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ZDRAVSTVENA ISPRAVNOST FLAŠIRANE VODE SA ASPEKTA KVALITETA VODE I AMBALAŽE

THE INFLUENCE OF WATER AND PACKAGING QUALITY ON BOTTLED WATER HEALTH SAFETY

REZIME

Pod pojmom flaširane vode podrazumeva se voda koja se pakuje u zdravstveno ispravnu ambalažu i koja je na tržištu dostupna za ljudsku upotrebu. Kod potrošača postoji još uvek nedovoljna upućenost u značaj pojedinih sastojaka i njihovo štetno ili korisno dejstvo na ljudski organizam a u svetu postoji mnogo zakonskih akata u kojima su normirani parametri kvaliteta flaširane vode. Da bi se ocenio uticaj kvaliteta ambalaže na kvalitet flaširane vode neophodno je istovremeno sagledati regulativu iz obe oblasti. Podaci koji se navode na deklaraciji nedovoljni su za sagledavanje kvaliteta same vode koja se flašira, a nema ni ukazatelja na potencijalno toksične elemente koji mogu migrirati iz ambalaže u vodu. Iako se voda pakuje u PET koji se smatra inertnim materijalom, određene komponente koje se dodaju pri proizvodnji PET materijala mogu da migriraju u vodu koja se prema tome mora redovno kontrolisati. Deklarisanje ovakvih proizvoda mora pratiti ažuriranje i praćenje potencijalno toksičnih parametara u skladu sa evropskom i svetskom regulativom. Uticaj ambalažiranja, transporta i skladištenja na promenu kvaliteta flaširanih voda sa aspekta potencijalno toksičnih supstanci, do sada je već pokazan u mnogim studijama u svetu, ali su retke studije iz ove oblasti u našojzemlji.

Ključne reči: flaširana voda, PET, ambalaža, zdravstvena ispravnost, kontrola kvaliteta, regulativa

ABSTRACT

The term bottled water refers to the water that is packaged in a health-correct packaging and that is available on the market for human consumption. Consumers still have insufficient knowledge of the importance of certain ingredients and their harmful or beneficial effects on the human body. Nowdays there are many legal acts in the world that regulate the quality of bottled water. In order to assess the impact of packaging quality on the quality of bottled water, it is necessary to look at the regulation, both in the field of water and in the field of packaging polymer. The information provided on the declaration is insufficient to see the quality of the bottled water itself, and there is no indication of the potential toxic elements that can migrate from the packaging into the water. Although PET is considered as inert material according certain components that are added to PET production can migrate in the water, that must be regurarly controlled. Declarations of such products must follow the updating and monitoring of potentially toxic parameters in accordance with European and world regulations. The impact of packaging, transport and storage on the change of bottled water quality from the aspect of potentially toxic substances has been shown in many studies in the world, however, studies of this type are rare in our country.

Key words: bottled water, PET, packaging, food safety,quality control, regulative

1. UVOD

Flaširane vode su se pojavile na tržištu razvijenih zemalja sveta, kao odgovor na nestašicu zdravstveno ispravne vode za piće. Pod pojmom flaširane vode podrazumeva se voda koja se pakuje u zdravstveno ispravnu ambalažu i koja je na tržištu dostupna za ljudsku upotrebu. Trka za profitom i nedostatak potrebnih količina vode za piće ugrožavaju kvalitet flaširanih voda, a takođe se zanemaruje njen uticaj na zdravlje u razmatranju mogućnosti njenog korišćenja. Kod potrošača postoji još uvek nedovoljna upućenost u značaj pojedinih sastojaka i njihovo štetno ili korisno dejstvo na ljudski organizam a u svetu postoji mnogo zakonskih akata u kojima su normirani parametri

1. INTRODUCTION

Bottled water has appeared on the market of developed countries, in response to the lack of healthy drinking water. The term bottled water refers to the water that is packaged in a health-correct packaging and that is available on the market for human consumption. The profit race and the lack of required quantities of drinking water impair the quality of bottled water, and its impact on health is also neglected. Consumers still have insufficient knowledge of the importance of certain ingredients and their harmful or beneficial effects on the human body. Nowdays there are many legal acts in the world that regulate the quality of bottled water (EEC, WHO, EPA, IBWA, FDA) [1-6].

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kvaliteta flaširane vode (EEC, WHO, EPA, IBWA, FDA) [1-6].

Za flaširanje voda najviše se koristi polimerna ambalaža, usled njenih dobrih karakteristika kao što su prozračnost, otpornost, niska cena i relativno lak proces dobijanja. Od svih polimera, najveći rast u proizvodnji zabeležio je poli(etilen tereftalat) (PET) koji se i najčešće upotrebljava za izradu ambalaže za flaširanje vode i drugih bezalkoholnih pića.

S obzirom da je upotreba polimerne prehrambene ambalaže u ove svrhe doživela ekspanziju tek u poslednjih 15-ak godina pored istraživanja postupaka reciklaže, u svetskim razmerama se intenzivno analiziraju supstance koje se mogu ispuštati iz ovakve vrste materijala, posebno one toksične. Uticaj ambalažiranja i uslova skladištenja na sastav mineralne vode i promenu koncentracije potencijalno toksičnih parametara, pokazan je u nekim studijama u svetu pa i u zemljama u regionu ali su još uvek retke studije ovog tipa uz našoj zemlji.

Da bi se ocenio uticaj kvaliteta ambalaže na kvalitet flaširane vode neophodno je sagledati regulativu, kako iz oblasti voda, tako i iz oblasti ambalaže od polimera. Uglavnom se ambalaža analizira odvojeno od gotovog proizvoda (najpre sirovina a onda i gotov proizvod – flaša izrađena od polimera), međutim za sagledavanje sveobuhvatnog kvaliteta gotovog proizvoda neophodno je ove regulative sagledavati istovremeno, uz detaljnu kontrolu potencijalno toksičnih jedinjenja koja su označena kao targeti. Podaci koji se navode na deklaraciji nedovoljni su za sagledavanje kvaliteta same vode koja se flašira, a nema ni ukazatelja na potencijalno toksične elemente koji mogu migrirati iz ambalaže u vodu. Pored posledica ovih migracija, takođe, proizvedena količina PET ambalaže predstavlja i ekološki problem pošto većina polimernih materijala nije ekološki razgradiva.

U skladu sa novim otkrićima u vezi sa plastičnom ambalažom, ona je počela da se i izbacuje iz upotrebe u nekim zemljama. Najpre su zabrane nastale u Australiji, pa zatim i u Americi i u Kanadi a zatim i u Švedskoj i Velikoj Britaniji pa i u Evropskoj Uniji. Iz Australije je potekla zabrana pa i inicijativa za povlačenje ambalaže od polikarbonatne plastike sa tržišta a koju su podržale i fabrike u Americi i u Kanadi. I u našoj zemlji se sve češće prijavljuju zamerke potrošača u vezi sa promenom kvaliteta flaširanih voda usled promene organoleptičkih svojstava. To ide u prilog tome da je neophodno sveobuhvatnije ispitivanje kvaliteta ovakve vrste proizvoda.

2. FLAŠIRANA VODA KAO NAJČEŠĆI TIP NAMIRNICE KOJA SE PAKUJE U POLIMERNU AMBALAŽU

U Republici Srbiji su normirani parametri kvaliteta

Polymeric packaging is mostly used for bottling water due to the good characteristics such as transparency, resistance, low cost and relatively easy process of their production. Of all polymers, the highest growth in production was recorded in poly (ethylene terephthalate), PET, which is most commonly used as packaging for bottling water and other non-alcoholic beverages.

Considering that the use of polymer food packaging for this purpose has only been expanded in the last 15 years, besides the research of recycling processes, substances that can be released from this kind of material especially those toxic, have been analyzed all over the world,. The impact of packaging and storage conditions on the composition of mineral water and the change in the concentration of potentially toxic parameters has been shown in some studies in the world as well as in countries in the region, but there are rare studies of this type in our country.

In order to assess the impact of packaging quality on the quality of bottled water, it is necessary to look at the regulation, both in the field of water and in the field of packaging polymer type. In general, the packaging is analyzed separately from the final product (first of all the raw material and then the final product - bottle made of polymer), however, in order to examine the overall quality of the product, it is necessary to take into account both regulations at the same time, with detailed control of potentially toxic compounds designated as targets. The information provided on the declaration is insufficient to see the quality of the bottled water itself, and there is no indication of the potential toxic elements that can migrate from the packaging into the water. In addition to the consequences of these migrations, also the quantity of PET packaging produced represents an ecological problem, since most of the polymeric materials are not environmentally degradable.

In accordance with the most recent research related to plastic packaging, their use has been forbbiden in some countries. Initially, bans were made in Australia, then in America and Canada, and then in Sweden and the United Kingdom as well as in the European Union. Australia has also outlawed an initiative to withdraw packaging from polycarbonate plastic from the market, supported by factories in America and Canada. In our country, consumer complaints about the change in the quality of bottled water due to changes in organoleptic properties that are increasingly reported. This supports the need for a more comprehensive examination of the quality of this type of product.

2. THE BOTTLED WATER AS THE MOST COMMON TYPE OF FOODSTUFF WHICH IS PACKED IN THE POLYMERIC PACKAGING

In the Republic of Serbia, the quality parameters prema kojima su flaširane vode svrstane u tri grupe: prirodnu mineralnu, prirodnu izvorsku i stonu vodu) [7]. Pod prirodnom mineralnom vodom podrazumeva se podzemna voda namenjena za ljudsku upotrebu u svom prirodnom stanju, a koju karakteriše sadržaj mineralnih materija i hemijskih elemenata zbog kojih se ona razlikuje od vode za piće. Pod prirodnom izvorskom vodom podrazumeva se voda koja je namenjena za ljudsku upotrebu u svom prirodnom stanju, a koja se flašira na izvoru. Stona voda je flaširana voda, koja se obrađuje u cilju poboljšanja kvaliteta, s tim što kvalitet obrade mora biti u skladu sa svim propisima koji se odnose na kvalitet vode za piće.

Prirodne mineralne vode se klasifikuju prema sadržaju mineralnih materija, a bez osvrta na efekte uticaja na zdravlje ljudi [8,9]. Mnogo bolja i prihvatljivija podela sa aspekta uticaja na zdravlje potrošača jeste podela na vode za piće, tj. za svakodnevnu upotrebu i mineralne vode kojima se, u zavisnosti od sastava, pripisuju i fiziološka dejstva. S obzirom da protiču kroz različite slojeve zemlje njihov kvalitet se može posmatrati i sa geohemijskog aspekta.

2.1. Zahtevani kvalitet flaširanih voda i upoređivanje svetske i domaće regulative

U Srbiji se godišnje proizvede oko 600 miliona litara flaširane prirodne i mineralne vode. I pored sve veće proizvodnje poslednjih godina, potrošnja flaširane vode u Srbiji još uvek je dvostruko manja nego u evropskim zemljama. Kvalitet vode za piće u Srbiji se reguliše na osnovu propisanih parametara u Pravilniku o higijenskoj ispravnosti vode za piće od 1998. godine (Sl. list SRJ br. 42/98) i sa dopunama iz 1999. godine (Sl. list SRJ 44/99) [10] kao i Pravilnikom o kvalitetu i drugim zahtevima za prirodnu mineralnu vodu, prirodnu izvorsku i stonu vodu (Sl. Glasnik RS br. 53/05 i 43/2013) [7] dok je domaća regulativa formulisana na osnovu podataka Smernica Svetske zdravstvene organizacije iz 1993.godine [11] i predloga Direktive EU iz 1994. godine, uzimajući u obzir iskustva iz sopstvene prakse.

Važno je napomenuti da je navedena Direktiva doneta na nivou EU dve godine kasnije uz odgovarajuće izmene predloga, što ima za posledicu izvesna neslaganja sa trenutno važećim Pravilnikom u našoj zemlji, a neusklađenost propisanih MDK vrednosti za neke od parametara može se uočiti poređenjem direktiva EU i standarda WHO sa Pravilnicima koji važe u Republici Srbiji. Iste godine kad i Pravilnik, doneta je Direktiva 98/83/EC koja se odnosi na vodu namenjenu za ljudsku upotrebu, a cilj joj je zaštita zdravlja od štetnih efekata bilo kakvog zagađenja koje se može naći u vodi i to tako što će se obezbediti da ona bude zdrava i čista. To znači da u njoj nisu prisutni mikroorganizmi, paraziti, kao ni supstance koje u broju ili koncentraciji predstavljaju potencijalnu

according to which bottled waters are classified into three groups are: natural mineral, natural spring and non-moving water) [7]. Natural mineral water is a groundwater intended for human consumption in its natural state, characterized by the content of mineral substances and chemical elements due to which it differs from drinking water. Under natural spring water means water intended for human consumption in its natural state, which is bottled at the sring. Non-movign water is bottled water, which is processed in order to improve quality, but the quality of processing must comply with all regulations related to the quality of drinking water.

Natural mineral waters are classified according to the content of mineral matter, without considering the impacts on human health [8,9]. Much better and more acceptable division from the aspect of the impact on the health of consumers is the classification of drinking water, i.e. for everyday use and mineral water, which, depending on the composition, are attributed to physiological effects. Since they flow through the different layers of the earth, so their quality can be viewed from a geochemicalaspect.

2.1. Required quality of bottled water and comparison of global and domestic regulations

In Serbia annually about 600 million liters of bottled natural and mineral waters are produced. Despite the increasing production in the last few years, consumption of bottled water in Serbia is still twice lower than in European countries. The quality of drinking water in Serbia is regulated on the basis of the prescribed parameters in the Regulation on hygienic correctness of drinking water since 1998 (Sl. list SRJ No. 42/98) and with amendments from 1999 (Sl. list SRJ 44/99) [10] and the Regulation on Quality and Other Requirements for Natural Mineral Water, Natural Source and Table Water (Sl. Glasnik of RS No. 53/05 and 43/2013) [7] while domestic regulations have been formulated from the data of the World Health Organization (WHO) Directive of 1993 [11] and the proposal for a EU directive from 1994, taking into account experience from own practice.

It is important to note that the above mentioned Directive was adopted at the EU level two years later with appropriate changes to the proposal, resulting in some disagreement with the current Regulation in our country, and the inconsistency of the prescribed MAC values for some of the parameters can be seen by comparing EU directives and WHO standards with Regulations which are valid in the Republic of Serbia. In the same year Directive 98/83/EC concerning water intended for human consumption was adopted, with the objective to protect health against the harmful effects of any pollution that can be found in water by ensuring that water is healthy and clean. This means that there are no microorganisms, parasites, or opasnost po ljudsko zdravlje, odnosno da zadovoljava minimum uslova datih kao vrednosti specifičnih parametara. Ovom Direktivom je obuhvaćeno 48 parametara od prethodnih 66 (iz Direktive iz 1980. godine), uključujući i 15 novih parametara. Za flaširanu vodu preporučeno je 50 parametara koji obuhvataju najvažnije parametre kvaliteta vode i koji su od značaja po zdravlje ljudi. Države članice su obavezne da pored parametra datih u Direktivi obuhvate i sve druge parametre neophodne za zaštitu ljudskog zdravlja na svojoj teritoriji, kao i da obezbede zahtevani kvalitet proizvodnje, distribucije i kontrole vode namenjene za ljudsku upotrebu. U slučaju da je neophodno doneti strožije standarde nego što ih propisuje Direktiva, potrebno je obavestiti Komisiju EU.

FDA (eng. Food and Drug Administration) je generalno usvojio MCL (Maximum Contamination Level) postavljene od strane EPA, za zagađivače u pijaćoj vodi, kao i dozvoljene nivoe za iste zagađivače u standardnim propisima za flaširanu vodu. Međutim, u nekim slučajevima, FDA standardi za flaširanu vodu razlikuju se od EPA standarda za javnu vodu za piće (što je npr. slučaj sa olovom).

Flaširana voda je regulisana kao hrana pod FFDCA (Federal Food, Drug, and Cosmetic Act) od strane FDA. Specifični FDA propisi u oblasti flaširanih voda pokrivaju CGMP (Current Good Manufacturing Practices) za proizvodnju flaširane vode i standarda identiteta i kvaliteta za flaširanu vodu. Nedavna regulativna aktivnost u oblasti flaširanih voda uključila je usvajanje dozvoljenih nivoa pojedinih dezinfekcionih sredstava i sredstava za dezinfekciju nusproizvoda u standardu kvaliteta za flaširanje vode i objavljivanje studije izvodljivosti o odgovarajućim metodama kako bi se potrošači informisali o sadržaju flaširane vode.

U cilju preglednog upoređivanja važeće domaće i svetske regulative u vezi sa flaširanom vodom sastavljena je Tabela 1 sa pregledom maksimalno dozvoljenih koncentracija u skladu sa važećom nacionalnom i svetskom regulativom.

Flaširane vode koje su se mogle naći na tržištu a koje su i flaširane na području Republike Srbije mogu se stavljati u promet samo u originalnom pakovanju, u ambalaži koja obezbeđuje očuvanje kvaliteta i higijenske ispravnosti [7]. Prema Pravilniku o kvalitetu i drugim zahtevima za prirodnu mineralnu vodu, prirodnu izvorsku vodu i stonu vodu Sl. List SCG, br. 53/2005 i 43/2013) [7] preporučene su MDK vrednosti parametara koje mogu predstavljati rizik po ljudsko zdravlje kao i parametri koji direktno određuju kvalitet i nomenklaturu mineralnih voda.

Na deklaracijama voda koje su analizirane, deklarisan je suvi ostatak na 180 °C i shodno tome izvršena je podela na: vode sa veoma niskim sadržajem mineralnih materija (suvi ostatak na 180 °C je do 50 mg/l), zatim sa niskim sadržajem mineralnih materija

substances that present a potential danger to human health in the number or concentration, in other words that they meet the minimum conditions given as values of specific parameters. This Directive covers 48 parameters from the previous 66 (from the 1980 Directive), including 15 new parameters. For bottled water, 50 parameters are recommended that include the most important parameters for water quality and for human health. Member States are obliged, in addition to the parameters given in the Directive, to include all other parameters necessary for the protection of human health in their territory, as well as to ensure the required quality of production, distribution and control of water intended for human consumption. In case of necessity to adopt more stringent standards than those prescribed by the Directive, it is necessary to inform the EU Commission.

The Food and Drug Administration (FDA) has generally adopted the Maximum Contamination Level (MCL) set by EPA for drinking water pollutants and permitted levels for the same contaminants in standard bottled water regulations. However, in some cases, FDA standards for bottled water are different from the EPA Public Drinking Water Standard (for example,in case of lead).

Bottled water is regulated as food under the FDA (Federal Food, Drug and Cosmetic Act) by the FDA. Specific FDA regulations for bottled waters cover CGMP (Current Good Manufacturing Practices) for the production of bottled water and standards of identity and quality for bottled water. The recent regulatory activity in bottled waters has included the adoption of permitted levels of individual disinfectants and products for disinfecting by-products in the quality standard for bottled water and the publication of a feasibility study on appropriate methods to inform consumers about the content of bottled water.

For the purpose of a transparent comparison of valid domestic and global regulations in relation to bottled water, Table 1 has been compiled with an overview of the maximum permissible concentrations in accordance with the applicable national and world regulations.

Bottled water that could be found on the market, bottled in the territory of the Republic of Serbia can only be marketed in the original packaging, in packaging that ensures the preservation of quality and hygienic safety [7]. According to the Regulation on quality and other requirements for natural mineral water, natural spring water and table water, Sl. List SCG, No. 53/2005 and 43/2013) [7] MAC values of parameters that can pose a risk to human health as well as parameters that directly determine the quality and nomenclature of mineral waters are recommended.

On the declarations of the analyzed water, the dry residue was declared at 180 °C and consequently the clasification is given: water with very low mineral content (dry residue at 180 °C is up to 50 mg / l), with low content of mineral (dry residue at 180 °C is between

Tabela 1. Upoređivanje domaćih i svetskih propisanih MDK vrednosti

Parametri	Jedinica mere	EEC[a] (1998)	WHO[a] (2011,2017)	EPA[a] (2018)	IBWA[a] (2003)	FDA[a] (2003)	Zakonodavstvo Republike Srbije[a] (2013) [7, 10]		
		Pijaća voda (MAC[b])	Pijaća voda (GV[c])	Pijaća voda (MCLG/MCL[d])	Pijaća voda (MAC[b])	Flaširana voda (MAL[f])	Stona voda (MAC[b])	Prirodna izvorska voda (MAC[b])	Prirodna mineralna voda (MAC[b])
Boja	Pt/Co	-	-	15[g]	5	15[h]	5	bez	
pH vrednost	-	6.5-9.5	-	6.5-8.5[g]	6.5-8.5	-	6.8-8.5	6.5-9.5	
BOD	mg/l	-	-	-	-	-			
TDS	mg/l	-	-	500[g]	500[h]	500[h]			
Mutnoća	NTU	-	-	1	0.5	5	1		
Bromati	mg/l	0.01	0.01	0/0.01	0.01	0.01	0.01	3.0	3.0
Hlor	mg/l	-	5	4	0.1	4	do 3.0		
Hloriti	mg/l	-	0.7	1	1	1	0.2		
Haloacetalne kiseline	mg/l	-	Videti[i]	0.06	0.06	0.06	-		
Ukupni trihalometani	mg/l	0.1	Videti[i]	0.08	0.01	0.08	0.1	0,1	
Aluminijum (Al^{3+})	mg/l	0.2	-	0.05-0.2[g]	0.2	0.2	0.2	0.2	
Amonijum jon (NH_4^+)	mg/l	0.5	-	-	-	-	0.1	0.5	
Antimon (Sb)	mg/l	0.005	0,02	0.006/0.006	0.006	0.006	0.003	0.005	0.005
Arsen (As)	mg/l	0.01	0.01	0/0.01	0.01	0.05	0.01	0.01	0.01
Azbest (vlakna>10μm)	10^6vlakna/L	-	-	7	-	-			
Barijum (Ba^{2+})	mg/l	-	0.7	2/2	1	2	0.7		1.0
Berilijum (Be)	mg/l	-	-	0.004/0.004	0.004	0.004			
Bor (B)	mg/l	1.0	2.4	-	-	-	0.3	1.0	
Kadmijum (Cd^{2+})	mg/l	0.005	0.003	0.005/0.005	0.005	0.005	0.003	0.003	0.003
Kalcijum (Ca^{2+})	mg/l	-	-	-	-	-	200		
Hloridi (Cl^-)	mg/l	250	-	250[g]	250[h]	250[h]	200	250	
Hrom (Cr), ukupni	mg/l	0.05	0.05	0.1/0.1	0.05	0.1	0.05	0.05	0.05
Bakar (Cu)	mg/l	2	2	1.0/1.3	1	1	2.0	2.0	1.0
Cijanidi (CN^-)	mg/l	0.05	0.07	0.2/0.2	0.1	0.2	0.05	0.05	0.07
Fluoridi (F^-)	mg/l	1.5	1.5	2[g]	0.8-1.7[j]	0.8-2.4[j]	1.2	1.5	5.0
Gvožđe (Fe)	mg/l	0.2	-	0.3[g]	0.3[h]	0.3[h]	0.3	0.2	
Olovo (Pb)	mg/l	0.01	0.01	0.015[j]	0.005	0.005	0.01	0.01	0.01
Magnezijum (Mg^{2+})	mg/l	-	-	-	-	-	50.0		
Mangan (Mn^{2+})	mg/l	0.05	0.4	0.05[g]	0.05[h]	0.05[h]	0.05	0.05	0.50
Živa (Hg)	mg/l	0.001	0.006	0.002/0.002	0.001	0.002	0.001	0.001	0.001
Nikl (Ni)	mg/l	0.02	0.07	-	0.1	0.1	0.02	0.02	0.02
Nitrati (NO_3^-)	mg/l	50	50	10/10	44	44	50	50	50
Nitriti (NO_2^-)	mg/l	0.5	3.0	1.1 (as N)	3.3	3.3	0.03	0.1	0.1
Kalijum (K^+)	mg/l	-	-	-	-	-	12.0		
Selen (Se)	mg/l	0.01	0.04	0.05/0.05	0.01	0.05	0.01	0.01	0.01
Srebro (Ag)	mg/l	-	-	0.1[g]	0.025	0.1			
Natrijum (Na^+)	mg/l	200	-	-	-	-	150	200	
Sulfati (SO_4^{2-})	mg/l	250	-	250[g]	250[h]	250[h]	250	250	
Talijum (Tl)	mg/l	-	-	0.0005/0.002	0.002	0.002			
Uranijum (U)	mg/l	-	0.03	-	0.03	0.03			
Cink (Zn^{2+})	mg/l	-	-	5[g]	5[h]	5[h]	3.0		
Ukupni pesticidi	mg/l	0.0005	Videti[i]	Videti[i]	Videti[i]	Videti[i]	0.0005	0.0005	
PAH	mg/l	0.0001	Videti[i]	Videti[i]	Videti[i]	Videti[i]	0.0002	0.0001	
Ukupni fenoli	mg/l	Videti[i]	Videti[i]	Videti[i]	0.001	0.001	0.001		

Legenda:

[a]izvori: EEC= European Economic Community, Council Directive 98/83/EC on the quality of water intented for human consumption; WHO = World Health Organization, Guidelines for Drinking – water Quality 4[th] Edition, 2011, with First Addendum to the 4[th] Edition, 2017; EPA= Environmental Protection Agency (US) 2018 Edition of the Drinking Water Standards and Health Advisories Tables; IBWA= International Bottled Water Association; FDA= Food and Drug Administration (US); Pravilnik o kvalitetu i drugim zahtevima za prirodnu mineralnu vodu, prirodnu izvorsku vodu i stonu vodu (objavljen u Službenom listu SCG br. 53/2005 i 43/2013), Pravilnik o higijenskoj ispravnosti vode za piće (Sl. list SRJ br. 42/98 i 44/99);

[b]MAC (MDK) – Maksimalno dozvoljena koncentracija; [d] MCL-Maksimalni nivo kontaminacije; [c]Standard kvaliteta; [f]MAL-Maksimalni dozvoljeni nivo; [g]Sekundarni maksimalni nivo kontaminacije, [h]Mineralna voda je oslobođena od dozvoljenog nivoa; [i]Nisu dostupne ukupne vrednosti i svaka pojedinačna supstanca ima svoj lični maksimalni nivo kontaminacije; [j]Privremena direktiva; [k]Nivo akcije

Table 1. Comparison of domestic and global prescribed MAC values

Parameter	Units	EEC[a] (1998)	WHO[a] (2011,2017)	EPA[a] (2018)	IBWA[a] (2003)	FDA[a] (2003)	The legislation of the Republic of Serbia[a] (2013) [7, 10]		
		Drinking water (MAC[b])	Drinking water (GV[c])	Drinking water (MCLG/MCL[d])	Drinking water (MAC[b])	Bottled water (MAL[f])	Table water (MAC[b])	Natural spring water (MAC[b])	Natural mineral water (MAC[b])
Colour	Pt/Co	-	-	15[g]	5	15[h]	5	without	
pH value	-	6.5-9.5	-	6.5-8.5[g]	6.5-8.5	-	6.8-8.5	6.5-9.5	
BOD	mg/l	-	-	-	-	-			
TDS	mg/l	-	-	500[g]	500[h]	500[h]			
Turbidity	NTU	-	-	1	0.5	5	1		
Bromate	mg/l	0.01	0.01	0/0.01	0.01	0.01	0.01	3.0	3.0
Chlorine	mg/l	-	5	4	0.1	4	do 3.0		
Chlorides	mg/l	-	0.7	1	1	1	0.2		
Haloacetal acids	mg/l	-	See[i]	0.06	0.06	0.06	-		
Total trihalomethanes	mg/l	0.1	See[i]	0.08	0.01	0.08	0.1	0,1	
Aluminum (Al^{3+})	mg/l	0.2	-	0.05-0.2[g]	0.2	0.2	0.2	0.2	
Ammonium ion (NH_4^+)	mg/l	0.5	-	-	-	-	0.1	0.5	
Antimony (Sb)	mg/l	0.005	0.02	0.006/0.006	0.006	0.006	0.003	0.005	0.005
Arsenic (As)	mg/l	0.01	0.01	0/0.01	0.01	0.05	0.01	0.01	0.01
Asbestos, (fibers >10μm)	10^6vlakna/L	-	-	7	-	-			
Barium (Ba^{2+})	mg/l	-	0.7	2/2	1	2	0.7		1.0
Berillium (Be)	mg/l	-	-	0.004/0.004	0.004	0.004			
Boron (B)	mg/l	1.0	2.4	-	-	-	0.3	1.0	
Cadmium (Cd^{2+})	mg/l	0.005	0.003	0.005/0.005	0.005	0.005	0.003	0.003	0.003
Calcium (Ca^{2+})	mg/l	-	-	-	-	-	200		
Chlorides (Cl^-)	mg/l	250	-	250[g]	250[h]	250[h]	200	250	
Chromium (Cr), total	mg/l	0.05	0.05	0.1/0.1	0.05	0.1	0.05	0.05	0.05
Copper (Cu)	mg/l	2	2	1.0/1.3	1	1	2.0	2.0	1.0
Cyanides (CN^-)	mg/l	0.05	0.07	0.2/0.2	0.1	0.2	0.05	0.05	0.07
Fluorides (F^-)	mg/l	1.5	1.5	2[g]	0.8-1.7[j]	0.8-2.4[j]	1.2	1.5	5.0
Iron (Fe)	mg/l	0.2	-	0.3[g]	0.3[h]	0.3[h]	0.3	0.2	
Lead (Pb)	mg/l	0.01	0.01	0.015[j]	0.005	0.005	0.01	0.01	0.01
Magnesium (Mg^{2+})	mg/l	-	-	-	-	-	50.0		
Manganese (Mn^{2+})	mg/l	0.05	0.4	0.05[g]	0.05[h]	0.05[h]	0.05	0.05	0.50
Mercury (Hg)	mg/l	0.001	0.006	0.002/0.002	0.001	0.002	0.001	0.001	0.001
Nickel (Ni)	mg/l	0.02	0.07	-	0.1	0.1	0.02	0.02	0.02
Nitrate (NO_3^-)	mg/l	50	50	10/10	44	44	50	50	50
Nitrite (NO_2^-)	mg/l	0.5	3.0	1.1 (as N)	3.3	3.3	0.03	0.1	0.1
Potassium (K^+)	mg/l	-	-	-	-	-	12.0		
Selenium (Se)	mg/l	0.01	0.04	0.05/0.05	0.01	0.05	0.01	0.01	0.01
Silver (Ag)	mg/l	-	-	0.1[g]	0.025	0.1			
Sodium (Na^+)	mg/l	200	-	-	-	-	150	200	
Sulphates (SO_4^{2-})	mg/l	250	-	250[g]	250[h]	250[h]	250	250	
Thallium (Tl)	mg/l	-	-	0.0005/0.002	0.002	0.002			
Uranium (U)	mg/l	-	0.03	-	0.03	0.03			
Zinc (Zn^{2+})	mg/l	-	-	5[g]	5[h]	5[h]	3.0		
Total pesticides	mg/l	0.0005	See[i]	See[i]	See[i]	See[i]	0.0005	0.0005	
PAH	mg/l	0.0001	See[i]	See[i]	See[i]	See[i]	0.0002	0.0001	
Total phenols	mg/l	See[i]	See[i]	See[i]	0.001	0.001	0.001		

Legend:

[a]Sources: EEC= European Economic Community, Council Directive 98/83/EC on the quality of water intented for human consumption; WHO = World Health Organization, Guidelines for Drinking – water Quality 4[th] Edition, 2011, with First Addendum to the 4[th] Edition, 2017; EPA= Environmental Protection Agency (US) 2018 Edition of the Drinking Water Standards and Health Advisories Tables; IBWA= International Bottled Water Association; FDA= Food and Drug Administration (US); Regulation on quality and other requirements for natural mineral water, natural spring water and table water (Sl. list SCG No. 53/2005 and 43/2013), Regulation on hygienic correctness of drinking water (Sl. list SRJ No. 42/98 and 44/99);

[b]MAC-Maximum Allowable Concentration; [d]MCL- Maximum Contamination Level;MCLG- Maximum Contamination Level Goal; [c]Quality standard; [f] MAL - Maximum Allowed Level; [g] SDRW - Secondary Maximum Level of Contamination, [h]Mineral water is released from the allowed level

[i]No available total values and each individual substance has its own maximum level of contamination; [j]Temporal directive; [k]Action level

(suvi ostatak na 180 °C je između 50 i 500 mg/l), vode sa srednjim sadržajem mineralnih materija (suvi ostatak na 180 °C je između 500 i 1500 mg/l) i vode sa bogatim sadržajem mineralnih materija (suvi ostatak na 180 °C je > 1500 mg/l) a prema važećem Pravilniku o kvalitetu i drugim zahtevima za prirodnu mineralnu, prirodnu izvorsku i stonu vodu (Sl. List SCG, br. 53/2005 i 43/2013) [7]. Na osnovu rezultata analiziranih parametara, može se zaključiti da su na tržištu od analiziranih voda najviše prisutne nisko mineralne vode (54%), zatim vode bogate mineralnim materijama (približno 18%), dok su vode sa srednjim sadržajem mineralnih materija zastupljene u iznosu od približno 28% (Slika 1).

Slika 1. Zastupljenost voda prema mineralnom sastavu: RM-vode bogate mineralima, MM-vode sa srednjim sadržajem minerala, LM-vode sa niskim sadržajem minerala
Figure 1. Water content by mineral composition: RM-rich mineral waters, MM-water with medium mineral content, LM-water with low mineral content

U zavisnosti od sadržaja CO_2 u flaširanoj vodi izvršena je podela na: prirodno gazirane vode, vode koje se naknadno gaziraju i vode koje ne sadrže CO_2, što je prikazano na Slici 2. Kao što se može videti na tržištu dominiraju vode koje ne sadrže CO_2 (zastupljenost od 57%), vode koje se gaziraju naknadno zastupljene su sa 27%, a prirodno gazirane sa 16%.

Prema Pravilniku o kvalitetu i drugim zahtevima za prirodnu mineralnu vodu, prirodnu izvorsku vodu i stonu vodu [7] ukoliko voda sadrži veću koncentraciju od vrednosti navedene u Tabeli 1 ovog Pravilnika, u nazivu proizvoda pa i na etiketi mora se navesti tip vode (bikarbonatna, magenzijumova, kalcijumova, natrijumova itd. [12]. Na tržištu Srbije među flaširanim vodama dominiraju vode bikarbonatnog tipa.

Prema sadržaju karakterističnih sastojaka analizirane flaširane vode mogu se svrstati u ugljeno-kisele vode (njih 43,3%), zatim bikarbonatne vode (40,0%), pa magnezijumove i natrijumove vode (36,7% i 30,0%), a svega 16,7% u fluoridne vode i u neznatnom procentu u hloridne i kalcijumove vode (po 3,3%).

Na etiketi na flaširanoj vodi se ne deklarišu parametri

50 and 500 mg/l), water with medium mineral content (dry residue at 180 ° C is between 500 and 1500 mg / l) and water with a rich mineral content (dry residue at 180 ° C is> 1500 mg/l) according to the current Regulation on Quality and Other Requirements for natural mineral, natural spring and non-moving water (Službeni glasnik of Serbia and Montenegro, No. 53/2005 and 43/2013) [7]. Based on the results of the analyzed parameters, it can be concluded that the lowest water content is present on the market from the analyzed waters (54%), followed by water rich in mineral substances (approximately 18%), while the waters with the mean content of mineral matter are approximately 28% (Figure 1).

Depending on the content of CO_2 in bottled water, a division was divided into: naturally carbonated waters, subsequently carbonated waters, and CO_2-free waters, as shown in Figure 2. As can be seen on the market, CO_2-free waters are dominant representation of 57 %), the waters that are being fertilized are subsequently represented with 27%, and naturally carbonated with 16%.

According to the Regulation on Quality and Other Requirements for Natural Mineral Water, spring water and non-moving water [7] if the water contains a higher concentration than the values indicated in Table 1 of this Regulation, the type of water (bicarbonate, magnesium, calcium, sodium water..) [12]. It has been shown that bicarbonate type waters are dominant in the analyzed Serbian bottled waters.

Slika 2. Zastupljenost voda prema sadržaju CO_2: C-prirodno gazirane vode, NC-gazirane mineralne vode, D - negazirane vode
Figure 2. Water content according to the content of CO2: C-naturally carbonated waters, NC-carbonated mineral waters, D-negated water

According to the content of the characteristic ingredients, the analyzed bottled water can be classified into carbon-acid water (43.3%), followed by bicarbonate water (40.0%), magnesium and sodium (36.7% and 30.0%), and only 16.7% of fluoride water and a small percentage of chloride and calcium water (3.3% each).

On the bottled water declaration, parameters that characterize water when it comes to the effect koji karakterišu vodu kada je u pitanju uticaj na reakcije oksido-redukcije. Sa fiziološkog aspekta, oksido-redukcioni status vode predstavlja zdravstveni faktor, a njega, pored deklaracijom predloženih parametara, u potpunosti definišu pH vrednost, redox potencijal i rH_2 faktor [13-15]. Pokazano je da većina analiziranih voda dostupnih na tržištu Republike Srbije ipak ima redukcione osobine [16].

on oxidizing reactions are not declared. From a physiological point of view, the oxidative reduction status of water is a health factor, and besides the declaration of the proposed parameters, it is fully defined by pH, redox potential and rH_2 factor [13-15]. It has been shown that most of the analyzed waters available on the market of the Republic of Serbia still have reduction properties [16].

3. AMBALAŽA ZA FLAŠIRANU VODU

Industrijska revolucija podstaknula je značajan razvoj u području ambalažnih materijala, ambalaže pa i metoda pakovanja. Zahvaljujući napretku u području pakovanja, došlo je do ekspanzije u proizvodnji novih ambalažnih materijala, prehrambenih proizvoda i modernog načina prodaje namirnica. Uvidelo se da uspeh na tržištu u velikoj meri zavisi od vrste ambalaže (pre svega od kvaliteta sirovine od koje se izrađuje), dizajna, specifičnosti u ispunjenju temeljnog zahteva ambalaže koja se koristi za pakovanje hrane sa naglaskom na zdravstvenu ispravnost (sigurnost ili bezbednost hrane), odnosno da je čuva od različitih hemijskih, mehaničkih i mikrobioloških uticaja u cilju povećanja roka ispravnosti (trajnosti) upakovanog sadržaja.

Tipovi ambalaže, prema materijalu, su metalna, staklena, polimerna, ali i papirna i kartonska i višeslojna ambalaža, pa i drvena ambalaža i palete. Danas se više od polovine industrijski proizvedene hrane pakuje u polimernu vrstu ambalaže.

3.1. Karakteristike PET kao najčešće korišćenog polimernog materijala za ambalažu za pića

Počev od 1950. god. svetska proizvodnja originalnog polimera je eksponencijalno rasla, od 1964.godine se povećala 20 puta da bi 2014.godine dostigla i 311 miliona tona [17]. Poli(etilen tereftatalat) (PET) je polimer koji ima sve veću primenu na domaćem i stranom tržištu zahvaljujući svojim izuzetnim fizičkim i mehaničkim svojstvima. Ovaj termoplastični polimer iz grupe poliestara se koristi u proizvodnji ambalaže za razna pića, sokove, alkoholne napitke, vodu, jestiva ulja, kućne deterdžente i ostalu ambalažu za pakovanje hrane, sintetička vlakna kao i za mnoge druge primene. PET je linearni, kondenzacioni polimer, koji nastaje postupkom polikondenzacije pri čemu se izdvaja i molekul vode, ako se koristi tereftalna kiselina, ili alkohol, ako se koristi estar tereftalne kiseline. U ovom postupku upotrebljavaju se približno ekvimolarne količine etilenglikola i tereftalne kiseline, odnosno dimetil tereftalata, u zavisnosti od postupka proizvodnje [18]. U zavisnosti od načina prerade, u PET-u mogu da dominiraju amorfne ili kristalinične oblasti. PET poseduje izuzetno dobra fizička, mehanička i elektro-izolaciona

3. PACKAGING FOR BOTTLED WATER

The industrial revolution has influenced considerable development in packaging materials, packaging and packaging methods. Thanks to the progress in the packaging area, there has been an expansion in the production of new packaging materials, food products and a modern way of selling food. It has been recognized that the success on the market largely depends on the type of packaging (primarily the quality of the raw material from which it is made), the design, the specificity in meeting the basic requirement of packaging used for food packaging with emphasis on health safety (safety or food safety), that is kept of various chemical, mechanical and microbiological influences in order to increase the life time of the packaged content.

Types of packaging, according to the material, are metal, glass, polymer, but also paper and cardboard and multilayer packaging, and also wooden packaging and pallets. Today more than half of industrially manufactured foods are packaged in a polymeric type of packaging.

3.1. Characteristics of PET as the most common polymeric material for beverage packaging

Beginning in 1950, the world production of the original polymer has grown exponentially, since 1964 it has increased 20 times to reach 311 million tons [17]. Poly (ethylene terephthalate) (PET) is a polymer that has an increasing application on the domestic and foreign markets thanks to its exceptional physical and mechanical properties. This thermoplastic polymer polyester is used in the production of packaging for various drinks, juices, alcoholic beverages, water, edible oils, home detergents and other food packaging, synthetic fibers as well as for many other applications. PET is a linear, condensation polymer, which is created by a polycondensation process, whereby a water molecule is also used, if terephthalic acid or alcohol is used, if the terephthalic acid ester is used. In this process, approximately equimolar amounts of ethylene glycol and terephthalic acid, or dimethyl terephthalate are used, depending on the production process [18]. Depending on the method of processing, PET can be dominated by amorphous or crystalline regions. PET has very good physical, mechanical and electro-insulating properties. The svojstva. Tačka topljenja sirovog uzorka PET-a je oko 280 °C, dok se za komercijalne proizvode, usled smanjene kristaliničnosti prouzrokovane hemijskim nečistoćama u polimernom lancu, kreće u rasponu od 255-260 °C. Zbog velike jačine, dobrih barijernih svojstava, visoke providnosti i dobre mogućnosti metaliziranja, PET se koristi kao ambalažni materijal u proizvodnji boca, kao vlakno za odeću, film. Pored ovih svojstava, kao i zbog stepena kristalnosti i nivoa orijentacije u završnom delu procesa proizvodnje koji se može kontrolisati, PET ima širok opseg primene.

PET je jedan od retkih polimernih materijala koji se uspešno može reciklirati i koji može biti podvrgnut svim postupcima reciklovanja, a kao takav predstavlja vrednu sekundarnu sirovinu. Sekundarnim reciklovanjem PET-a (topljenje i mehanička prerada prečišćenog PET-a) dobija se regranulat koji se može prerađivati na različite načine. Prerada polimernog otpada uslovljena je karakteristikama samog materijala, tipa i čistoće otpada, a samu preradu otežava kombinovani otpad i zaprljani otpad. Treba napomenuti da se za proizvodnju ambalaže – polimernih flaša uglavnom koriste ti regranulati, odnosno recikliran PET. Usled toga se pojavljuju i razlike u kvalitetu ambalaže a odatle uglavnom i potiče narušavanje osobina ambalaže i gubljenje osnovne uloge – da zaštiti gotov proizvod i spreči narušavanje njegovog kvaliteta. Na tržištu su prijavljeni slučajevi sa narušenim kvalitetom (uglavnom organoleptičkim ustanovljenjem). U praksi je pokazano da ukoliko se reciklirani granulat dodaje u iznosu manjem od 30%, tada proizvođači imaju finansijski gubitak zbog čega se koristi veliki udeo recikliranog PET-a u proizvodnji.

Za razliku od ostalih plastičnih materijala, PET ima dobre barijerne karakteristike, on je čist ugljovodonik koji sadrži C, H i O, i inertan je u odnosu na sadržaj sa kojim može doći u dodir pri pakovanju. Međutim, niskomolekularne komponente koje se dodaju pri proizvodnji PET materijala kao što su: acetaldehid, etilenglikol i dietilenglikol mogu da migriraju u sadržaj pa mogu i da utiču na promenu senzorskih svojstava, naročito acetaldehid, pa je zbog toga, potrebna redovna kontrola ove ambalaže po pitanju zdravstvene ispravnosti.

3.2. Potencijalno toksične supstance koje mogu da migriraju iz polimerne ambalaže

Organizacije kao što je Udruženje protiv raka dojke (Breast Cancer Fund) [19] i Safer Chemicals, Healthy Families [20] neprestano upozoravaju da se hemikalije koje izazivaju zabrinutost ne smeju nalaziti u upakovanoj hrani i drugim proizvodima. Kao preporuka za sprečavanje kontaminacije, brojni istraživači upućuju na preduzimanje koraka za izbegavanje unosa ovakvih toksičnih supstanci. Jedna od preporuka jeste i da se hrana i piće čuva u staklenim posudama ili od nerđajućeg čelika

melting point of the crude PET sample is about 280 ° C, while for commercial products, due to reduced crystallinity caused by chemical impurities in the polymer chain, ranges from 255-260 °C. Due to high strength, good barrier properties, high transparency and good metallization capabilities, PET is used as a packaging material in the production of bottles, as fiber for clothing, film.. In addition to these properties, as well as the degree of crystallinity and level of orientation in the final part of the production process that can be controlled, PET has a wide range of applications.

PET is one of the rare polymeric materials that can be successfully recycled and which can be subjected to all recycling processes, and as such represents a valuable secondary raw material. Secondary recycling of PET (melting and mechanical processing of purified PET) produces a regranulat that can be processed in different ways. The processing of polymer waste is conditioned by the characteristics of the material itself, the type and the purity of the waste, and the processing itself makes it difficult for combined waste and contaminated waste. It should be noted that the production of packaging - polymeric bottles is mainly used by these regranulates, or recycled PET. Hence, the differences in the quality of the packaging and hence mainly cause distortion of the characteristics of the packaging and the loss of the basic role - to protect the finished product and prevent its quality. In practice it has been shown that if the recycled granulate is added to less than 30%, then the producers have a financial loss and hence a large amount of recycled PET is used in production.

Unlike other plastic materials, PET has good barrier characteristics, it is a pure hydrocarbon containing C, H and O, and is inert with respect to the content with which it can come into contact with the packaging. However, the low molecular weight components that are added to the production of PET materials such as acetaldehyde, ethylene glycol, and diethylene glycol can migrate to the content and may also affect the change in the sensory properties, in particular acetaldehyde, and therefore requires regular control of this package in terms of health safety.

3.2. Potentially toxic substances that can migrate from polymeric packaging

Organizations such as the Breast Cancer Fund (Breast Cancer Fund)) [19] and Safer Chemicals, Healthy Families [20] have repeatedly warned that chemicals that cause concern should not be found in packaged foods and other products. As a recommendation for the prevention of contamination, many researchers have been advised to take steps to avoid the introduction of such toxic substances. One of the recommendations is that food and drinks are stored in glassware or stainless steel instead of plastic packaging whenever it is possible (especially if the umesto u plastičnoj ambalaži kad god je to moguće (pogotovo ako je hrana koja se čuva masna ili kisela).

Pod uticajem svetlosti i temperature polimeri iz PET ambalaže se rastvaraju pa i dospevaju u sadržaj (vodu). Smrzavanjem vode u plastičnoj flaši tokom leta mogu se otpustiti prilično velike količine dioksina koji nije rastvoriljiv u vodi ali jeste u mastima, pa se, kada dospe u ljudski organizam on sakuplja u masnom tkivu. Isto se dešava ukoliko se hrana greje u plastičnoj ambalaži u mikrotalasnoj peći.

Ftalati su industrijske hemikalije koje imaju široku primenu u mnogim komercijalnim aplikacijama. Usled prisutnosti u životnoj sredini, ftalati se takođe često mogu naći u rekama i podzemnim vodama, kao i u vazduhu, pijaćoj vodi, zemljištu i hrani [21] Istraživači u Holandiji otkrili su i do 3,5 µg/L dietilheksil ftalata (DEHP) u pijaćoj vodi. Takođe, ftalati se mogu naći i u kišnici. Studije su pokazale da su ftalati detektovani u masnim prehrambenim proizvodima kao što su meso i mlečni proizvodi zatim u ljudskoj krvi, mleku porodilja i metaboliti ftalata detektovani su u urinu odraslih i dece.

U Velikoj Britaniji se više ne koristi u proizvodnji folija i većine ostalih polimernih masa za pakovanje hrane. Mastilo koje se koristi za štampanje na plastici, tablama i folijama upakovanih proizvoda često sadrži ftalate kao i neki od lepkova koji se koriste pri pakovanju.

DEHP (di(2-ethylhexyl) phthalate) je najčešće korišćeni oblik ftalata, uglavnom za PVC, i u Zapadnoj Evropi njegova upotreba čini 30% svih plastifikatora (DEHP Information Centre, 2006). On je jedan od najčešće detektovanih ftalata u uzorcima životne sredine [22] (čini čak četvrtinu ukupno proizvedenih plastifikatora ikada [23]) pa i najčešće analiziran. Otpušta se iz produkata krvi, intravenoznih i vrećica za dijalizu, kao i cevčica napravljenih od polivinil hlorida (PVC). Omekšani PVC može da se sastoji od najviše 40% DEHP [24].

Izloženost ftalatima se može pojaviti direktno preko upotrebe potrošačkih proizvoda i plastike koja ih sadrži [25]. Zbog velike zabrinutosti javnosti i nadležnih organa zbog izloženosti ftalatima, Evropski parlament [26] je 2005. godine uveo urgentne zabrane upotrebe 6 oblika ftalata (DEHP, DINP, DBP, DIDP, DNOP, BBP) u proizvodima za domaćinstvo za kućnu upotrebu kao i medicinskim sredstvima, kao odgovor na akcioni zdravstveni plan i komisije za životnu sredinu „Commission's Environment and Health Action Plan 2004-2010".

Ftalati mogu da se absorbuju kroz kožu ili inhaliraju upotrebom parfema, različitih vrsta kozmetičkih proizvoda i proizvoda za ličnu higijenu koji ga sadrže [25]. Pokazano je da je referentna populacija izloženija oblicima ftalata DEP, DBP i BBP (a to su ftalati koji se obično nalaze u proizvodima za ličnu higijenu) nego DEHP obliku, što ukazuje na to da je izloženost ovim

stored food is fat or acid).

Under the influence of light and temperature, polymers from PET packaging are dissolved and get into the water content. Frozen water in a plastic bottle during the summer can release a fairly large amount of dioxin that is not water-soluble but it is soluble in the fat, so when it enters the human body it is collected in the fat tissue. The same reaction take place if the food is heated in a plastic container in a microwave oven.

Phthalates are industrial chemicals that have wide application in many commercial applications. Due to the presence in the environment, phthalates can also often be found in rivers and underground waters, as well as in the air, drinking water, soil and food [21]. Researchers in the Netherlands discovered up to 3.5 µg/L diethyl hexyl phthalate (DEHP) in drinking water. Phthalates can also be found in the rain. Studies have shown that phthalates are detected in fatty foods such as meat and dairy products, then in human blood, breast milk and phthalate metabolites were detected in adults and children urine.

In the UK, phthalates are avoided in the production of foils and most other polymeric food packaging materials. The ink used for printing on plastics, sheets and sheets of packaged products often contains phthalates as well as some of the adhesives used in the packaging.

DEHP (di (2-ethylhexyl) phthalate) is the most commonly used form of phthalate, mainly for PVC, and in Western Europe, its use accounts for 30% of all plasticizers (DEHP Information Center, 2006). It is one of the most commonly detected phthalates in environmental samples [22] (it accounts for as much as a quarter of the total plasticizers ever produced [23]) and is most often analyzed. It is released from blood products, intravenous and dialysis bags, as well as tubes made of polyvinylchloride (PVC). Soft PVC can consist of up to 40% DEHP [24].

Exposure to phthalates can occur directly through the use of consumer products and plastic that contains phthalates [25]. In 2005, the European Parliament [26] imposed urgent ban on the use of 6 forms of phthalate (DEHP, DINP, DBP, DIDP, DNOP, BBP) in household products for home use and medical in response to the „Commission's Environmental and Health Action Plan 2004-2010".

Phthalates can be absorbed through the skin or inhaled using perfumes, various types of cosmetic products and personal hygiene products [25]. It has been shown that the reference population is more exposed to forms of phthalate DEP, DBP and BBP (and these are phthalates commonly found in personal hygiene products) than DEHP form, indicating that exposure to these products is the most important source of exposure. Phthalates are soluble in fats and can therefore usually be found in foods containing proizvodima najbitniji izvor izloženosti. Ftalati su rastvorljivi u mastima i zbog toga se obično mogu naći u namirnicama koje sadrže masnoće [27]. Takođe, ftalati mogu da migriraju u hranu (pretežno masnu hranu kao što su sirevi i meso) iz plastične ambalaže za hranu i eventualnih štamparskih boja koje se koriste na omotima [25] iako postoji nejasnoća u pogledu obima korišćenja ftalata u materijalima koji dolaze u kontakt sa hranom.

Postoje evidentni razlozi za zabrinutost u vezi sa putevima izloženosti ftalata, s obzirom na najosetljivije kategorije ljudi koje su izložene, posebno trudnice pa i odojčad u kritičnim fazama razvoja. Uglavnom, njihovo toksično delovanje se odnosi na prenatalnu i razvojnu toksičnost, estrogene efekte i indukciju astme. Pokazano je da su ftalati izuzetno opasni po ljudsko zdravlje, jer izazivaju oštećenja reproduktivnog sistema, povećavajući rizik od alergija, a mogu izazvati astmu pa i rak. Podaci o znatnoj izloženosti američke populacije ftalatima, može se sagledati na osnovu objavljenih studija o nivoima metabolita ftalata u uzorcima urina. Rezultati ovih studija su pokazali da su četiri metabolita ftalata – monoetil ftalat, mono-2-etilheksil ftalat, mono-butil ftalat i mono-benzil ftalat bila prisutna u više od 75% uzoraka američkih ispitanika [28]. Dok ftalati generalno imaju nisku akutnu toksičnost, neki od oblika izazivaju ozbiljnu zabrinutost preko njihovih svojstva da remete endokrini sistem i njihovih potencijalnih negativnih efekata na muški reproduktivni razvoj, na fetuse kod životinja koji su posebno osetljivi.

Ftalati su privremeno zabranjeni još 1999. god., pa je 2005.god. ponovo obnovljena zabrana u evropskim okvirima. Na bazi podataka o sastavu ftalatnih estara u Evropi se najčešće koriste bis(2-etilheksil) ftalat (DEHP), diizononil ftalat (DINP), diizodecil ftalat (DIDP), butil benzil ftalat (BBP), dibutil ftalat (DBP), diizobutil ftalat (DIBP), ditridecil ftalat (DTDP), dietil ftalat (DEP) i dimetil ftalat (DMP). Većina njih se nalazi na Normanovoj listi emergentnih supstanci među plastifikatorima.

U skladu sa Agencijom Velike Britanije za standarde u vezi hrane (UK Food Standards Agency-FSA), upotreba ftalata u svrhe pakovanja hrane je ograničena, uglavnom na proizvodnju materijala kao što su lepkovi i neke boje za štampu. Nedavna istraživanja od strane „Greenpeace“ takođe je otkrila da PVC ambalaža koja je korišćena u Velikoj Britaniji može da sadrži ftalate koji mogu da migriraju u hranu (meso, sir). Prema “FOODPLAST: A Plasticiser Information Centre, ftalati se ne koriste u plastičnim folijama, već se umesto njih koriste kao adipati kao plastifikatori.

DEHP je deklarisan kao „prioritetno opasna supstanca“ u okviru Evropske okvirne direktive o vodama (EU Water Frame Directive) [29] i klasifikovan u EU kao „toksičan za reprodukciju“. Iako još uvek ne postoji

fat [27]. Phthalates can also migrate into food (mainly fatty foods such as cheeses and flesh) from plastic packaging for foods and possible color printing used on the wrapper [25] although there is some lack of understanding regarding the extent of use of phthalates in materials that come into contact with food.

There are evident reasons for concern about phthalate exposure pathways, given the most vulnerable categories of people exposed, especially pregnant women and infants at critical development stages. Basically, their toxic activity relates to prenatal and developmental toxicity, estrogen and asthma induction. It has been shown that phthalates are extremely dangerous to human health, as they cause damage to the reproductive system, increasing the risk of allergies, and can cause asthma and cancer. Data on the significant exposure of the American population to phthalates from the view point of published studies of levels of metabolite phthalate in urine samples. The results of these studies have shown that four metabolites of phthalate - monoethyl phthalate, mono-2-ethylhexyl phthalate, mono-butyl phthalate and mono-benzyl phthalate were present in more than 75% of samples of American subjects [28]. While phthalates generally have low acute toxicity, some of the forms cause serious concern over their ability to disturb the endocrine system and their potential negative effects on male reproductive development, on fetuses in animals that are particularly sensitive.

Phthalates were temporarily banned in 1999, and in 2005, re-newed ban in European frameworks. On the European market, bis (2-ethylhexyl) phthalate (DEHP), diisononyl phthalate (DINP), diisodecyl phthalate (DIDP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP), diisobutyl phthalate (DIBP), ditridecyl phthalate (DTDP), diethyl phthalate (DEP) and dimethyl phthalate (DMP) are the most commonly used phthalates. Most of them are on the „Norman list of emergent substances“ among plasticizers.

According to the UK Food Standards Agency (FSA), the use of phthalates for the purpose of food packaging is limited, mainly to the production of materials such as adhesives and some color printing. Recent research by Greenpeace has also revealed that PVC packaging used in the UK can contain phthalates that can migrate into food (meat, cheese). According to FOODPLAST: A Plasticiser Information Center, phthalates are not used in plastic films, instead adipates are used.as plasticizers.

DEHP is declared as a “priority hazardous substance” within the framework of the EU Water Frame Directive [29] and is classified in the EU as “reproductive toxicity”. Although there is still insufficient evidence in humans of the carcinogenicity of DEHP, it is classified as a B2 by the US EPA as a likely carcinogen for humans. In a dovoljno dokaza kod ljudi po pitanju kancerogenosti DEHP, on je od strane US EPA svrstan u grupu B2 kao verovatni karcinogen za ljude. U nedavnoj proceni rizika EU po pitanju DEHP naglašena je potreba za više informacija o riziku novorođenčadi koje su izložene DEHP preko kontaminiranog majčinog mleka.

U poslednje objavljenom USEPA izdanju, 2018 Edition of the Drinking Water Standards and Health Advisories Tables, u tabeli „Secondary Drinking Water Regulations" među hemikalijama koje mogu štetno uticati na zdravlje navedeni su dimetil ftalat (DMP), dietil ftalat (DEP), benzil butil ftalat (BBP) kao i DEHP za koji je i utvrđen maksimalni nivo kontaminacije (MCL-maximum contamination level), u iznosu od 0,006 mg/L.

U domaćoj regulativi o vodama, ograničenje u vezi ftalata navodi se u Pravilniku o higijenskoj ispravnosti vode za piće [10] u kojem se posebno ograničava DEHP u iznosu od 0,008 mg/L (u Listi IIIb – maksimalno dopuštene koncentracije organskih supstanci u vodi za piće; a ista koncentracija je navedena kao maksimalno dopuštena u Listi XIb gde su navedene maksimalno dopuštene organske supstance u vodi za piće za vreme vanrednog stanja). Ograničavanje ftalata u regulativi predloženo je i Pravilnikom o ograničenjima i zabranama proizvodnje, stavljanja u promet i korišćenja hemikalija (Sl. Glasnik RS br. 90/2013, 25/2015 i 2/2016).

Bisfenol A je jedna od najčešćih hemijskih supstanci kojoj smo svakodnevno izloženi. Pripada grupi derivata difenil metana i bisfenola a predstavlja gradivni blok polikarbonatne plastike i takođe se koristi u proizvodnji epoksidnih smola koje se nalaze u mnogim proizvodima široke potrošnje [30]. Takođe je rasprostranjen u mnogim termalnim prilivima i drugim proizvodima od papira, uključujući i reciklažne papirne proizvode. Ima ga čak i u kompakt diskovima, zatim u unutrašnjoj strani konzerve, ali i u plastičnim flašama i čašama. Polikarbonska plastika sadrži bisfenol-A, hemijsku supstancu koja bi mogla biti štetna za ljude čak i u malim količinama. Takođe se nalazi u flašicama za bebe, nekim šoljama, glodalicama, flašama za vode, posudama za čuvanje hrane i materijalima za oblaganje više vrsta hrane i limenkama za piće. Kontinualno se objavljuju različite kontradiktorne studije u vezi upozorenja na toksično dejstvo BPA. Testovi na životinjama pokazuju da BPA deluje kao hormon estrogen. To se ne odnosi samo na razvoj polnih organa, već i na razvoj ponašanja, a konstatovana je kancerogenost. Strahuje se da bi takve vrste poremećaja mogle da se konstatuju i kod čoveka.

Krajem 2007. godine, nakon višemesečnih savetovanja i analize rezultata, objavljeno je zajedničko mišljenje 38 vodećih svetskih stručnjaka u području endokrinologije u kojem su upozorili i javnost da je hronično trovanje stanovništva bisfenolom A (BPA) sve učestalija pojava. Prosečne koncentracije ovog otrovnog jedinjenja u krvi

recent EU risk assessment on the issue of DEHP, the need for more information on the risk of newborns exposed to DEHP via contaminated breast milk is highlighted.

In the latest published USEPA edition, the 2018 Edition of the Drinking Water Standards and Health Advisories Tables, in the table "Secondary Drinking Water Regulations" among the chemicals that may have a harmful effect on health are the dimethyl phthalate (DMP), diethyl phthalate (DEP), benzyl butyl phthalate (BBP) as well as DEHP for which the maximum level of contamination (MCL-Maximum Contamination Level) has been established, in the amount of 0.006 mg/L.

In domestic water regulations, the limitation on phthalate is stated in the Regulation on hygienic correctness of drinking water (Sl. list SRJ No. 42/98) and with amendments from 1999 (Sl. list SRJ No. 44/99) [10] in which DEHP is particularly limited in the amount of 0.008 mg/L (List IIIb - maximum permissible concentrations of organic substances in drinking water, and the same the concentration is listed as maximum permitted in List XIb wherein the maximum permitted organic substances in drinking water are listed during the emergency state). Restriction of phthalates in the regulation is proposed by the Regulation on restrictions and prohibitions on the production, placing on the market and use of chemicals (Sl. Glasnik RS No. 90/2013, 25/2015 i 2/2016).

Bisphenol A is one of the most common chemicals we are daily exposed. It belongs to the group of diphenyl methane and bisphenol derivatives and is a building block of polycarbonate plastics and is also used in the production of epoxy resins found in many consumer goods [30]. It is also widespread in many thermal inflows and other paper products, including recycled paper products. It's even in compact discs, then on the inside of the can, but also in plastic bottles and glasses. The polycarbonic plastic contains bisphenol-A, a chemical substance that could be harmful to humans even in small quantities. It is also found in baby bottles, some cups, milling machines, water bottles, food storage containers, and coating materials for many types of food and cans. Various contradictory studies on the toxicity of BPA continuously published. Animal tests show that BPA acts as an estrogen hormone. This not only refers to the development of full organs, but also to the development of behavior, and carcinogenicity has been established. It is frightened that such types of disorders could be found also in humans.

At the end of 2007, after several months of consultation and analysis of the results, a joint opinion was published by 38 leading global experts in the field of endocrinology, in which they warned the public that chronic inhalation of the population with bisphenol A (BPA) is an increasing phenomenon. The average concentrations of this toxic compound in the blood of ispitanika (oko 2 ng/mL) bile su veće su od onih za koje je kod eksperimentalnih životinja dokazano da izazivaju čitav spektar zdravstvenih poremećaja. Okupljeni naučnici zahtevali su zakonske korekcije za dozvoljene koncentracije BPA a svima su preporučili izbegavanje polikarbonatne plastike prilikom ishrane. Ova je zabrana potekla iz Australije i informacije su se širile brzo da bi i američke i kanadske fabrike odlučile da preduzmu inicijativu povlačeći ambalažu od polikarbonatne plastike iz radnji.

Pored pomenutih organskih supstanci, u PET ambalaži se ispituju i mnoge neorganske supstance, poput teških metala. Posebno je često ispitivanje migracije antimona iz PET ambalaže u tečnost koja je upakovana u nju. U mnogim studijama [31,32]. kod ovakvih uzoraka parametar koji je ispitivan je **antimon (Sb)**, s obzirom da se on često koristi kao katalizator u reakcijama polikondenzacije pri proizvodnji PET-a. Kao rezultat, antimon je inkorporiran u neke boce od PET-a, koje se koriste za ambalažiranje pića, u koncentraciji 100 – 300 mg/kg [31]. Uzimajući u obzir njegovu toksičnost, mogućnost otpuštanja antimona iz ambalaže u sadržajni rastvor, može uzrokovati zabrinutost, što je motivisalo neke studije da se bave ispitivanjem sadržaja antimona u PET-u i otpuštenog u pića. Ispitivani su i uticaji pH vrednosti, temperature kao i proteklog vremena [32].

Antimon je u vodi za piće regulisan kontaminant koji poseduje i akutne i hronične zdravstvene efekte. Potiče od antimona trioksida (Sb_2O_3) koji je najvažniji katalizator u proizvodnji PET-a. O uticaju antimona i mogućnosti otpuštanja iz ovakve ambalaže najpre su izvršene studije u Kanadi i u Evropi pa tek onda i u Americi (2008). U studiji o ispitivanju antimona u flaširanim vodama Kanade i Evrope, pokazano je da su vode postale kontaminirane tokom skladištenja usled otpuštanja Sb iz PET ambalaže [33]. Flaše napravljene korišćenjem PET obično sadrže stotine mgSb/kg ambalažnog materijala. Da bi se potvrdilo da stepen kontaminacije flaširane vode raste sa vremenom, usled otpuštanja Sb iz PET-a, čitava kolekcija flaširanih voda koja je ranije ispitivana [33] je ocenjena ponovo, nakon perioda skladištenja u originalnom pakovanju. Pored analize flaširane vode koje su komercijalno dostupne, takođe su vršeni su i neki jednostavni eksperimenti otpuštanja, korišćenjem netaknute podzemne vode koja je skladištena u PET bocama tokom 6 meseci. Vršeno je i ispitivanje koncentracije Sb u različitim brendovima flaširanih voda, iz 16 različitih zemalja i ispitivan je i uticaj katalizatora [34].

4. ZAKLJUČAK

Dosadašnja ispitivanja i analiza kvaliteta flaširanih voda, ukazuju na prvom mestu neophodnost potpunijeg deklarisanja flaširanih voda, bilo da se radi o informisanju potrošača bilo da je u pitanju značaj fizioloških karakteristika vode. Ovakvim detaljnim

the examinees (about 2 ng/mL) were higher than those that have proven to cause a whole spectrum of health disorders in animal testing. The scientists required legal corrections for the allowed concentrations of BPA, and recommended that everyone should avoid eating from polycarbonate plastics packaging. This ban came from Australia and the information spread rapidly so that both US and Canadian factories decided to take the initiative by pulling out the plastic polycarbonate packaging from the store.

Besides mentioned organic substances, many inorganic substances, such as heavy metals, are also being tested in PET packaging. Particularly frequent is the testing of the migration of antimony from the PET packaging into the content liquid. In many studies [31,32] in such samples the **antimony** parameter (Sb) was tested, since it is often used as a catalyst in polycondensation reactions in the production of PET. As a result, the antimony is incorporated into some PET bottles used for the packaging of beverages at a concentration of 100-300 mg/kg [31]. Taking into account its toxicity, the possibility of releasing antimony from the packaging into the content solution can cause concern, which has motivated some studies to test the content of antimony in PET and released into the beverage. The effects of pH value, temperature and time were also examined [32].

Antimony is a drinking water regulated contaminant that has both acute and chronic health effects. It comes from antimony trioxide (Sb2O3), which is the most important catalyst in PET production. Studies in Canada and Europe, and then in America (2008) were first made on the impact of antimony and the possibility of laying off from such type of packaging. In a study on antimony testing in bottled waters of Canada and Europe, it has been shown that the waters have become contaminated during storage due to the release of Sb from PET packaging [33]. Bottles made using PET usually contain hundreds of mgSb/kg of packaging material. To confirm that the degree of contamination of bottled water increases over time, due to the release of Sb from PET, the entire collection of bottled water previously examined [33] was evaluated again after the storage period in the original package. In addition to the analysis of bottled water commercially available, some release experiments were also undertaken using untouched groundwater stored in PET bottles for 6 months. Concentrations testing of Sb in other bottled water brands from 16 different countries were also shown, and the effect of the catalyst was examined [34].

4. CONCLUSION

Recent studies and analysis of the bottled water quality, indicate in the first place the necessity for a more complete declaration of bottled waters, whether it is about informing consumers, whether it is the importance of the physiological characteristics of deklarisanjem, flaširana voda bi postala važan faktor od životnog značaja, a smanjile bi se posledice lošeg uticaja na ljudsko zdravlje usled prekomernog konzumiranja voda sa bogatim sadržajem mineralnih materija. Tržište Republike Srbije obiluje širokom lepezom flaširanih voda, sa lokaliteta različitog hidrogeohemijskog sastava što zahteva svrstavanje voda po zdravstvenom značaju preko oksido-redukcionih osobina. Iako se voda pakuje u PET koji se smatra inertnim materijalom, određene komponente koje se dodaju pri proizvodnji PET materijala mogu da migriraju vodu koja se prema tome mora redovno kontrolisati.

Iako se samo mala frakcija antimona iz PET plastičnih boca otpušta u vodu, ipak, treba imati u vidu korišćenje alternativnih vrsta polimerne ambalaže koja ne sadrži antimon, pogotovo tamo gde izlaganje ekstremnim uslovima može da izazove oslobađanje antimona iz PET plastične ambalaže.

S obzirom da su mnoge studije u vezi sa toksičnošću bisfenola A dale protivrečne rezultate, nesporno je donošenje novih, ažuriranih ograničenja u skladu sa evropskom regulativom. Još uvek nije utvrđena dinamika kojom bi se obavljala kontrola prometa u ovoj oblasti, pa je neophodno izjednačavanje domaće regulative sa svetskom regulativom.

Deklarisanje ovakvih proizvoda mora pratiti ažuriranje i praćenje potencijalno toksičnih parametara u skladu sa evropskom i svetskom regulativom. Pored sveobuhvatnije deklaracije, potrebno je i poznavanje uslova pod kojima se ambalaža transportuje i skladišti, kao bitnih faktora koji mogu uticati na migraciju toksičnih supstanci. Uticaj ambalažiranja, transporta i skladištenja na sastav flaširanih voda sa aspekta potencijalno toksičnih supstanci, do sada je već pokazan u mnogim studijama u svetu pa i u zemljama u regionu, međutim nedostaju studije ovog tipa u našoj zemlji.

ZAHVALNICA

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water. By this detailed declaration, bottled water would become an important factor of vital importance, and the consequences impact on human health would be reduced due to excessive consumption of water with a high content of mineral substances. The market of the Republic of Serbia has a wide range of bottled waters from the site of a different hydrogeochemical composition, which requires the classification of water by a health significance through oxidizing-reducing properties. Although PET is considered as inert material according certain components that are added to PET production can migrate in the water, that must be regurarly controlled.

Although only a small fraction of antimony from PET plastic bottles is released into the water, however, the use of alternative types of polymeric packaging that does not contain antimony should be taken into consideration, especially where exposure to extreme conditions can cause the release of antimony from PET plastic packaging.

Considering that many studies related to the toxicity of Bisphenol A have contradictory results, it is necessary to adopt new, updated restrictions in line with European regulations. The dynamics that will be used to control the traffic in this area are not determined, so it is necessary to equalize domestic regulations with world regulations.

Declarations of such products must follow the updating and monitoring of potentially toxic parameters in accordance with European and world regulations. In addition to the more comprehensive declaration, knowledge of the conditions under which the packaging is transported and stored as important factors that can influence to the migration of toxic substances, is also needed. The impact of packaging, transport and storage on the composition of bottled waters from the perspective of potentially toxic substances has been shown in many studies in the world as well as in countries in the region, however, studies of this type in our country are missing.

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