Effect of Microplastics on Aquatic Ecosystems

건국대학교 안 윤 주

Youn-Joo An, Konkuk University

Why #microplastic ?

- We are in “Plastic Age”, 환경 다매체를 순환하는 미세플라스틱, 이제는 “Plastic cycle”
- COVID-19 팬더믹으로 폐플라스틱 발생량 급증=> 미세플라스틱과 코로나19: “신데믹(Syndermic)”의 시대

과기부 웹진 (안윤주, 2018.6)

Plastic Age에 살다? 미세플라스틱과 함께?

과학과 기술 (안윤주, 2018.7)

폐플라스틱 : 미세플라스틱이 되어 돌아오다

미세플라스틱은 생태계 내에서 잠재적 위험성 지녀… 과학적 증거 수집 통한 관리·규제방안 마련 필요

과학과 기술(안윤주, 2021.4)

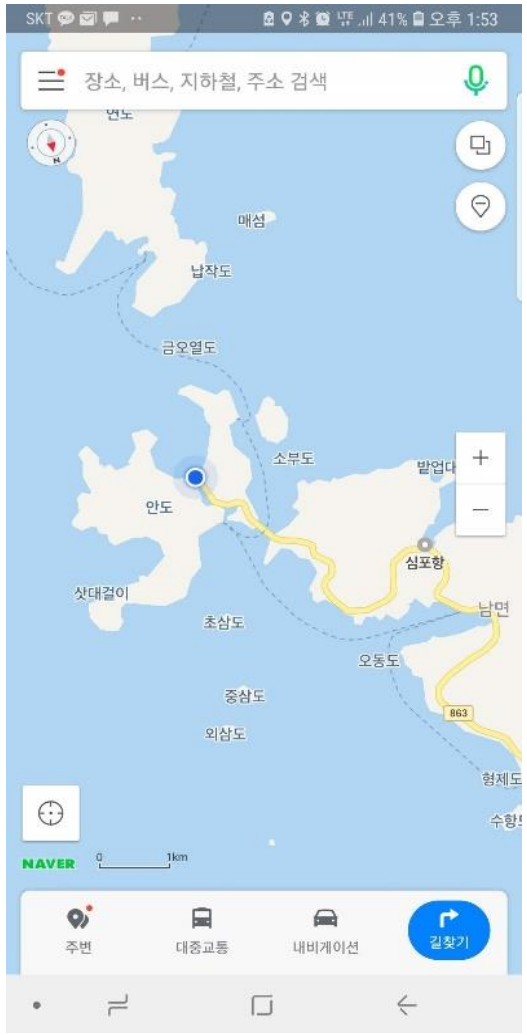
FOCUS | 미세플라스틱과 코로나19:신데믹(Syndermic)의 시대

추자도

숙주머리 해변 (June 2018)

여수

금오도 (2018.09)



여수 돌산도

무술목 해변 (September 2021)

미세플라스틱 생성중 !

PS nanoplastics #inhibit_reproduction in the Daphnia

Abnormal embryonic development in the freshwater crustacean *Daphnia galeata*

www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

Polystyrene nanoplastics inhibit reproduction and induce abnormal embryonic development in the freshwater crustacean *Daphnia galeata*

Received: 6 April 2017
Accepted: 6 September 2017
Published online: 21 September 2017

Rongxue Cui, Shin Woong Kim & Youn-Joo An

We assayed the toxicity of polystyrene nanoparticles (PS-NP, 52 nm) to *Daphnia galeata*. Survival and reproduction were significantly decreased in individuals exposed to 5 mg/L of PS-NP for 5 days, and embryos showed abnormal development, including a low hatching rate. Using fluorescence confocal microscopy, we recorded the transfer of PS-NP from the external surface of the body to the internal organs, including the thoracic appendices, ovaries, caudal appendices, and brood chamber, as well as PS-NP storage in lipid droplets. Although embryos were exposed to PS-NP in the brood chamber, they did not internalize PS-NP. Exposed *D. galeata* adults that were not pregnant stored significantly fewer lipid droplets than did the control group, and the lipid droplets that they did store were smaller; meanwhile, there were no significant changes in lipid storage in exposed pregnant individuals. Some embryos showed a high level of lipid storage, a response that occurs when embryos experience an abnormal state, and these embryos showed a very low hatching rate. However, the offspring of exposed adults showed normal survival and lipid storage. This study provides visual evidence that confirms the transfer and effects of PS-NP in *Daphnia* species, and suggests a relationship between toxicity and lipid storage.

Scientific Reports 7 (2017) 12095

최신기사

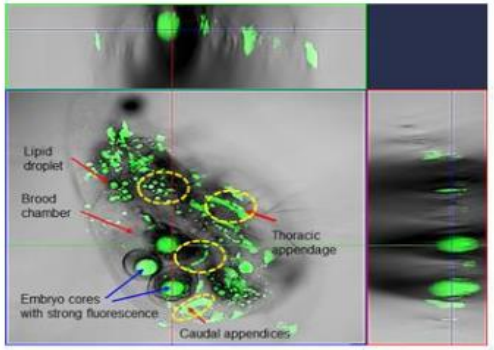
"미세 플라스틱에 노출된 물벼룩 83%가 사망"

송고시간 | 2017/10/19 14:02

건국대 안윤주 교수 '화학물질이 담수 생태계에 미치는 영향' 밝혀

(대전=연합뉴스) 박주영 기자 = 세계적으로 가장 많이 쓰이는 화학물질인 플라스틱이 담수 생태계에 미치는 영향이 밝혀졌다.

한국연구재단은 건국대 안윤주 교수 연구팀이 지름 100나노미터(㎚·10억분의 1m) 이하의 플라스틱 입자인 미세 플라스틱이 호수·강 등에 서식하는 물벼룩 알주머니에 침투해 생존을 위협한다는 사실을 발견했다고 19일 밝혔다.

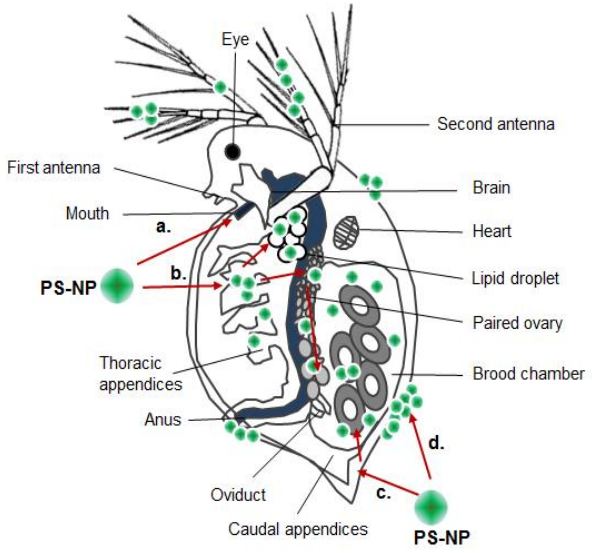


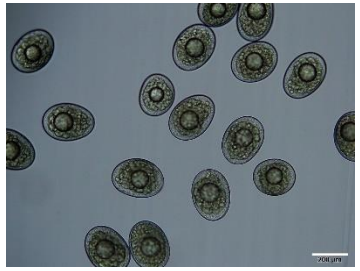
유리 물벼룩 체내에 미세 플라스틱이 쌓인 모습
[한국연구재단 제공=연합뉴스]

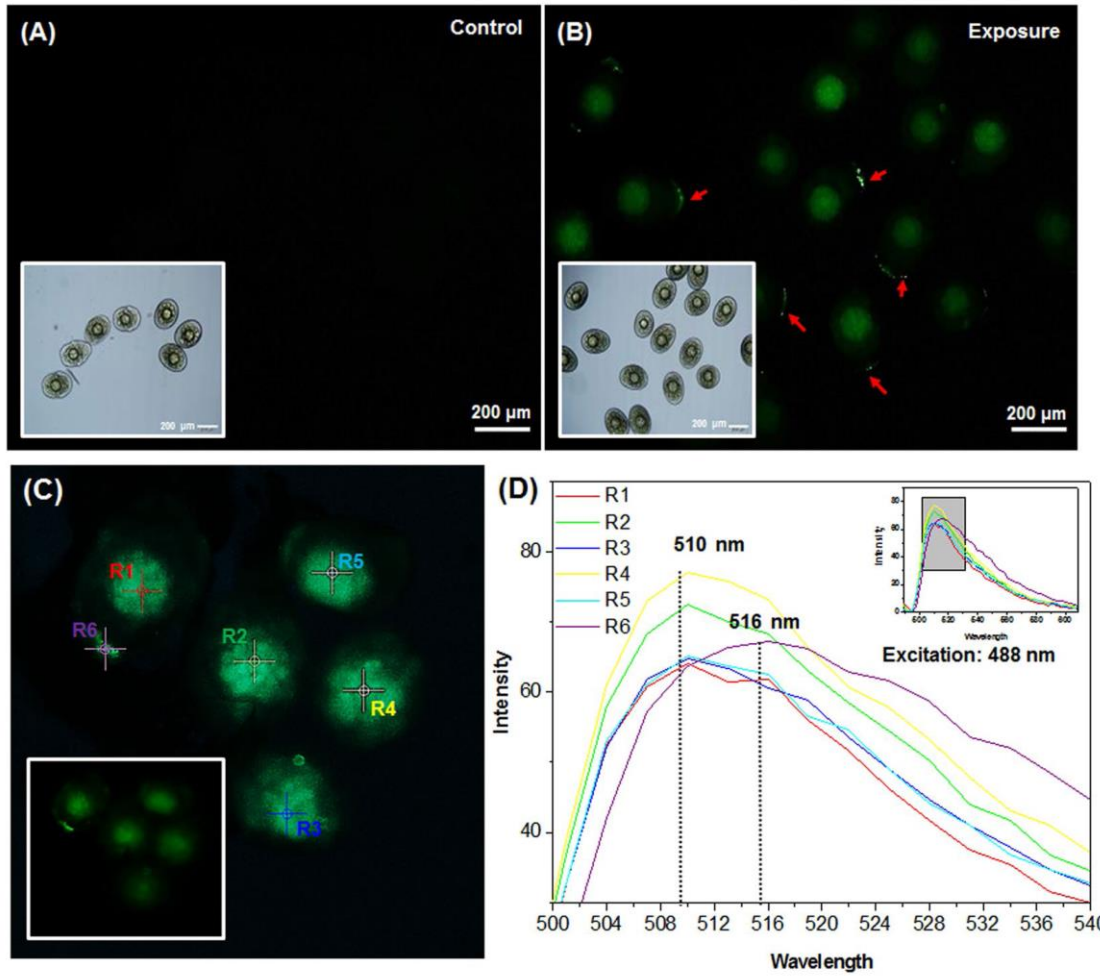
PS nanoplastics #inhibit_reproduction in the Daphnia

Abnormal embryonic development in the freshwater crustacean *Daphnia galeata*

Photo by R. Cui of An's Lab







Scientific Reports 7 (2017) 12095

Sub-acute exposure to nanoplastics via two-chain trophic transfer

From brine shrimp *Artemia franciscana* to small yellow croaker *Larimichthys polyactis*

Marine Pollution Bulletin 175 (2022) 113314

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Sub-acute exposure to nanoplastics via two-chain trophic transfer: From brine shrimp *Artemia franciscana* to small yellow croaker *Larimichthys polyactis*

Lia Kim, Rongxue Cui, Jin Il Kwak, Youn-Joo An *

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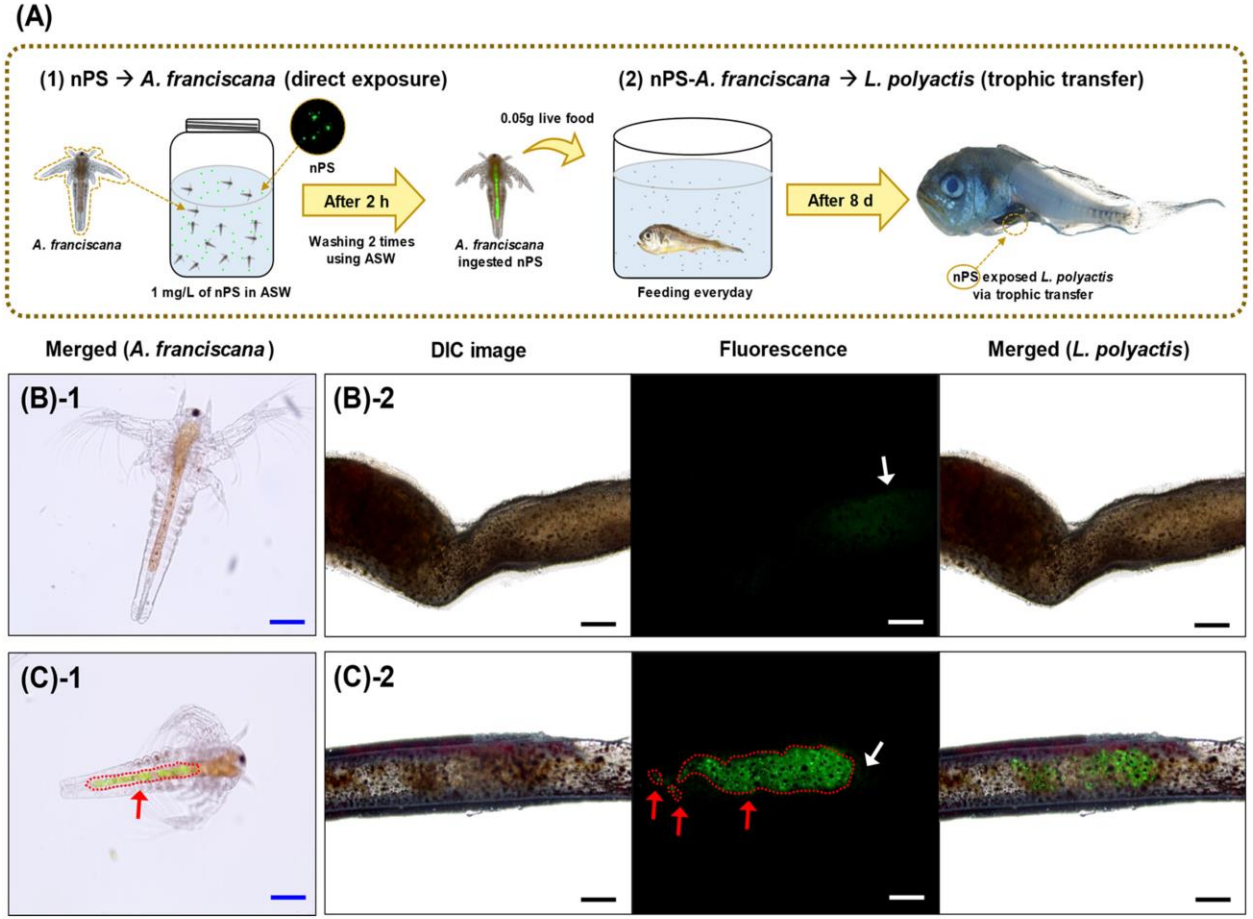
ARTICLE INFO

Keywords:
Food web
Nanoplastic
Indirect exposure
Swimming ability

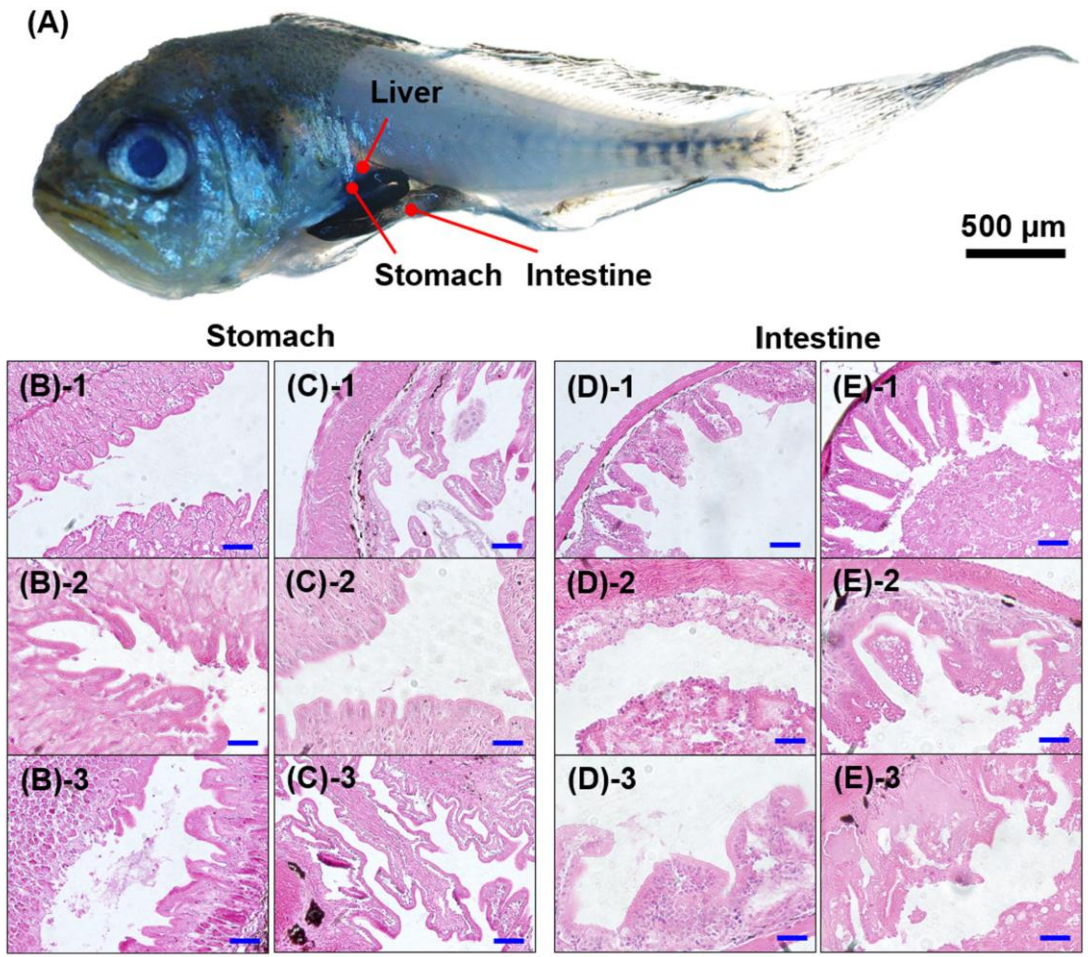
ABSTRACT

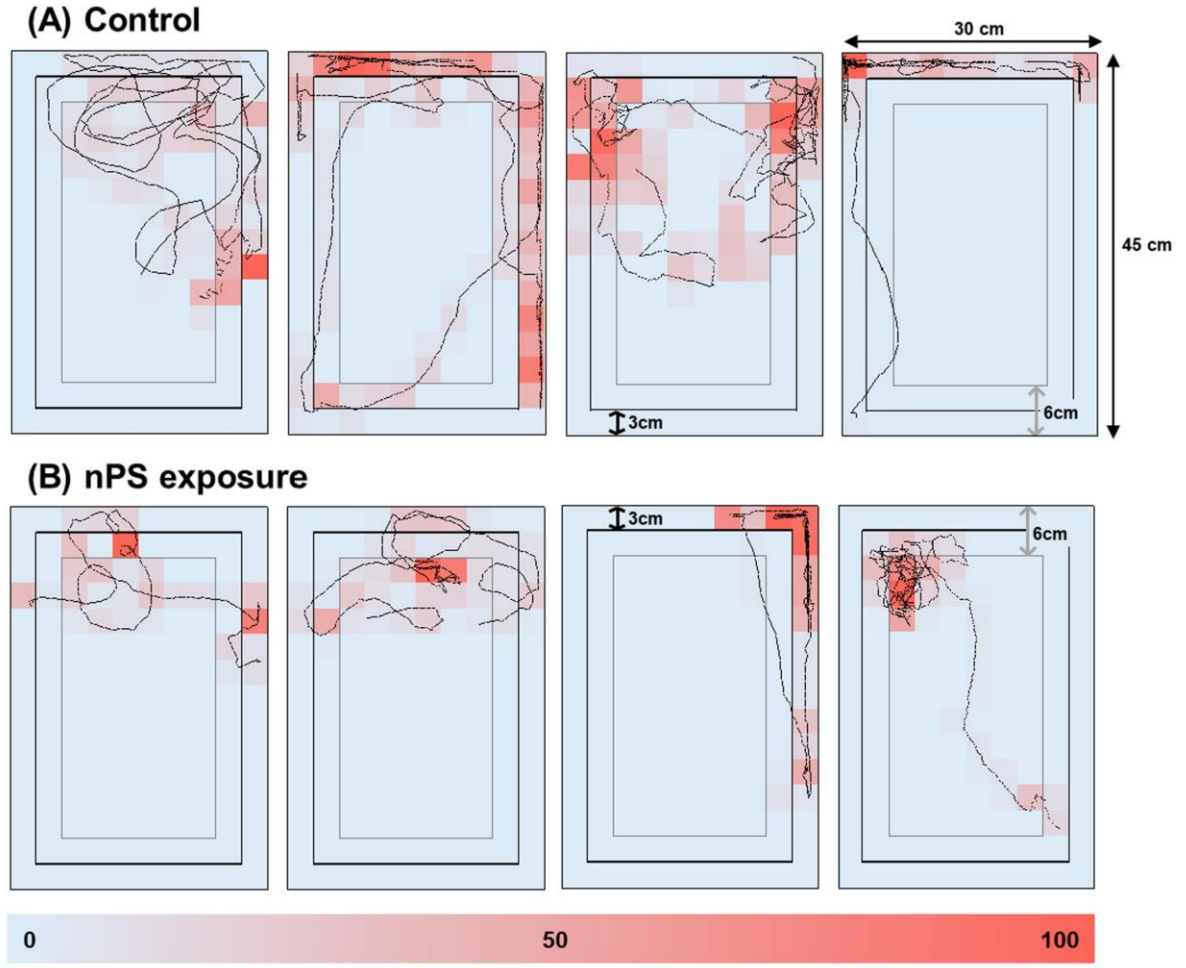
This study investigated the trophic transfer of nanoplastics in marine food chains. We fed nanoplastic-exposed *Artemia franciscana* (brine shrimp) to *Larimichthys polyactis* (small yellow croaker) daily for eight days. Subsequently, the overall health condition, histopathological damage to the liver and digestive tract, and swimming ability of the fish were measured. After the sub-acute exposure to nanoplastics via trophic transfer, the fish showed inhibited growth, severe liver damage, as well as a poorer swimming ability compared to the control. The swimming ability was especially affected, in terms of the overall movement as well as thigmotaxis. The results thus clarified that even an indirect exposure to nanoplastics could induce neurotoxic effects and affect the swimming ability of the fish. As fish are well-known human food resources, the possibility of such trophic transfers affecting higher trophic level organisms, such as humans, cannot be ruled out.



Sub-acute exposure to nanoplastics via two-chain trophic transfer

From brine shrimp *Artemia franciscana* to small yellow croaker *Larimichthys polyactis*





Marine Pollution Bulletin 175 (2022) 113314

Effects of synthetic and natural microfibers on Daphnia magna

Are they dependent on microfiber type ?

Contents lists available at ScienceDirect

Aquatic Toxicology

journal homepage: www.elsevier.com/locate/aqtox

Effects of synthetic and natural microfibers on Daphnia magna–Are they dependent on microfiber type?

Dokyung Kim, Haemi Kim, Youn-Joo An*

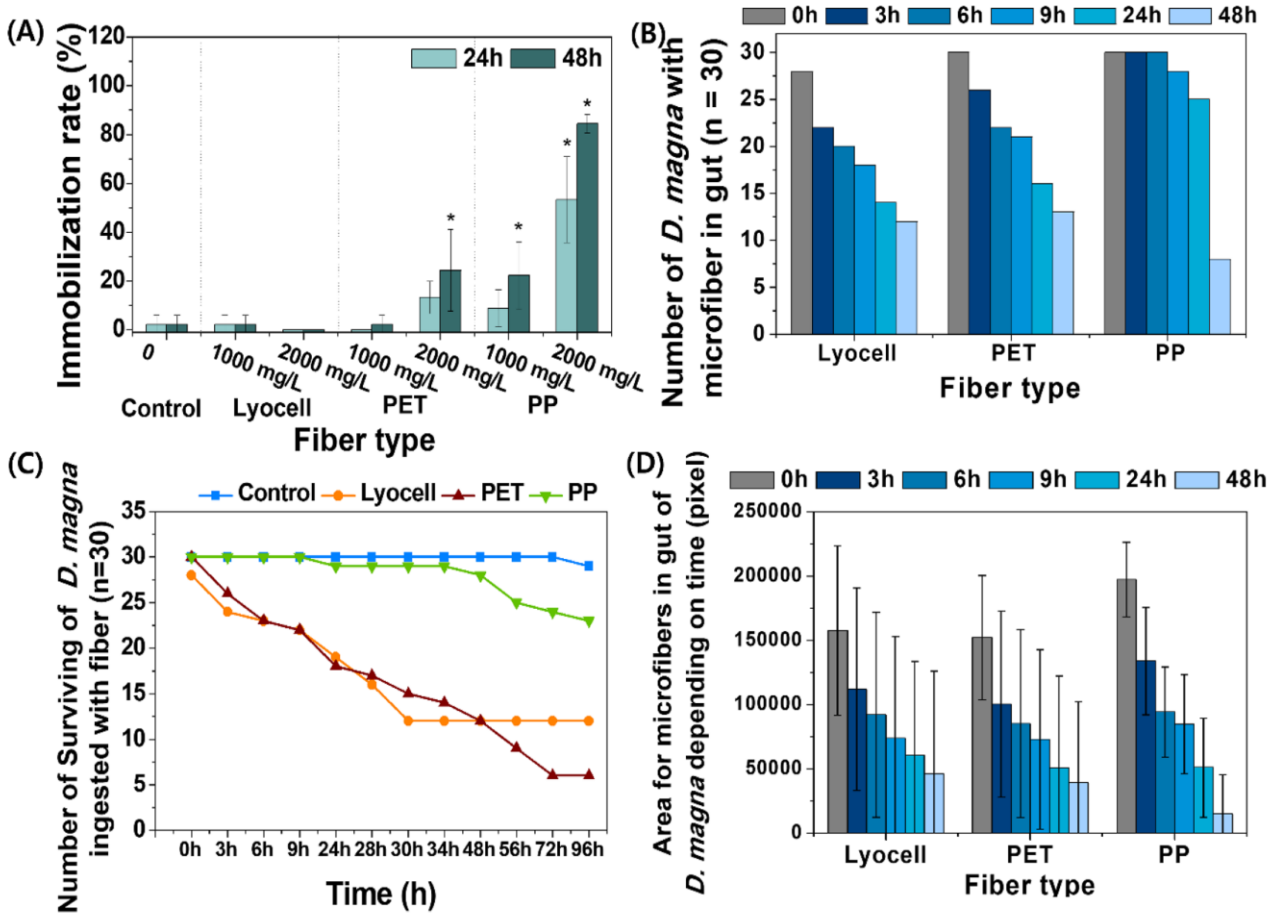
Department of Environmental Health Science, Konkuk University, 120 Neungdong-ro, Gwangjin-gu, Seoul 05029, Korea

ARTICLE INFO

Keywords:
Microfibers
Daphnia magna
Depuration
After effects

ABSTRACT

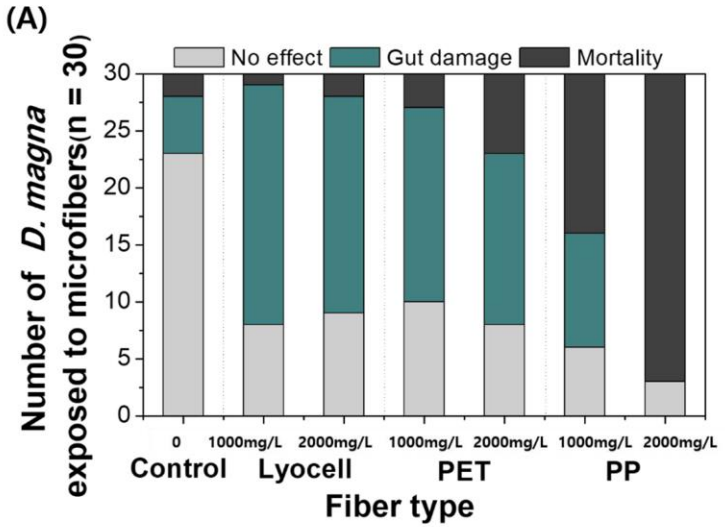
Microfibers, which are sourced from textiles and some products from the fishery industry, are the biggest contributors to microplastic pollution in aquatic ecosystems. In addition to these synthetic microfibers, naturally derived microfibers can also be found in aquatic environments. However, there are limited studies on the ecotoxicity of natural microfibers. To shed light on this topic, this study assessed and compared the toxicity of natural and synthetic microfibers on Daphnia magna, using lyocell, polyester (PET) and polypropylene (PP) microfibers. To evaluate the adverse effect of microfibers on D. magna, after effects including depuration, food intake, growth, mortality, and immobilization rate were continually observed for up to 96 h after the initial 48 h of exposure to the microfibers. Immobilization rate decreased in the following order: PP, PET, and lyocell. However, the depuration of microfibers in the lyocell and PET treatment groups was similar, with higher mortality rates than in the PP treatment group. Furthermore, despite the high rates of food intake following exposure, the lyocell and PET exposed groups exhibited growth inhibition during the same period. This growth inhibition corresponded with, and was likely due to, reductions in the length of gut microvilli, probably an expression of gut damage, which is believed to have reduced nutrient absorption in the affected individuals. Based on the results of this study, it was confirmed that even natural microfibers, and not just synthetic microfibers, can have adverse effects on aquatic organisms. This study confirmed not only the toxicity of microfibers, but also the consequences of their after effects. These results could be the basis for future research on the after effects of microplastics on aquatic organisms and provide directions for further microplastic ecotoxicity studies.

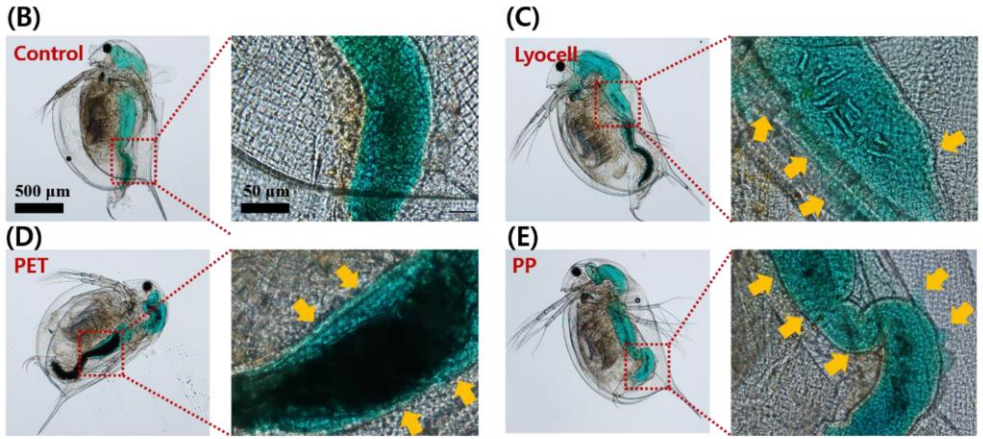


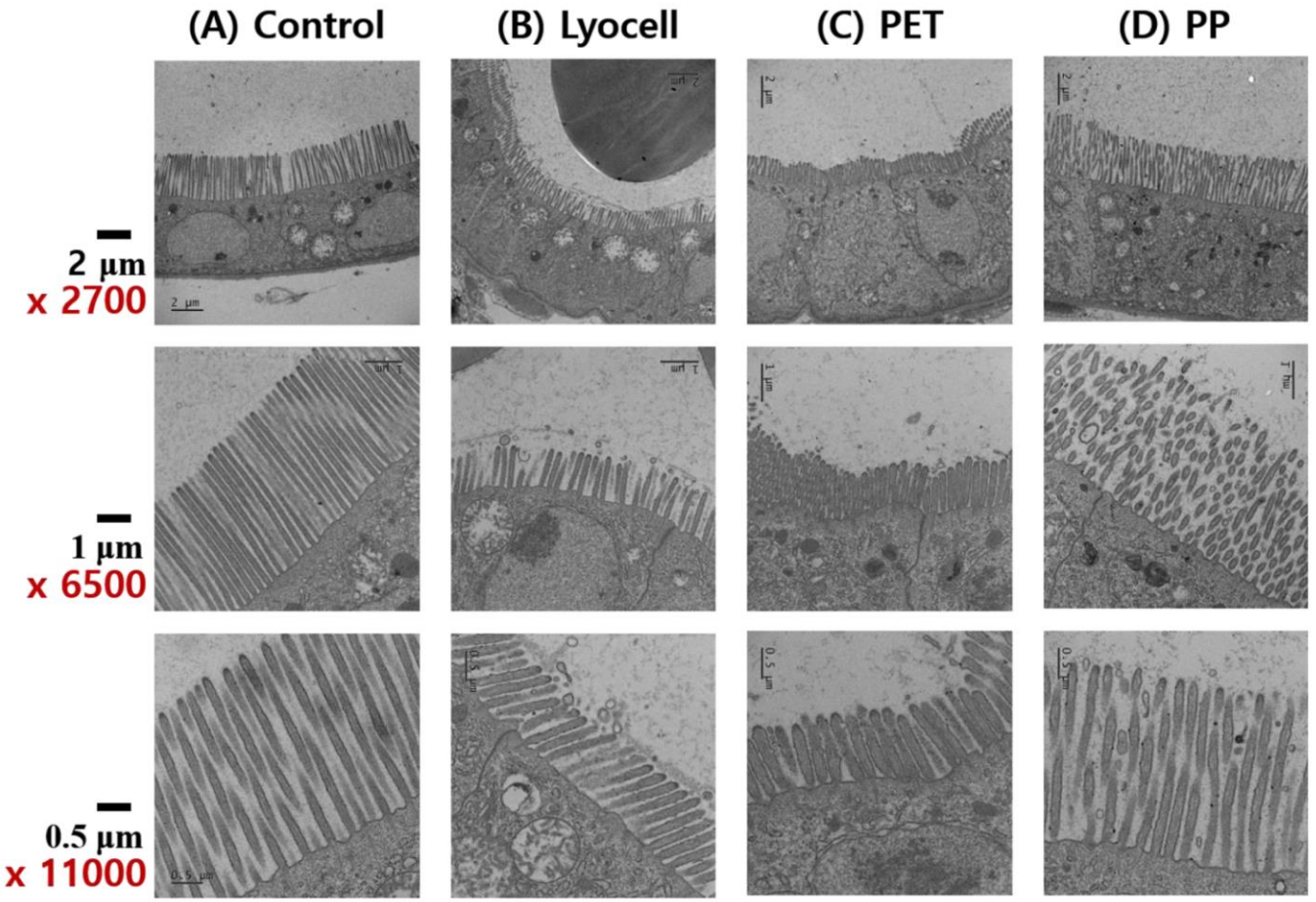
Aquatic Toxicology 240 (2021) 105968

Effects of synthetic and natural microfibers on Daphnia magna

Are they dependent on microfiber type ?







Aquatic Toxicology 240 (2021) 105968

Gut damage in the brine shrimp

Synthetic and natural microfibers induce gut damage in the brine shrimp *Artemia franciscana*

Contents lists available at ScienceDirect

Aquatic Toxicology

journal homepage: www.elsevier.com/locate/aqtox

Synthetic and natural microfibers induce gut damage in the brine shrimp *Artemia franciscana*

Lia Kim [a], Sang A. Kim [a], Tae Hee Kim [b], Juhea Kim [c], Youn-Joo An [a,*]

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[b] Advanced Textile R&D Department, Korea Institute of Industrial Technology, Ansan, 426-171, Republic of Korea
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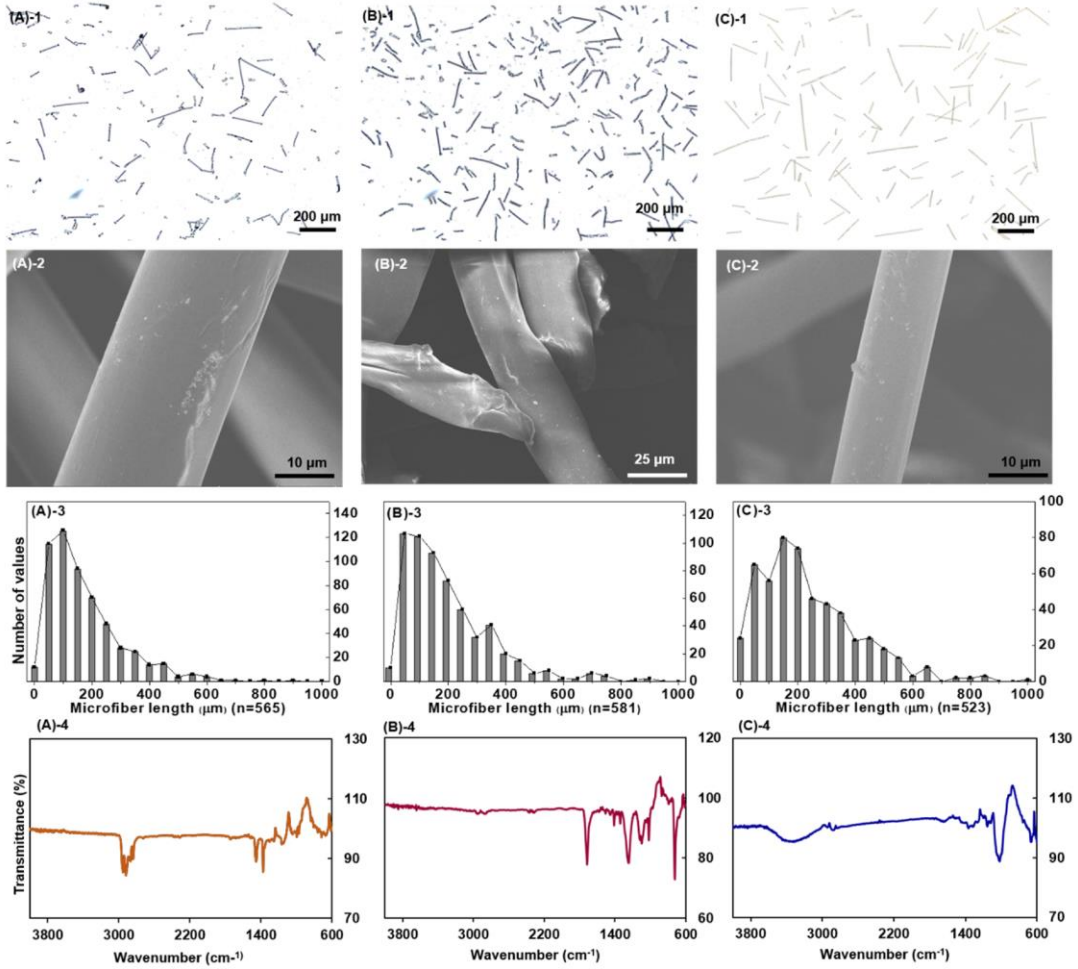
ARTICLE INFO

Keywords:
Microfiber
Artemia franciscana
Synthetic
Gut damage

ABSTRACT

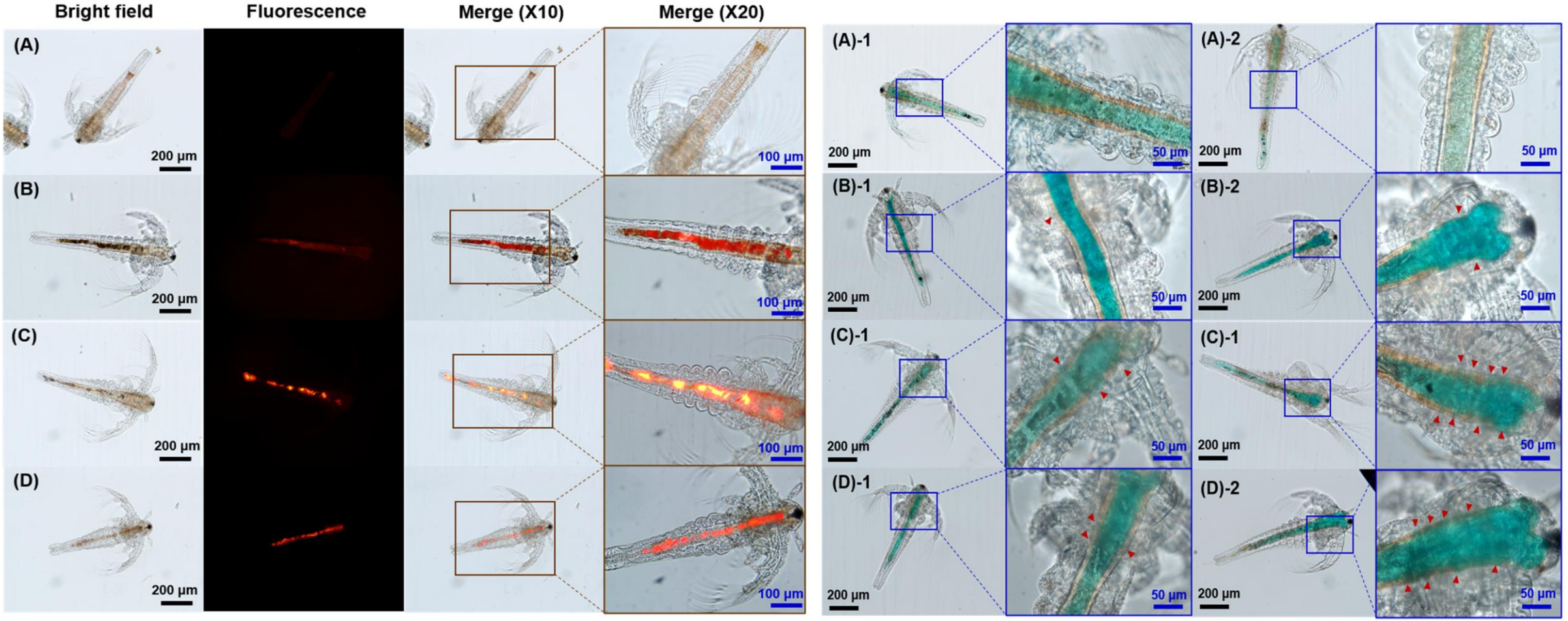
The increasing amount of microplastics in aquatic ecosystems is a significant environmental issue, with adverse effects on marine organisms including invertebrates and vertebrates. This study examined the effects of three types of microfibers on the brine shrimp *Artemia franciscana* as the test species. The brine shrimps were exposed to two commonly found synthetic microfibers (polypropylene and polyethylene terephthalate) and one natural fiber (lyocell). The results suggest that the polyethylene terephthalate microfibers induced high mortality in *A. franciscana*, while the lyocell caused the least detrimental effects. Gut damage of microfiber-exposed *A. franciscana* was observed using the dye leakage in the gut layer, and the results show that gut damage occurred in all exposure groups of synthetic and natural microfibers. Overall, our findings indicate that gut damage induced by all three microfibers eventually led to adverse effects and mortality of *A. franciscana*, highlighting the harmful effects of microfibers, regardless of polymer type.



Aquatic Toxicology 232 (2021) 105748

Gut damage in the brine shrimp

Synthetic and natural microfibers induce gut damage in the brine shrimp *Artemia franciscana*



Aquatic Toxicology 232 (2021) 105748

#Trophic_transfer of Microplastics in a 4-species food chain

The alga *Chlamydomonas reinhardtii*, water flea *Daphnia magna*, fish *Oryzias sinensis*, and fish *Zacco temminckii*

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Trophic transfer and individual impact of nano-sized polystyrene in a four-species freshwater food chain

Received: 13 February 2017
Accepted: 19 December 2017
Published online: 10 January 2018

Yooeun Chae, Dokyung Kim, Shin Woong Kim & Youn-Joo An

This study investigated the trophic transfer, individual impact, and embryonic uptake of fluorescent nano-sized polystyrene plastics (nanoplastics) through direct exposure in a freshwater ecosystem, with a food chain containing four species. The alga *Chlamydomonas reinhardtii*, water flea *Daphnia magna*, secondary-consumer fish *Oryzias sinensis*, and end-consumer fish *Zacco temminckii* were used as test species. In the trophic transfer test, algae were exposed to 50 mg/L nanoplastics, defined as plastic particles <100 nm in diameter; higher trophic level organisms were exposed through their diet. In the direct exposure test, each species was directly exposed to nanoplastics. Microscopic analysis confirmed that the nanoplastics adhered to the surface of the primary producer and were present in the digestive organs of the higher trophic level species. Nanoplastics also negatively affected fish activity, as measured by distance traveled and area covered, and induced histopathological changes in the livers of fish that were directly exposed. Additionally, nanoplastics penetrated the embryo walls and were present in the yolk sac of hatched juveniles. These observations clearly show that nanoplastics are easily transferred through food chain, albeit because of high experimental dosages. Nevertheless, the results strongly point to the potential health risks of nanoplastic exposure.

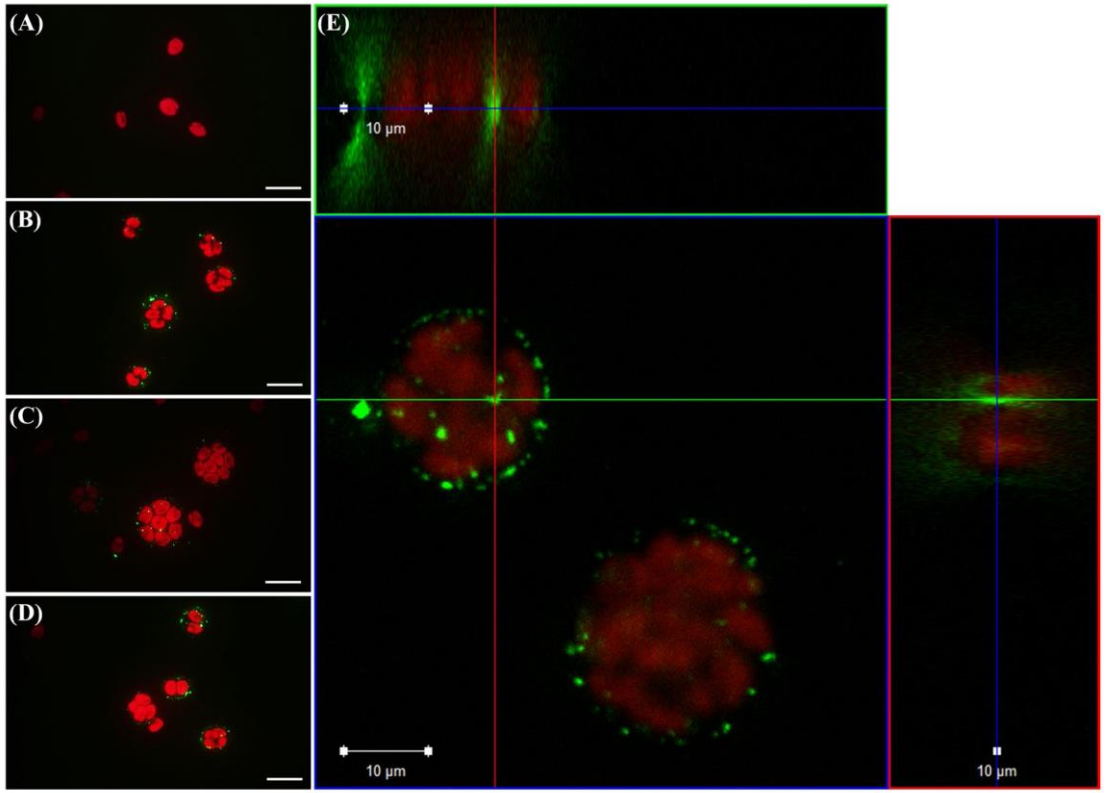

Figure 1. Observation via optical microscopy (**a**–**d**) and confocal laser scanning microscopy (**e**) of the alga *Chlamydomonas reinhardtii* (red emissions) directly exposed to nano-sized polystyrene (nPS; green emissions) for 72 h. Scale bar = 20 (**a**–**d**) and 10 μm (**e**).

Scientific Reports 8 (2018) 284

#Trophic_transfer of Microplastics in a 4-species food chain

The alga *Chlamydomonas reinhardtii*, water flea *Daphnia magna*, fish *Oryzias sinensis*, and fish *Zacco temminckii*

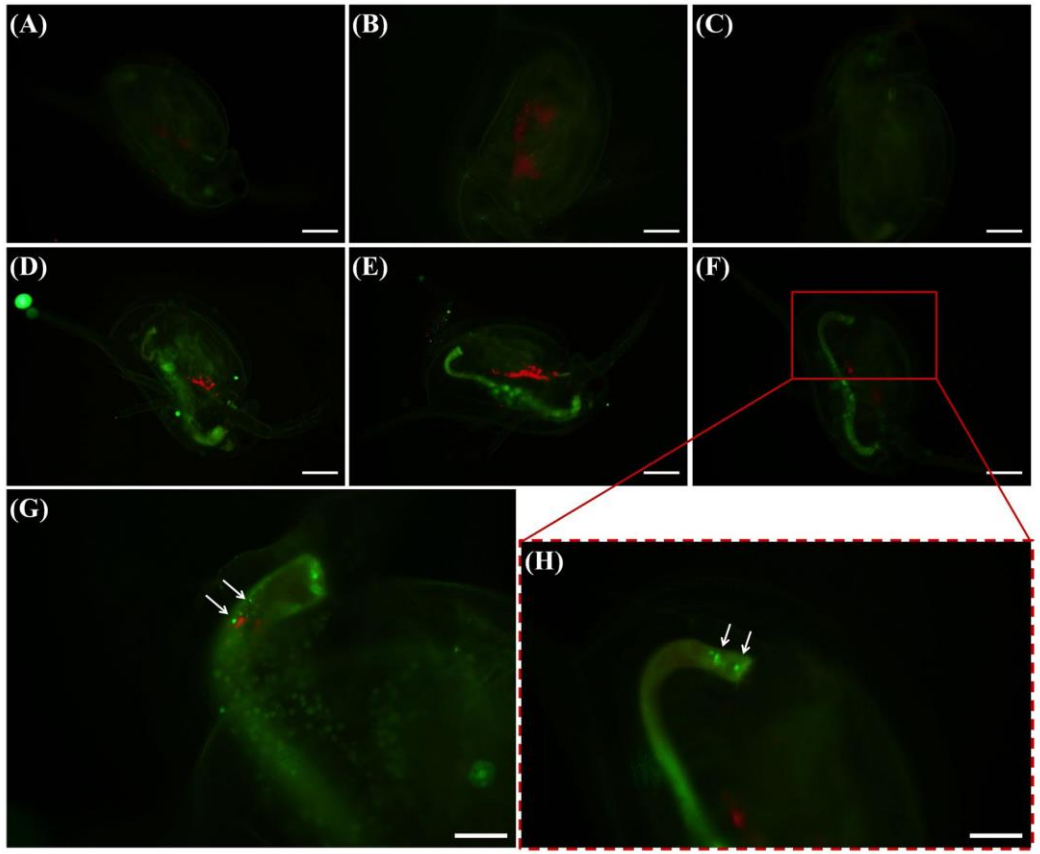

Figure 2. Green fluorescence of nano-sized polystyrene (nPS) in *Daphnia magna* that had consumed *Chlamydomonas reinhardtii* (red fluorescence). Control groups (**a**–**c**), exposed groups (**d**–**h**), and expanded pictures of exposed individuals (**g**,**h**). Scale bar = 200 (**a**–**f**) and 100 μm (**g**,**h**).

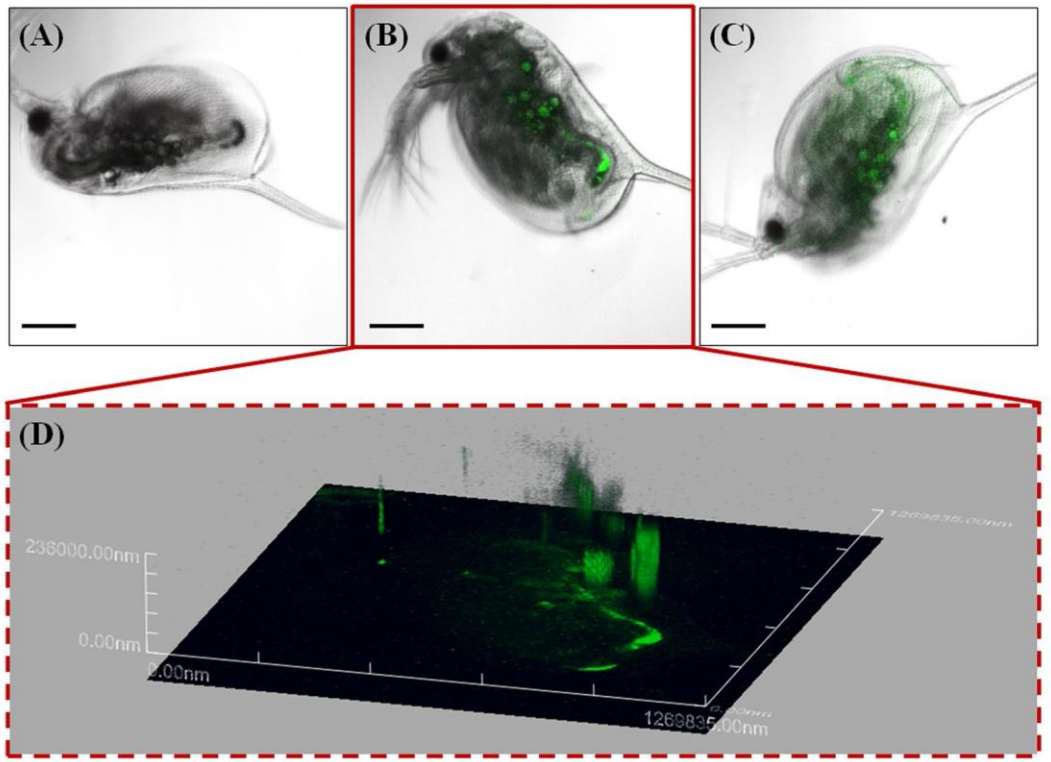

Figure 3. Confocal laser scanning microscope (CLSM) images of *Daphnia magna* that were not exposed to nano-sized polystyrene (nPS; green emissions) (**a**) and that were exposed through the diet (**b**,**c**). Z-stack image of individual exposed through the diet (**b**), observed using CLSM (**d**). Z-stack image (**d**) provides evidence of nPS uptake through dietary exposure of *D. magna*. Green fluorescent nPS was observed in the gut of exposed *D. magna*. Scale bar = 200 μm.

Scientific Reports 8 (2018) 284

#Trophic_transfer of Microplastics

“Our findings clearly show that plastic particles are easily transferred through the food chain. They strongly point to the potential health risks of nanoplastic exposure” (Youn-Joo An)

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News Opinion Lifestyle Culture Sport

Environment

by
Tom
Bawden

4 months
Thursday February 1st 2018

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Tiny plastic particles are strewn all the way along the food chain

(STEFAN SAUER/AFP/Getty Images)

Researchers also found that the minute particles – less than a billionth of a centimetre wide – damaged the fishes livers and made them lethargic so that they travelled shorter distances and patrolled a smaller area.

The plastic’s journey

The passage of the plastic in the study began when fragments stuck to an algae plant on the bottom rung of the food chain and ended up, via a water flea and a small fish, inside the eco-system’s top predator – the Korean dark chub.

This is an edible fish, indicating that the particles could make one further stop outside the marine ecosystem – at the dinner plate.

“Our findings clearly show that plastic particles are easily transferred through the food chain. And they strongly point to the potential health risks of nanoplastic exposure,” said Professor Youn-Joo An, of Konkuk University in Seoul.

> **“Our findings clearly show that plastic particles are easily transferred through the food chain. And they strongly point to the potential health risks of nanoplastic exposure,”**
>
> **Youn-Joo An**

https://inews.co.uk/news/environment/tiny-plastic-particles-strewn-way-along-food-chain/

#위드플라스틱 시대

- 환경, 그리고 생물체 내에서 조각화, 미세화되는 플라스틱

미세플라스틱의 환경 영향, 그리고 위드플라스틱 시대

GS칼텍스 ● 2022/7/15

GS Caltex 미디어 허브

Home › ESG › 미세플라스틱의 환경 영향, 그리고 위드플라스틱 시대

미세플라스틱의 환경 영향, 그리고 위드플라스틱 시대

By GS칼텍스 — On 2022/7/15

미세플라스틱, 지구상에서 가장 풍부한 오염물질

비닐봉지를 쓴 황새, 플라스틱 그물에 걸린 붉은 바다거북, 플라스틱 링에 목이 졸린 물개, 면봉을 감고 다니는 해마, 플라스틱과 뒤엉킨 산호초… 생태계에서 흔하게 발견되는 모습이다. 그리고 플라스틱이 분해되는 과정에서 생기는 미세플라스틱은 이제 전 국민에게 익숙한 용어가 되었다.

필자는 생태독성학자이다. 생태독성학은 환경 속 오염물질과 생태수용체 간의 상호영향에 대해 연구하는 학문이라고 할 수 있다. 요즘 생태독성학에서 화두가 되고 있는 문제는 역시 미세플라스틱이다. 필자가 에디터로 있는 SCIE(과학인용색인 확장판) 저널인 '유해물질저널(Journal of Hazardous Materials)'에 투고되는 논문의 상당한 부분이 미세플라스틱과 관련되어 있을 만큼, 미세플라스틱 문제는 현재 우리가 당면한 매우 심각한 환경문제 중 하나다 .

위드플라스틱의 시대

플라스틱, 그리고 미세플라스틱의 위험성이 부각되면서 요즘 ZERO플라스틱, 플라스틱FREE, 플라스틱OUT과 같은 운동이 활발하다. 그러나 이미 호모 플라스티쿠스(Homo plasticus)로 불리는 인류가 과연 플라스틱 없는 생활을 감당할 수 있을까? 생분해플라스틱 등 대체품 개발을 위한 과학기술적 해법, 보여주기 식이 아닌 ESG기반의 기업의 노력, 정부의 지속성 있는 대책이 절실한 시점이다. 기후위기 시대, 탄소중립 시대에서 필요한 것은 플라스틱 재사용·재활용·재활용을 포함한 슬기로운 위드플라스틱 생활이 아닐까?

안윤주 교수 | 건국대학교 환경보건과학과

생태독성학자이며 건국대학교 상허생명과학대학 학장으로 재직 중이다. 환경독성보건학회 회장을 역임했으며 두산연강환경학술상 대상(2021)을 수상했다. JTBC〈차이나는 클라스〉, CBS〈김현정의 뉴스쇼〉, OBS〈인사이드스토리〉 등에서 미세플라스틱에 대해 이야기했다.

Thank you

An’s Lab homepage,
www.zerotox.konkuk.ac.kr

안윤주 교수 | 바다에 고기 반, 플라스틱 반. 이대로 지켜만 보실 건가요? 플라스틱 재활용의 진실 [환경읽어드립니다]

조회수 1만회 • 1개월 전

사피엔스 스튜디오

출연 : 생태독성학자 안윤주 0:00 오프닝 0:30 플라스틱이 빼앗아간 생명 2:53 대체 왜 플라스틱 재활용은 어려울까? 4:25 플라스틱