot10^{-4}$	$1.1\cdot10^{-4}$	19.76	1264.64
Russia – MRE package					
Meat*					
Ivanovo region	summer	$1.4\cdot10^{-4}$	$1.6\cdot10^{-4}$	$(16 – 112)\cdot10^3$	$(1024 – 7168)\cdot10^3$
	winter	$0.5\cdot10^{-4}$	$1.4\cdot10^{-4}$		
Kostroma region	summer	$0.5\cdot10^{-4}$	$8.2\cdot10^{-4}$	$(200 – 280)\cdot10^3$	$(12800 – 17920)\cdot10^3$
	winter	$1.6\cdot10^{-4}$	$1.6\cdot10^{-4}$		
Milk*					
Ivanovo region	summer	$3.3\cdot10^{-4}$	$3.0\cdot10^{-4}$	$(33 – 170)\cdot10^3$	$(2112 – 10880)\cdot10^3$
	winter	$2.2\cdot10^{-4}$	$2.2\cdot10^{-4}$		
Kostroma region	summer	$5.5\cdot10^{-4}$	$2.7\cdot10^{-4}$	$(52 – 277)\cdot10^3$	$(3328 – 17728)\cdot10^3$
	winter	$2.2\cdot10^{-4}$	$2.2\cdot10^{-4}$		
Bottled water for adults					
USA		–	$(7.1–8.2)\cdot10^{-5}$	15.7 – 18.0	1004.8 – 1152
Russia		–	$(6.8 – 10.0)\cdot10^{-5}$	15.0 – 22.0	960 – 1408

Bottled water for kids				
Russia	$8.3 \cdot 10^{-5}$	$2.6 \cdot 10^{-5}$	24.54	1570.56
Drinking water of a Russian brand				
Bottled	$2.0 \cdot 10^{-3}$	$3.0 \cdot 10^{-3}$	494.0	31616.0
Water run through a water cooler	$2.0 \cdot 10^{-3}$	$3.0 \cdot 10^{-3}$	494.0	31616.0
Mineral	$6.0 \cdot 10^{-3}$	$6.0 \cdot 10^{-3}$	1153.0	73792.0
Spring water[2]	$(1 – 26) \cdot 10^{-5}$		$(0.27 – 9.22) \cdot 10^3$	$(17.28 – 590.08) \cdot 10^3$
Tap water[2]	$(0.5 – 5.5) \cdot 10^{-5}$	$(0.5 – 3.8) \cdot 10^{-5}$	2.22 – 20.55	142.08 – 1315.20

[1]Currency exchange rate on 04/18/2019 1 $ = 64 rubles
[1] Курс валюты на 18.04.2019 г. 1 $ = 64 рубля
[2] the table shows the average values of LLE, for spring and tap water the observation period was 2003–2013, for meat and milk - 2006–2010
[2] в таблице приведены усредненные значения LLE, для родниковой и водопроводной воды период наблюдений составлял 2003 – 2013 гг., для мяса и молока – 2006 – 2010 гг

It should be noted that the aforementioned R_{popul} values are calculated values. They are not permanent and vary widely from year to year. To describe the risk on the basis of these values is a difficult task due to the absence of elaborated assessment criteria. The Table 2 shows the results of the assessment of risk from consuming the analyzed samples of food and drinking water containing pollutants as well as the values of LLE for persons inhabiting Ivanovo and Kostroma regions calculated by the authors.

When the LLE value is known, it is possible to calculate potential damage to population health per in monetary terms (damage caused by LLE) – Table 3.

Table 4

Damage acceptability criteria

***Таблица 4.* Критерии приемлемости ущерба**

Damage amount, $	Damage amount, RUB*	Degree of acceptability
4,100 – 65,800	262,400 – 4,211,200	Minimal
65,800 – 1,200,000	4,211,200 – 76,800,000	Low
1,200,000 – 16,500,000	76,800,000 – 1,056,000,000	Medium
16,500,000 – 205,800,000	1,056,000,000 – 13,171,200,000	High
more than 205,800,000	more than 13,171,200,000	Maximal

* Currency exchange rate on 04/18/2019 1 $ = 64 rubles
* Курс валюты на 18.04.2019 г. 1 $ = 64 рубля

The most significant health damage is caused by consuming meat and milk produced by Ivanovo and Kostroma regions cattle farms (approximately $16,000 – 280,000 per year), as well as drinking spring water – $270 through 9,200 per year. The minimal damage is caused by consuming tap water ($2,220 through 20,550 per year), bottled water ($15,000 through 24,540 per year), and fruit and vegetable purees ($7,520 per year) [23].

The obtained amounts of damage are approximate. Using the table 3, these amounts can be estimated as:

- minimal – for spring water;
- less than minimal – for tap and bottled drinking water and food (oatmeal porridges, meat purees, fruit and vegetable purees, lever pate, dry biscuits) and similar products from MRE package;
- low (acceptable) – for meat and milk.

Thus, the calculated amounts of economic damage caused by risks indicate that the degree of contamination of meat and dairy products produced by Ivanovo and Kostroma farms is rather low.

CONCLUSION

Along with sanitary and hygienic criteria of food production, the risks from consuming such food should be taken into consideration. Hence, the proposed methodology of calculating the potential damage from decrease in population health (life quality), namely from consuming drinking water (spring, tap, and bottled water), as well as food for adults and children (meat and dairy products, dry instant oatmeal porridges, canned meat, homogenized fruit and vegetable purees, lever pate and dry biscuits), can be used to justify the costs of environmental protection measures as well as safety measures taken by health protection and welfare authorities.

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