



Investigation of Possible Toxic Effects of Personal Care Products on *Daphnia magna* in the Kucukcekmece Lagoon, Marmara Sea (Turkey) ^[*]

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Abstract: Polyethylene glycols (PEGs) used in personal care products (PCPs) are preferred in a wide range of fields thanks to their solubility, viscosity properties, and low toxicity levels which were detected on mammals nearly 60 years ago. This study was aimed to determine the effect of acute toxicity of personal care products and PEGs which are used particularly in personal care and pharmaceutical products on aquatic ecosystems. In this scope, this study was determined the individual acute toxicities of PEGs; the acute toxicity of baby shampoo and body lotion which are among personal care products containing PEGs; and the possible acute toxicity of these products when they reach the surface waters. *Daphnia* sp. Acute Immobilisation Test was used to determine the toxic effect on aquatic organisms. The acute toxicity class of PEGs was identified as non-toxic (Class 0). While the body lotion was highly toxic (Class 5) at the end of the 48-hour exposure time without being applied to any surface water, it was non-toxic (Class 0) for all stations when applied to surface water. While the baby shampoo was practically non-toxic (Class 1) at the end of the 48-hour exposure time without being applied to any surface water, it was slightly toxic (Class 2) for station 1 and station 2 when applied to surface water. When PCPs including these liquid plastics, which are found to have non-toxicity characteristics, it is obvious that different toxic effects can emerge apart from the individual toxicity on surface waters.

Keywords: Acute toxicity, *Daphnia magna*, Personal Care Products (PCPs), Polyethyleneglycol (PEG), Surface waters.

Küçükçekmece Lagünü'nde (Marmara Denizi, Türkiye) Kişisel Bakım Ürünlerinin *Daphnia magna* Üzerindeki Olası Toksik Etkilerinin Araştırılması

Öz: Kişisel bakım ürünlerinde kullanılan polietilen glikoller (PEG'ler), çözünürlük, viskozite özellikleri ve yaklaşık 60 yıl önce memelilerde tespit edilen düşük toksisite seviyeleri sayesinde çok çeşitli alanlarda tercih edilmektedir. Bu çalışmanın amacı, kişisel bakım ürünlerinin ve özellikle kişisel bakım ve eczacılık ürünlerinde kullanılan PEG'lerin sucul ekosistemler üzerindeki akut toksisitesinin etkisini tespit etmektir. Bu kapsamda, bu çalışmada PEG'lerin bireysel akut toksisiteleri; PEG içeren kişisel bakım ürünleri arasında yer alan bebek şampuanı ve vücut losyonunun akut toksisitesi; ve bu ürünlerin yüzey sularına ulaştıklarında olası akut toksisitesi belirlenmiştir. Sucul organizmalar üzerindeki toksik etkiyi belirlemek için, *Daphnia* sp. Akut Hareketsizlik Testi kullanılmıştır. PEG'lerin akut toksisite sınıfı, toksik olmayan olarak belirlenmiştir (Toksosite Sınıfı-0). Vücut losyonu, 48 saatlik maruziyet süresinin sonunda herhangi bir yüzey suyuna uygulanmadan yüksek derecede toksik (Toksosite sınıfı-5) iken, yüzey suyuna uygulandığında tüm yüzeyel su numuneleri için toksik değil (Toksosite sınıfı-0) olarak belirlenmiştir. Bebek şampuanı, 48 saatlik maruziyet süresinin sonunda herhangi bir yüzey suyuna uygulanmadan pratik olarak toksik olmayan (Toksosite sınıfı-1) iken, yüzey suyuna uygulandığında istasyon 1 ve istasyon 2 için hafif toksiktir (Toksosite sınıfı-2). Toksik olmayan özelliklere sahip olduğu tespit edilen bu sıvı plastikleri içeren PCP'ler, yüzey sularındaki bireysel toksisite dışında farklı toksik etkilerin ortaya çıkabileceği açıktır.

Anahtar kelimeler: Akut toksisite, *Daphnia magna*, Kişisel Bakım Ürünleri, Polietilen glikol (PEG), Yüzeyel sular.

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INTRODUCTION

Personal care products (PCPs) comprise a wide range of products such as skin, hair, body care, oral health and dental care, and makeup products. The amount of pharmaceuticals and active ingredients in personal care products, which are used in large quantities around the world, is almost at the same level as the number of agricultural chemicals (Daughton & Ternes, 1999). The interest in these products has increased in recent years due to the frequency of use and chemical structure of them (Liu & Wong, 2013), because personal care products, unlike drugs, are not subject to metabolic changes in the human body. Therefore, large quantities of PCPs are mixed directly into the receiving environment without going through any change.

PCPs journey may start from sewage and end in surface water, even in drinking water basins and/or soil (Kim et al., 2009). This results from the disposal of the wastes in treatment plants which cannot be performed by conventional methods (Çetinkaya Karafakı, 2018). These products may be threatening since they are potentially permanent, bio accumulative, biologically active, and continuously discharged into the aquatic environment (Brausch & Rand, 2011). PCPs are among the most frequently detected compounds among primary pollutants in surface water, even at nanogram levels (Pablos et al., 2015).

Today, another remarkable danger in personal care products are microplastics. Polyethylene microbeads, which are mostly encountered in skin cleaning products, are 10–700 µm in diameter and generally below 500 µm. In such particle sizes, they can easily access the digestive systems of aquatic organisms and may be fatal to them (Wardrop et al., 2016). Microbeads found in personal care products and cosmetics have been recently banned in the USA, Canada, and the European Union. However, it is still widely used in many countries, including Turkey (Hernandez et al., 2017; Ustabaşı & Baysal, 2019). However, microbeads are not the sole plastic-type found in personal care products.

Different polymeric structures are used as solvent, thickener, plasticizing agent, softener and surfactant in personal care products today. In particular, hydrophilic PEGs having different molecular weights are found in almost all cosmetic product compositions. Depending on the molecular weight, PEGs are used in liquid, waxy solid and solid forms in cosmetic, pharmaceutical and food industries. Food and Drug Administration (FDA), based on the Inactive Ingredient Database (FDA, 2019) declared that the maximum amount used of PEG decreased in line with increasing molecular weight PEG 400, 4000, 6000 and 8000 are 960.48, 449.6, 450 and 100 mg per dosage form, respectively.

There are studies conducted on sources, fate, and effects of microplastics in aquatic and terrestrial

environments; their uptake by organisms and possible effects on them (Cheung & Fok, 2016; Duis & Coors, 2016; Kalčíková et al., 2017; Lei et al., 2017). In the literature review, therefore, it is difficult to come across a study conducted on the fate and effects of water-soluble liquid plastics contained in these products. Previous studies investigated the intended use of various PEG compounds and concluded that their use in cosmetics is relatively safe for public health (CIR Expert Panel, 2004; Fruijtier-Pöllth, 2005; Jang et al., 2015; Lanigan et al., 2001). The number and variety of PEGs studied remained limited due to the wide range of PEGs. Considering the importance of PCPs, the addition of new products, the advancement of technology and public health as well as environmental health, it is believed that the current studies fall short to reflect the future picture.

Chronic and acute tests conducted with *Daphnia magna* are among the most common studies in the field of aquatic toxicology (Martins et al., 2007; Sönmez et al., 2016). *D. magna* has been an essential organism for ecotoxicology due to its ease of reproduction in the laboratory and its place in the food chain (Imhoff et al., 2017). It also makes it possible to use these organisms to determine the toxicity of liquid plastics because they are fed by filtering water.

This study was aimed to determine the effect of acute toxicity of personal care products and PEGs which are used particularly in personal care and pharmaceutical products on aquatic ecosystems. In this scope, this study was determined the individual acute toxicities of PEGs; the acute toxicity of baby shampoo and body lotion which are among personal care products containing PEGs; and the possible acute toxicity of these products when they reach the surface waters. Samples of surface waters with seawater, freshwater and brackish water composition were taken to determine the toxic effect of PCPs in surface waters.

MATERIAL AND METHOD

In this study, PEG was selected as polymer material and subjected to acute toxicity tests at different concentrations. As PEG products are present alone, two different PCP products containing PEG were selected and their acute toxicity was studied. Finally, a scenario was created for the discharge of selected PCPs to the surface waters (seawater, freshwater and brackish water) with 3 different compositions and the acute toxicity test was applied in the prepared sets.

Selection of PEGs: Polyethylene glycols 200, 300, 400 and 600 are fluid and 1000, 2000, 4000, 6000 and 10.000 are solid. The number demonstrates the mean molecular weight of polyethylene glycols in a given product. Table 1

presents the PEGs selected within the scope of the present study and their use in PCPs. In the experimental studies, PEGs of Sigma-Aldrich brand were used.

Table 1. PEGs selected within the scope of the present study and their use in PCPs (Jang et al., 2015).

Polymer	Description as cosmetic ingredients
PEG 600	Humectant, Shower and bath products, creams and lotions, shampoos, shaving products and liquid soaps.
PEG 1500	Perfume fixative, softener, non-greasy lubricant. Moisture stabilizing effect in creams. Leaves a pleasant feel on the skin. In lotions, acts as a cleansing agent.
PEG 2000	Nonionic, moisturizing, lubricating
PEG 6000	Non-ionic, binder, lubricant, suspending agent
PEG 10000	Slip and mold-release agent, water soluble carrier substance, softener, moisture-stabilizing effect in creams. Leaves a pleasant feel on the skin.

Selection of PCPs: Two different products, baby shampoo, and body lotion were selected as personal care products having the common feature of containing PEG. In addition to having PEG in common, both products have the potential to be eco-friendly/greener than other products.

The first product, baby shampoo is widely used in Turkey, its chemical content is formed for relatively sensitive skins due to its usage area. The product is stated to be in line with the Cosmetic Act no. 5324 and Cosmetic Regulation in force in Turkey which were modelled and prepared in accordance with the Regulation (EC) No 1223/2009 of the European Parliament and of the Council on Cosmetic Products. It contains mix of PEG esters (as polyethyleneglycol oleate and polyethyleneglycol stearate) along with different chemicals.

The other product, body lotion is produced by an environmentally sensitive company. It is sold at higher prices since it is known to be more sensitive to its equivalents in the Turkish market. It contains the compound of PEG esters (polyethyleneglycol stearate) along with different chemicals.

Selection of Surface Waters: It is observed that water quality has deteriorated as pollution levels increased over time in the Kucukcekmece Lagoon where seawater, freshwater, and brackish water compositions coexists in Istanbul province (Sivri et al., 2012). Both the connection of the lake to the Sea of Marmara and the pollution carried by rivers to the lake further increased the pressure on it. The sample of the surface water was collected to identify the toxicity of personal care products, the toxicity of which was determined in surface water. Samples were taken from 3 different stations from surface water with different composition on the southwest coast of Istanbul.

Special attention was paid to the dispersibility of PCPs at different salinity rates while selecting the stations. Therefore, the Avclar Coast, which is connected with the lagoon, with seawater composition (Station 1), the channel of Kucukcekmece Lagoon, which has a channel for transitional waters between the lake and sea, with brackish

water composition (Station 2), and Kucukcekmece Lagoon with a composition close to freshwater (Station 3) were selected. The information obtained regarding these stations is presented in Table 2. The general view of the stations is presented in Figure 1.

Table 2. Sampling Stations and compositions of surfacewaters⁷.

Stations	Name of Stations	Composition of water (%)	Coordinates
Station 1	Avclar Coast	Seawater (22%)	40° 58' 47,11" N 28° 46' 8,07" E
Station 2	Kucukcekmece Channel	Brackish water (11%)	40° 58' 51,13" N 28° 46' 23,51" E
Station 3	Kucukcekmece Lake	Freshwater (6%)	40° 59,4' 48" N 28° 45' 45,80" E

In accordance with Water Pollution Control Instruction Methods of Sampling and Analysis, surface water samples taken from each station were brought to Microbiology Research Laboratory (CEMIK) in Department of Environmental Engineering at Istanbul University-Cerrahpasa.



Figure 1. General view of the study area (adapted from Google Earth).

The test was based on the OECD guideline *Daphnia magna* Acute Immobilisation Test (OECD, 2004). *Daphnia* not older than 24 hours were exposed to the sample concentration. The vessels were completely filled with appropriate volumes of dilution water and samples. First of all, individual acute toxicity of PEGs was studied (Figure 2). Preliminary tests were performed to determine the concentration range. Afterwards, 100, 80, 40, 20, 10, 5, 1 and 0.1 g L⁻¹ concentrations at which immobility/immortality was observed for each PEG.

In the second step, preliminary tests were performed to detect the concentrations of baby shampoo and body lotion (Figure 2). According to the data obtained, the concentrations of body lotion to be studied were determined as 20 g L⁻¹, 10 g L⁻¹, 5 g L⁻¹, 1 g L⁻¹, 0.5 g L⁻¹, 0.25 g L⁻¹, 0.10 g L⁻¹, 0.05 g L⁻¹, and 0.01 g L⁻¹, respectively. For baby shampoo, the toxicity test was performed at concentrations;

1 g L⁻¹, 0.8 g L⁻¹, 0.6 g L⁻¹, 0.5 g L⁻¹, 0.4 g L⁻¹, 0.25 g L⁻¹, 0.2 g L⁻¹, and 0.05 g L⁻¹. In the final step, the body lotion and baby shampoo were applied to surface water samples (Figure 2).

Then, Daphnids were placed into test beakers. Minimum 2 mL of test solution was needed for each test organism; hence 50 mL test media was studied for 10 daphnids. The organisms were unfed and did not go through the aeration during the test. The temperature, pH and DO values were checked. The controls were kept under the same conditions. Studies were performed in parallel for each set. In addition, low-speed (60 rpm) rinsing movement was applied to ensure adaptation to natural conditions.

Any immobility and abnormal behaviour were recorded after 24 and 48 hours. Each beaker was checked for immobilized daphnids at the 24th and 48th hours. For each period (24 and 48 hours) during which the observations were recorded, the test result was expressed as EC₅₀ with the Probit Analysis method as proposed by EPA to express the dose-response relationship (EPA, 1991).

During acute exposures, daphnids observed to be immobilized were taken from the test environment. At the end of the experiment, immobilized/dead daphnids in each beaker were analysed in KRUSS brand-MBL 2000 binocular microscope environment; physical integrity of organisms was analysed and photographed.

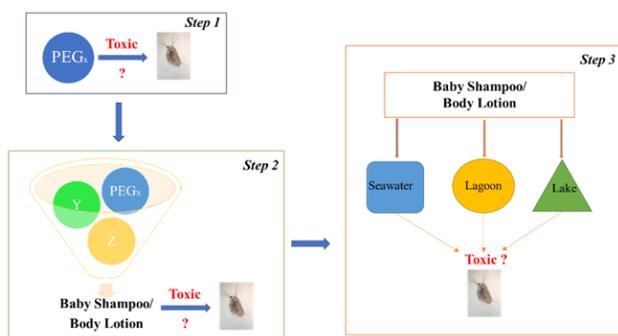


Figure 2. Experimental set.

Classification of Acute Toxicity: It is possible for products containing PEGs, and PEGs to mix in surface waters unless they are satisfactorily or appropriately dissolved at wastewater purification plants. Therefore, this study grounds on the toxicity classification which is based on toxicity in wastewaters (Table 3).

Table 3. Classification of toxicity (adapted from GESEAMP (2017)).

Classification	EC ₅₀ (mg L ⁻¹)	Acute Toxicity
0	> 1000	Non-Toxic
1	>100-≤1000	Practically Non-toxic
2	>10-≤100	Slightly Toxic
3	>1-≤10	Moderately Toxic
4	>0.1-≤1	High Toxic
5	>0.01-≤0.1	Very High Toxic
6	≤0.01	Extremely Toxic

RESULTS AND DISCUSSION

No mortality/immobility was observed in the control group after the 24- and 48- hour exposure time for all sets. Findings of each set are presented below under separate titled.

Acute Toxicity Classification of PEGs: Figure 3 presents the immobilization rate (%) at the end of 24- and 48-hours exposure of the acute toxicity test performed with *D. magna* for PEG 600, 1500, 2000, 6000 and 10.000. Generally, mortality rates increased with increasing exposure time (except PEG 600). Considering the 24-hour exposure, in general, mortality rates reduced as the number of PEG molecules increased (except PEG 6000). No immobile/dead daphnids were counted at either concentration of 1 g L⁻¹ or 0.1 g L⁻¹ studied for both exposure periods. For PEG 6000 and PEG 10000, the mortality rate was found to be 50% or more after the 48-hours of exposure.

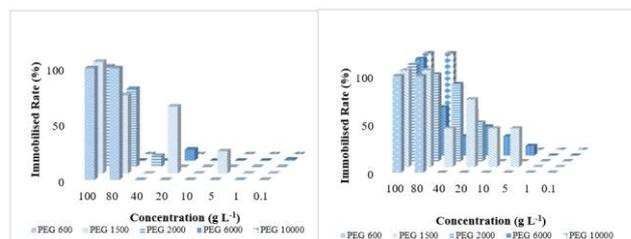


Figure 3. Concentration-affiliated immobilized rate at the end of exposure (24 and 48 hours from left to).

Table 4 presents the acute toxicity value of the PEGs studies as (EC₅₀) g L⁻¹ and the related acute toxicity class. Accordingly, PEG 600, 1500, 2000, 6000 and 10.000 did not have any acute toxicity effect on *D. magna* and were identified as non-toxic. Studies on the toxicological and physiological effects of PEGs have been published in a few journals several years ago. Acute toxicity of different PEGs ranging from PEG 200 to PEG 10.000 on Guinea pig and rabbit, was studied especially between 1938 and 1949. In a study conducted by Symth et al., (1950), the findings obtained were in parallel with the previous studies showing that acute oral toxicity and dermal toxicity were very low. In a review by Fruijtier-Pölloth, (2005), it was also found that most of the PEGs and their derivatives studied so far cause very low toxicity after single or repeated exposure to mammals.

At the end of the 24-hour exposure time, a linear relationship was found between EC₅₀ (g L⁻¹) and PEG molecular weight, just as in mortality (%). However, EC₅₀ values at and above 1000 mg L⁻¹ are classified as non-toxic. Therefore, the relationship has no effect on the toxicity class. In the study conducted by Symth et al. (1950), clear tendency towards a slight decrease in acute toxicity was interpreted with large increases in molecular weight. The statement of reduced toxicity as molecular weight increases is also

reported in review of Fruijtjer-Pöllöth (2005) on polyethylene glycols (PEGs) and derivatives used in cosmetic products.

Table 4. Acute toxicity rates and classes of PEGs.

Sample	24 h		48 h	
	EC ₅₀ (g L ⁻¹)	Classification of acutotoxicity	EC ₅₀ (g L ⁻¹)	Classification of acutotoxicity
PEG 600	>10000	0	>10000	0
PEG 1500	20.917	0	22.861	0
PEG 2000	65.216	0	25.280	0
PEG 6000	>100000	0	>100000	0
PEG 10000	>100000	0	>100000	0
PEG 600	>10000	0	>10000	0

Apart from calculating EC₅₀ values affiliated to mortality rates, dead/immobilized daphnids were examined with a microscope to see the effect of exposure. A microscopic image of *D. magna* in control is presented in Figure 4 for a more solid comparison. Negative effects of the exposure were detected on daphnids in PEG 600, unlike other PEGs, at the 24th hour (Figure 5-a, b). At the 48th hour of exposure, the effects of PEG 2000 (Figure 6) and PEG 6000 (Figure 7) were detected on Daphnids in addition to PEG 600 (Figure 5-c, d) at the highest concentrations studied (100 and 80 g L⁻¹). This effect, particularly emerging at high concentrations, is due to the fact that daphnids' digestion systems decrease in volume. In the literature, no related finding has been found, so this behaviour is important.



Figure 4. Microscope image of living *Daphnia magna* in control sample (Magnification power 4x10).

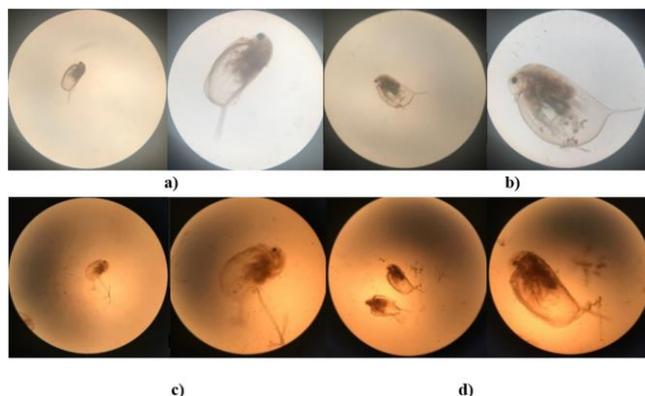


Figure 5. The effects of PEG 600 on daphnids after the 24-hour exposure a) 100 g L⁻¹ (Magnification power, respectively=4x10 and 10x10) b) 80 g L⁻¹ (Magnification power, respectively = 4x10 and 10x10), The effects of PEG 600 on daphnids after the 48-hour exposure c) 100 g L⁻¹ (Magnification power, respectively = 4x10 and 10x10) d) 80 g L⁻¹ (Magnification power, respectively =4x10 and 10x10).

This finding is important to indicate that the effect on the aquatic organisms may differ by the chemical structure of the polymer type studied. However, this negative effect is thought to be due to the difference in density of working PEGs, which are distinctive features of the polymer, rather than chemical bonds. It is believed more polymers are taken by the daphnids since they are fed by draining water and the density of PEG 600 is relatively lower than PEG 2000 and PEG 6000 (PEG 600 (1.126 g cm⁻³), PEG 2000 (1.21 g cm⁻³), and PEG 6000 (1.2 g cm⁻³) respectively).

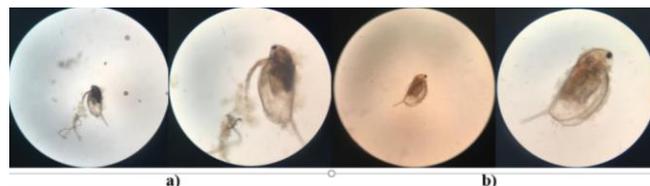


Figure 6. The effects of PEG 2000 on daphnids after the 48-hour exposure a) 100 g L⁻¹ (Magnification power, respectively = 4x10 and 10x10) b) 80 g L⁻¹ (Magnification power, respectively = 4x10 and 10x10).



Figure 7. The effects of PEG 6000 on daphnids after the 48-hour exposure-100 g L⁻¹ (Magnification power, respectively=4x10 and 10x10).

Acute Toxicity Classification of PCPs: For body lotion, the EC₅₀ value was found to be 1547 mg L⁻¹ at the end of the 24-hour test period while it was found 0.039 mg L⁻¹ at the end of the 48-hour test period. In terms of acute toxicity classification, the class of body lotion changed from 0 (non-toxic) to 5 (very high toxic). The body lotion toxicity value (0.039 mg L⁻¹) obtained at the end of 48 hours was found to be higher than the 24-hour test period, and there was a major alteration among the acute toxicity class. Although the concentration of this active substance remained constant, it led to an increase in toxicity with the increase in contact time with the organism. Famous toxicologists like Peter Wells stated that toxicity depends on both concentration and exposure time and presents on a comprehensive basis (Wells, 1984; Lessard & DeMarco, 2000). For a healthy interpretation of the results, 24 and 48 hour EC₅₀ values, EC₅₀ (mg L⁻¹) and acute toxicity classification are presented in Table 5 for body lotion and baby shampoo. For baby shampoo, the EC₅₀ value was found to be 316.35 mg L⁻¹ at the end of the 24-hour test period while it was 177.47 mg L⁻¹ at the end of the 48-hour test period. There was no change in acute toxicity class in the 24- and 48-hour exposures.

Studies in the literature are mainly carried out on the individual toxicity of the chemicals contained in personal

care products (Daughton & Ternes 1999). Safety Data Sheets (SDS), prepared by each brand, show information about the ecotoxicity of the ingredients. In the SDS study, it was found that the mean result of acute toxicity test of the chemical having the highest percentage in hand&body lotion products of different brands performed with *D. magna*, varied between 1.955 mg L⁻¹ (48 h) and > 500 mg L⁻¹ (24 h). Results of the acute toxicity test performed *D. magna* for chemicals contained in the baby shampoo of a certain brand varied between 0.12 mg L⁻¹ and 2564 mg L⁻¹. The literature review shows that the toxicities of the chemicals usually contained in each PCP are studied individually and not evaluated on a product basis (Brausch & Rand, 2011).

The study supports the difference in toxicity found at 24 and 48 hour exposure time. Acute toxicity test results of a brand with *D. magna* for chemicals in baby shampoo contents vary between 0.12 mg L⁻¹ and 2564 mg L⁻¹. When the literature is evaluated, it is seen that the toxicities of the chemicals usually included in each PCP are studied individually and not evaluated on a product basis.

Table 5. The mean of acute toxicity test result of body lotion and baby shampoo.

Sample	24 h		48 h	
	EC ₅₀ (g L ⁻¹)	Classification of acutetoxicity	EC ₅₀ (g L ⁻¹)	Classification of acutetoxicity
Body Lotion	<1547	0	0.039	5
Baby Shampoo	316.35	1	177.47	1

Table 6. Acute toxicity classification of surface waters and PCPs interaction with surface waters.

Sample	Surface waters		Body Lotion		Baby shampoo	
	EC ₅₀ (g L ⁻¹)	Classification of acutetoxicity	EC ₅₀ (g L ⁻¹)	Classification of acutetoxicity	EC ₅₀ (g L ⁻¹)	Classification of acutetoxicity
Station 1	46.37	2	4927	0	62.67	2
Station 2	567.8	1	1100	0	85.18	2
Station 3	211.54	1	4927	0	118.62	1

Depending on the concentrations studied in the determined toxicity of the body lotion, 20000 mg L⁻¹, 1000 mg L⁻¹, 100 mg L⁻¹, 10 mg L⁻¹ concentrations were selected. Depending on the concentrations studied in the determined toxicity of the baby shampoo, 1000 mg L⁻¹, 500 mg L⁻¹, 100 mg L⁻¹, 50 mg L⁻¹ concentrations were selected to study. 48-hour toxicity test results of the application of the body lotion and baby shampoo to surface water are presented as EC₅₀ and classification of acute toxicity in Table 4. While the body lotion was highly toxic (Class 5) at the end of the 48-hour exposure time without being applied any surface water, it was non-toxic (Class 0) for all stations when applied to surface water. When PEG-containing PCPs are applied to surface waters, it is possible to claim that even PEG-containing non-toxic products can cause toxicity in the aquatic ecosystem because surface waters (especially seawater) are composed of different chemical structures. While the baby shampoo was practically non-toxic (Class 1) at the end of the 48-hour exposure time without the being applied to any surface

Acute Toxicity Classification of PCPs Interaction with Surface Waters: In this part of the study, the toxicity of the surface water samples was determined as the first step. It was studied at 50%, 25%, 12.5% and 6.25% for each station, and high mortality rates were found in the toxicity test.

The EC₅₀ value after the 48-hour test period was found to be 46.37 mg L⁻¹ for station 1 and EC₅₀>100 mg L⁻¹ for station 2 and 3. It was determined that surface water samples with fresh and brackish water composition taken from the stations 2 and 3 were practically non-toxic (Class 1), and the seawater sample taken from station 1 was slightly toxic (Class 2) (Table 6). It was determined that the station 1 was different from the other stations since the chemical structures may also lead to salinity as involved in seawater. The toxicity of the samples was considered, a 3.125% dilution rate at which no mortality was observed was taken as a basis in the study. With this study, an optimistic scenario was created for the contamination of personal care products in the sampling area. The potential toxic effects of the presence of personal care products in non-toxic concentrations in aquatic areas have been tried to be determined with different scenarios. Thus, the body lotion and baby shampoo were applied to surface water samples diluted at the specified rate.

water, it was slightly toxic (Class 2) for station 1 and station 2 when applied to surface water. In addition, baby shampoo application to surface waters changed the toxicity class of the station 2 (from Class 1 to Class 2). The baby shampoo was practically non-toxic only for station 3.

CONCLUSION

To our knowledge, this is the first study to examine PEGs, which are known to be non-toxic, in natural waters. This study proves the non-toxic feature of only PEGs (600, 1500, 2000, 6000 and 10000) on were on *D. magna*. In summary, PEGs are non-toxic, but PEGs are not used alone in PCPs. Different chemical structures (mists and sulfate structures) contained in PEG-containing products may cause toxicity. In particular, structures that are toxic, carcinogenic to the environment and public health should be strictly excluded from PCPs formulations of these products. To conclude, even specific assessments on each chemical mixture do not mean that those personal

care products are completely safe for the environment. When the personal care products including these liquid plastics, which are found to have non-toxicity characteristics, it is obvious that different toxic effects can emerge apart from the individual toxicity.

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REFERENCES

- Brausch, J.M. & Rand, G.M. (2011).** A review of personal care products in the aquatic environment: Environmental concentrations and toxicity. *Chemosphere*, **82**(11), 1518-1532. DOI: [10.1016/j.chemosphere.2010.11.018](https://doi.org/10.1016/j.chemosphere.2010.11.018)
- Cheung, P.K. & Fok, L. (2016).** Evidence of microbeads from personal care product contaminating the sea. *Marine Pollution Bulletin*, **109**(1), 582-585. DOI: [10.1016/j.marpolbul.2016.05.046](https://doi.org/10.1016/j.marpolbul.2016.05.046)
- CIR Expert Panel. (2004).** Final report of the amended safety assessment of PEG-5, -10, -16, -25, -30, and -40 soy sterol. *International Journal of Toxicology*, **23**, 23-47.
- Çetinkaya Karafakı, F. (2018).** İlaç, kozmetik ve kişisel bakım ürünleri atıklarının çevre üzerine etkileri ve AB Ülkelerinin ve Türkiye'nin bakış açısı. *Journal of Disaster and Risk*, **1**(1), 63-71. (in Turkish).
- Daughton, C.G. & Ternes, T.A. (1999).** Pharmaceutical sand personal care products in the environment: Agents of subtlechange? *Environmental Health Perspectives*, **107**(6), 907-938. DOI: [10.1289/ehp.99107s6907](https://doi.org/10.1289/ehp.99107s6907)
- Duis, K. & Coors, A. (2016).** Microplastics in the aquatic and terrestrial environment: Sources (with a specific focus on personal care products), fate and effects. *Environmental Sciences Europe*, **28**(2), 1-25. DOI: [10.1186/s12302-015-0069-y](https://doi.org/10.1186/s12302-015-0069-y)
- EPA. (1991).** *Short Term Methods for Estimating The Chronic Toxicity of Effluents and Receiving Waters to Fresh Organisms*; U.S Environmental Protection Agency, U.S. Army Corps of Engineers, Washington.
- FDA (Food and Drug Administration). (2019).** <https://www.fda.gov/>. (20 August 2019).
- Fruijtier-Pölloth, C. (2005).** Safety assessment on polyethylene glycols (PEGs) and their derivatives as used in cosmetic products. *Toxicology*, **214**, 1-38. DOI: [10.1016/j.tox.2005.06.001](https://doi.org/10.1016/j.tox.2005.06.001)
- GESEAMP. (2002).** MO/FAO/UNESCO±IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. https://www.jodc.go.jp/info/ioc_doc/GESAMP/GESAMP64.pdf. (6 June 2019).
- Hernandez, L.M., Yousefi, N. & Tufenkji, N. (2017).** Are the nanoplastics in your personal care products? *Environmental Science & Technology Letters*, **4**(7), 280-285. DOI: [10.1021/acs.estlett.7b00187](https://doi.org/10.1021/acs.estlett.7b00187)
- Imhof, H.K., Rusek, J., Thiel, M., Wolinska, J. & Laforsch, C. (2017).** Do microplastic particles affect *Daphnia magna* at the morphological, life history and molecular level? *PloSone*, **12**(11), e0187590. DOI: [10.1371/journal.pone.0187590](https://doi.org/10.1371/journal.pone.0187590)
- Jang, H.J., Shin, C.Y. & Kim, K.B. (2015).** Safety evaluation of polyethyleneglycol (PEG) compounds for cosmetic use. *Toxicological Research*, **31**(2), 105.
- Kalčíková, G., Alič, B., Skalar, T., Bundschuh, M. & Gotvajn, A.Ž. (2017).** Wastewater treatment plant effluents as source of cosmetic polyethylene microbeads to freshwater. *Chemosphere*, **188**, 25-31. DOI: [10.1016/j.chemosphere.2017.08.131](https://doi.org/10.1016/j.chemosphere.2017.08.131)
- Kim, J.W., Ishibashi, H., Yamauchi, R., Ichikawa, N., Takao, Y., Hirano, M., Koga, M. & Arizono, K. (2009).** Acute toxicity of pharmaceutical and personal care products on freshwater crustacean (*Thamnophilus platyuru*) and fish (*Oryzias latipes*). *The Journal of Toxicological Sciences*, **34**(2), 227-232. DOI: [10.2131/jts.34.227](https://doi.org/10.2131/jts.34.227)
- Lanigan, R.S. & Yamarik, T.A. (2001).** Cosmetic Ingredient Review Expert Panel, Final report on the safety assessment of PEG-6, -8, and -20 sorbitanbeeswax. *International Journal of Toxicology*, **20**, 27-38.
- Lei, K., Qiao, F., Liu, Q., Wei, Z., Qi, H., Cui, S., Yue, X., Deng, Y. & An, L. (2017).** Microplastics releasing from personal care and cosmetic products in China. *Marine Pollution Bulletin*, **123**(1-2), 122-126. DOI: [10.1016/j.marpolbul.2017.09.016](https://doi.org/10.1016/j.marpolbul.2017.09.016)
- Lessard, R.R. & DeMarco, G. (2000).** The significance of oil spill dispersants. *Spill Science & Technology Bulletin*, **6**(1), 59-68. DOI: [10.1016/S1353-2561\(99\)00061-4](https://doi.org/10.1016/S1353-2561(99)00061-4)
- Liu, J.L. & Wong, M.H. (2013).** Pharmaceuticals and personal care products (PPCPs): A review on environmental contamination in China. *Environment International*, **59**, 208-224. DOI: [10.1016/j.envint.2013.06.012](https://doi.org/10.1016/j.envint.2013.06.012)
- Martins, J., Teles, L.O. & Vasconcelos, V. (2007).** Assays with *Daphnia magna* and *Danio rerio* as alert systems in aquatic toxicology. *Environment International*, **33**(3), 414-425. DOI: [10.1016/j.envint.2006.12.006](https://doi.org/10.1016/j.envint.2006.12.006)
- OECD. (2004).** Guideline 202: *Daphnia* sp. Acute Immobilisation Test, Adopted 14 April 2004. OECD Guideline for the Testing of Chemicals. Organisation for Economic Cooperation and Development, France.
- Pablos, M.V., García-Hortigüela, P. & Fernández, C. (2015).** Acute and chronic toxicity of emerging

contaminants, alone or in combination, in *Chlorella vulgaris* and *Daphnia magna*. *Environmental Science and Pollution Research*, **22**(7), 5417-5424.

- Sivri, N., Seker, D.Z., Balkis, N. & Zan, A. (2012).** Analysis of chlorophyll-a distribution on the south-western coast of Istanbul during 2008-2010 using GIS. *Fresenius Environmental Bulletin (FEB)*, **21**(11), 3233-3242. DOI: [10.1371/journal.pone.0187590](https://doi.org/10.1371/journal.pone.0187590)
- Smyth, H.F., Carpenter, C.P. & Weil, C.S. (1950).** The toxicology of the polyethylene glycols. *Journal of the American Pharmaceutical Association (Scientific ed.)*, **39**(6), 349-354.
- Sönmez, V.Z., Sivri, N. & Dökmeçi, A.H. (2016).** Determination of The Toxicity of Different Discharge Waters using Acute Toxicity Tests Approved for National Pollutant Discharge Permit in Turkey. *Biosciences, Biotechnology Research Asia*, **13**(2), 1-8. DOI: [10.13005/bbra/2076](https://doi.org/10.13005/bbra/2076)
- Ustabasi, G.S. & Baysal, A. (2019).** Occurrence and risk assessment of microplastics from various toothpaste. *Environmental Monitoring and Assessment*, **191**(7), 438.
- Wardrop, P., Shimeta, J., Nugegoda, D., Morrison, P.D., Miranda, A., Tang, M. & Clarke, B.O. (2016).** Chemical pollutants sorbed to ingested microbeads from personal care products accumulate in fish. *Environmental Science & Technology*, **50**(7), 4037-4044. DOI: [10.1021/acs.est.5b06280](https://doi.org/10.1021/acs.est.5b06280)
- Wells, P.G. (1984).** The toxicity of oil spill dispersants to marine organisms: A current perspective. In: Allen, T.E. (Ed.), *Oil Spill Chemical Dispersants: Research, Experience, and Recommendations*, STP 840 (American Society for Testing and Materials, Philadelphia, PA).
- WPCIMSA (2009).** *Water Pollution Control Instruction Methods of Sampling and Analysis*, No:27372-Government Gazette of Republic of Turkey.