Hygienic safety characteristics of bottled water, used for potable water supply

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On the basis of the results of performed analysis of literature references concerning influence of phthalates on population health indicators it was found out that their influence at prenatal period may lead to asthma development in children, as well as to allergy, obesity; they also provide anti-androgens effect, leading to growth inhibition and delay in sexual maturation, and to variance of systolic pressure. In case of men phthalates are associated with decreasing of testosterone level and sperms quality, that indicates at their possible role in male sterility. In case of women phthalates are associated with increase of the risk of the second type of diabetes appearance, as well as leiomyoma, endometriosis and breast carcinoma. Laboratory studies performed in accordance with Customs union's technical regulation TP TC 005/2011 enabled to detect phthalates in the packages of bottled water, able to migrate into the bottled water. The results justify the necessity to monitor phthalates in bottled water.

Keywords: bisphenol A, phthalates, bottled water, drinking water, polyethyleneterephthalate, polycarbonate.

Actuality

Recently for portable water supply bottled water is increasingly used. For packaging water, food products, drugs etc. plastics is commonly used. For production polycarbonate packaging plastics bisphenol A (BPA) and phthalates [1; 2] are used.

BPA are regularly detected in urine, in blood, in milk in other biological samples [3–5]. BPA effect results to such consequences for human health as diabetes, obesity and cardiovascular diseases (coronary heart disease, hypertensive disease, coagulation failure), cancer diseases (breast cancer, prostatic and thyroid cancer), pathology of nerve (neurogenesis disorder, apoplexies, Parkinson's diseas) and reproductive (sex cycle disorder, endometriosis, changes in lactiferous gland, in prostate) systems. Performed investigations demonstrated, that higher levels of BPA in urine during period of pregnancy increase possibility of fetal weight decrease. It was proved, that BPA may penetrate through the human placenta and, therefore may present a risk for fetal development. BPA impact may be one of the reasons of chronic respiratory diseases (asthma), and also delay of development and psychical disorders (anxiety, depression, hyperactivity, aggression) [6; 7].

It was determined [8; 9], that low doze BPA impact in embryonic period influences the cell of prostate, increasing proneness towards pre-cancer lesion of these organ and hormonal disorders in adults. There are exists an opinion, that prostate cells are susceptive to BPA impacts at embryonic period. BPA impacts induces DNA adducts at this pathology.

BPA may disturb reproduction processes in women, suppressing DNA methylation. Neonatal BPA impact on mouses results to ingibiting of oocytes maturation [10–12].

BPA (even at low dozes) may propagate through placenta, accumulates in fetus and exert negative impact at duration of the whole antepartum period. On of the adverse consequences for fetus health is decrease of mass body centile at birth.

Besides, BPA impact across pregnancy may lead to increase of accidental abortions number, abnormal pregnancy duration, increase of male genital organs abnormalities and childhood obesity [6; 13].

At present time it was discovered, that those persons, who were subjected to BPA impact, increases the risk of coronary artery atherosclerosis development. So, in patients with severe stenosis of coronary arteries increase of BPA concentration in urine was detected as compared with persons without atherosclerosis. It was found that more susceptible to cardiovascular diseases were carriers of some genetic polymorphisms, associated with decrease cells response to oxidative stress. It is necessary to point out that one of the possible molecular mechanism of bisphenol A action may be its influence namely on oxidative stress [14–16].

Phtalates preset a wide spectrum of chemical compounds. After absorption phtalates are rapidly metabolized and removed through urinary system and gastrointestinal tract. Biological half-life of different metabolite phtalates constitutes approximately from 3 to 18 hours [17–19].

There is a certain information, that phtalates impact may cause multiple negative side effects for human health, including endocrine disorders, neural development disorders, disorders of cardiovascular and reproductive systems. Phalates may provide impact by means of different mechanisms, from nuclear hormone receptors (including estrogen receptors, androgen receptors) to membrane and nonsteroidal receptors and other mechanisms [20].

It is well known, that perinatal phtalates impact may cause reproductive abnormalities, including defects of epididymis development, deferent duct, seminal vesicles, prostate, external genitalia (hypospadias), cryptorchidism, testis trauma, decrease of anogenital distance and changes of sexual differentiation. Besides, increasing number of epidemiological studies demonstrated the phtalates impact on human may cause numerous side effects, such as increase of respiratory and allergic diseases in children, depression of lungs function and depression in elderly person, high risk of liver function decrease and cardiometabolic disorders in men, neurodevelopment slowing in infants, and also increased risk of overweight and obesity [21–24].

Phtalates possess sufficiently confirmed antiandrogenic activity in investigations performed at rodents, resulting in circulating testosterone decreasing. All the biomonitoring studies of human confirmes the opinion that phtalates impact impairs sperm quality (decreasing spermatozoids mobility and sperm volume, aneuploidy of spermatozoids) and decrease the level of reproductive hormones, causing the problem with fertility in men at reproductive age [25]. Also phtalates impact on men results to development of phtalates

syndrome. Anogenital distance (AGD) together with hypospadias, cryptorchidism and epididymidis diseases, deferent duct, seminal vesicles and prostate gland constitute phtalate syndrome. And phtalate impact on women health results to endometriosis, leiomyoma, breast cancer and diabetes of 2nd type [26; 27]. Phtales are associated with increased risk of premature birth — one of the main reasons of neonatal mortality [28].

With regard to phtalates impact on cardiovascular system, there exist a little evidence . In children and pregnant women, phtalates impact is accompanied by increase of arterial pressure. It was discovered that the main DEHP metabolite exerts cardiotoxic action. Epidemiological studies permit to reveal correlations, but not the casual relations between the impact and the disease. Nevertheless, that sphere requires further inquiry, bacause the data indicates increased risk of cardiovascular diseases resulted from phtalates impact [29–31].

The purpose of investigation performance is to study characteristics and analysis of package samples made of polymer material, contacting with portable water.

Material and methods

As a research objects, seven samples of bottles made from polyethyleneterephthalate (PET) and from polycarbonate (PC), manufactured in Russian Federation by the following six manufacturers: LLC "Formplact", LLC "Aquantic", LLC "Alfatechform", LLC "Plast-M". Presented products are available in trading network of Saint-Petersburg.

Characteristics of test products presented in Table 1.

Table 1. **Characteristics of test products samples**

№ Item	Description of bottled water package sample
1	Sample of portable water package (PET bottle — 6.0 l); package manufacturer LLC "Formplast"
2	Sample of portable water package (PET bottle (disposable) — 19.0 l); package manufacturer LLC "Aquatic"
3	Sample of portable water package (PET bottle (reusable) — 19.0 l); package manufacturer LLC "Aquatic"
4	Sample of portable water package (PET bottle (with water) — 6.0 l); package manufacturer LLC "Alfatechfarm"
5	Sample of portable water package (PET bottle with handle — 19.0 l); package manufacturer LLC "Plast-M"
6	Sample of portable water package (PET bottle green — 19.0 l); package manufacturer LLC "Plast-M"
7	Sample of portable water package (PET bottle green — 19.0 l); package manufacturer LLC "Plast-M"

Sanitary-and-hygienic tests of polymer (package) materials were performed by Chemical-analytical centre «Arbitrag» Federal state unitary enterprise "VNIIM named after D. I. Mendeleev" Detection of phtalates — di(2-ethylhexyl) phtalate, di(isobutyl) phtalate, di(n-butyle)phtalate was carried out in polymeric material, which was used for packaging portable water.

Results of investigation

All the measurements were performed in accord with Technical regulation of Customs union TR TS 005/2011 "About package safety" and "Instruction on sanitary-chemical products tests, manufactured from polymer and other synthetic materials, designed to contact with food products".

Results of packages and bottled water tests after 30 days of storage in plastic package presented in tables 2 and 3.

Table 2. **Results of polymeric (packaging) materials testing (mg/kg)**

nurses	Sample number						
	1	2	3	4	5	6	7
Di(2-ethylhexyl)phtalate	1.6 2.0 3.7	2.4 2.3 2.4	2.7 2.7 2.9	2.9 3.7 3.7	2.7 2.0 2.1	1.8 2.1 2.4	4.5 3.6 4.4
Di(n-butyl)phtalate	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	30 29 35	2.4 2.5 2.4
Di(isobutyl)phtalate	2.7 4.2 3.7	5.4 7.0 6.2	6.7 6.3 6.7	2.0 2.5 2.2	3.3 3.4 3.0	3.3 3.1 3.4	4.5 4.6 4.8
Bisphenol A	–	–	–	15 19 12	–	–	9.0 7.5 9.8

Table 3. **Results of bottled water testing after 30 days of storage in plastic package (mg/l)**

Samples	At temperature 20 °C			At temperature 40 °C		
	Di (2-ethylhexyl) phtalate	Di (n-butyl) phtalate	Di (isobutyl) phtalate	Di (2-ethylhexyl) phtalate	Di (n-butyl) phtalate	Di (isobutyl) phtalate
1	18	2.6	6.4	19	2.6	6.5
2	14.5	2.6	2.6	13	2.6	7.2
3	8.55	2.6	4.05	13	2.6	3.5
4	16	2.6	9.75	20.5	2.6	6.35
5	14.5	2.6	6.1	16.5	2.6	4.1
6	71	2.6	19.15	24.5	2.6	10.1
7	13	2.6	10.05	54.5	4.3	15
Average value	22.22	2.6	8.3	23	2.84	7.54
Median value	14.5	2.6	6.4	19	2.6	6.5

Phtalates and biphenol A are hazardous for human health in microquantities, their content in portable water are rated at level 8000 microgram/l[1]. Phalates possess ability to migrate from package material into aqueous medium and they provide monodirectional action with bisphenol A and may enter into human organism not only with portacle water, but also with foodstuff packaged into plastic.

Conclusions

Results of performed investigations enable to justify the necessity of monitoring phalates in bottled portable water due to phalates ability to migrate from plastic package into aqueous medium and ability of intermedium penetration into human organism in conjunction with bisphenol A.

Total amount of toxic substances penetrated from plastic packages may exceed reference concentration and produce considerable risk to public health.

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