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EFSA
European Food Safety Authority

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Re-evaluation of the risks to public health related to the presence of bisphenol A (BPA) in foodstuffs

Green Warriors of Norway/Norges Miljøvernforbund appreciate the new re-evaluated and established the new tolerable daily intake (TDI) of 0.04 ng Bisphenol-A (BPA) kg per day. It is a significant reduction from the 2015 established TDI levels, however we are still concerned the new TDI is still not established low enough regarding its potential for permanent and generational health damage.

We appreciate the extensive dataset provided by EFSA regarding BPA and health risk factors, but we will add the following points of our utmost concern:

- BPA represent a significant more potent health risk than previous research and knowledge has shown.
- BPA has shown generational damage in rainbow trout, ***"Bisphenol A in eggs causes development-specifc liver molecular reprogramming in two generations of rainbow trout"***.[1] Our concern is that similar generational damage also may be found in humans.
- The cocktail effect where BPA together with other chemicals and toxins may impose more dangerous effects on the human health than each chemical by itself.
- Many new sources of BPA in our food through environmental pollution entering and accumulating up through all levels of our food chain. These sources come in addition to the food coming in direct contact with BPA holding materials. The increased environmental pollution with BPA containing materials, epoxy, plastics, and micro and nano sized particles impose a significant higher risk for each year.
- The trojan horse effect where pieces and particles containing BPA may shield the chemicals from normal environmental degradation and therefore represent a greater hazard up through the food chain than the chemical in its original form. Most plastic and epoxy are only broken up in

[1] https://www.researchgate.net/publication/320630432_Bisphenol_A_in_eggs_causes_development-specific_liver_molecular_reprogramming_in_two_generations_of_rainbow_trout/fulltext/59f37f8ca6fdcc075ec349ab/Bisphenol-A-in-eggs-causes-development-specific-liver-molecular-reprogramming-in-two-generations-of-rainbow-trout.pdf?origin=publication_detail

smaller pieces, but they remain and accumulate and remain as non-degradable in the environment. When they enter the digestive tract, there is an increased risk of they being released into the organism, and passed on up and accumulated through the food chain. ***"An increase in temperature or a pH change can cause the ester bonds between the BPA molecules in polycarbonate plastic and epoxy resin to be broken through hydrolysis and thus release BPA to the environment."*** [2] This is further explained in a Swedish report; *"**Effects from consumption of plastics has been ascertained for phytoplankton and zooplankton, mussels, marine worms, shellfish, fish and birds. Biological effects can also be caused by added chemicals, that is used to give certain characteristics to the plastic material, is released and absorbed. In the same way, monomers and by-products from the production process can leak out. External chemicals from the surrounding environment, such as long-lasting organic pollutants with high level of affinity to plastic, is to be absorbed to the surface of the plastic particle."*** [3] It's of especially high concern that these types of micro and nano sized plastic and epoxy particles mostly do not degrade and may remain as an environmental and health hazard for several hundreds of years, of not thousands. Each point of pollution is added to all other sources, and each year's pollution is added to the accumulated amounts of all previous years.

- Norway, in difference from the rest of Europe, has its main supply of drinking water in open fresh water sources and reservoirs. This poses a direct threat of micro plastic pollution, much of which may also contain BPA and other hazardous chemicals. It is of utmost importance that EFSA make an inter-agency approach to limit all existing sources of these kinds of pollutants to the environment and prevent new from being established. In addition to micro plastic particles that may include BPA and other environmental and health damaging toxins
- Two recent scientific reports from Sweden[4] and from the Republic of Korea[5] show that some of the existing scientific knowledge is dominated by publications associated with the industry. This raises concern for the new established TDI of 0.04 ng BPA/kg per day may still being too high. The same principle is the case for the official numbers of micro plastics particles eroded from wind turbine blades into the environment. Most of the data is directly produces by the very same industry which has a financial gain of keeping the numbers as low as possible. It's also a known fact that the total amount released into the environment, in reality is much higher than the natural erosion by itself, due to current methods and procedures of in situ maintenance and repair.
- The precautionary principle must be adhered to in all regulatory measures regarding the food safety protocols, environmental sources through our food chain and drinking water, and also to the established tolerance (TDI) levels.

[2] https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6772-4.pdf?pid=20662

[3] https://www.researchgate.net/publication/306184402_Human_exposure_to_endocrine_disrupting_compounds_Their_role_in_reproductive_systems_metabolic_syndrome_and_breast_cancer_A_review

[4] https://www.sciencedirect.com/science/article/pii/S1462901121002537?via%3Dihub

[5] https://www.sciencedirect.com/science/article/abs/pii/S0304389421010402?via%3Dihub

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BPA – One problematic chemical, many sources

As mentioned in our summary, there are several sources of BPA pollution to the environment and to human consumption and health. In addition to the direct sources of the substance in its original form, most sources of the release of BPA are, when it is contained in various materials of all sizes. Most of those, ranging from various epoxy composites, rubber, and plastic products is degraded and eroded into smaller particles when exposed to the environment. Micro- and nano sized particles pose a significant environmental and health related risk where each source is accumulated and added to every other source and the accumulation from previous years. This is due to most of these types of particles being non degradable in the environment, before being subjected to hydrolysis in the gastrointestinal tract of organisms in the food chain. BPA and other chemicals bound inside such particles is also as an effect protected from the same environmental impacts of degradation the substance in it's free form is subject to. This is what's called the "Trojan Horse effect". The amounts of pollution we release today, will in large extents remain as a severe hazard in the environment for hundreds, if not thousands, of years to come.

> **Human exposure to endocrine disrupting compounds: Their role in reproductive systems, metabolic syndrome and breast cancer. A review**
>
> *«Bisphenols are not covalently bound to the polymeric structure, from which with time, or due to physical and/or chemical factors such as heat and acidity, can be gradually released into the external environment, contaminating water, soil and sediments, and later the rest of the agro-food chain».*
>
> *«Unfortunately, changes in temperature and pH cause hydrolysis of ester bonds in the compound itself resulting in leaching of bisphenols into foods and beverages.» M. Giulivo et al. / Environmental Research 151 (2016) 251–264.*[6]

There are several sources for BPA to reach into the environment, and into the human body. Human exposure may result in several disturbing and negative health effects, and its ability to disrupt propagation functions and cause generational damage in various species may also disrupt entire populations and ecosystems.

[6] https://doi.org/10.1016/j.envres.2016.07.011

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A recent study **"Plastic Products Leach Chemicals That Induce In Vitro Toxicity under Realistic Use Conditions"** (2021), from Lisa Zimmermann, Zdenka Bartosova, Katharina Braun, Jörg Oehlmann, Carolin Völker, and Martin Wagner, show that;

> **Plastic Products Leach Chemicals That Induce In Vitro Toxicity under Realistic Use Conditions (2021)**
> Lisa Zimmermann, Zdenka Bartosova, Katharina Braun, Jörg Oehlmann, Carolin Völker, and Martin Wagner
>
> ***Abstract***
> *Plastic products contain complex mixtures of extractable chemicals that can be toxic. However, humans and wildlife will only be exposed to plastic chemicals that are released under realistic conditions. Thus, we investigated the toxicological and chemical profiles leaching into water from 24 everyday plastic products covering eight polymer types. We performed migration experiments over 10 days at 40 °C and analyzed the migrates using four in vitro bioassays and nontarget high-resolution mass spectrometry (UPLC-QTOF-MSE). All migrates induced baseline toxicity, 22 an oxidative stress response, 13 antiandrogenicity, and one estrogenicity.*
>
> *Overall, between 17 and 8681 relevant chemical features were present in the migrates. In other words, between 1 and 88% of the plastic chemicals associated with one product were migrating. Further, we tentatively identified ∼8% of all detected features implying that most plastic chemicals remain unknown. While low-density polyethylene, polyvinyl chloride, and polyurethane induced most toxicological endpoints, a generalization for other materials is not possible.*
>
> ***Our results demonstrate that plastic products readily leach many more chemicals than previously known, some of which are toxic in vitro. This highlights that humans are exposed to many more plastic chemicals than currently considered in public health science and policies.***[7]

We must therefore put significant restrictions on all existing sources and stop new sources from occurring or being implemented.

Examples of current significant sources of BPA in microplastics to the environment:

- Rubber tires.
- Micro plastics in cosmetics.
- Plastic products that are exposed to physical forces on land, in our waterways or in the ocean.
- Epoxy composites used in boats and in wind turbine wings.
- Epoxy paint on ships and offshore installations.
- Microplastics released from the feeding systems in offshore open fish farms.
- Degrading of ropes, nets and various fishing equipment.

[7] https://pubs.acs.org/doi/10.1021/acs.est.1c01103

Summary and demands

We will in our comments show that epoxy compounds are a Trojan Horse regarding to the spread of Bisphenol A (BPA, EC No.: 201-245-8 CAS No.: 80-05-7, 4,4'-isopropylidenediphenol1) to the environment and to our food chain.

Regarding the concerns we raise, we will put forth some demands in accordance with a precautionary principle. Based on the documentation we present in this brief, we are significantly concerned for the biochemical pollution BPA can cause in unknown proportions regarding the environment, biodiversity, marine and fresh water sources, and the food chain we all are dependent upon.

We do ask on what scale is BPA levels a threat as a biochemical pollutant in different environments and towards different food chains? Do we as humans have enough knowledge to predict long term effects and harm?

> *"This is the first systematic review, to our knowledge, to assess and quantify MP contamination of seafood and human uptake from its consumption, suggesting that action must be considered in order to reduce human exposure via such consumption. Further high-quality research using standardized methods is needed to cement the scientific evidence on MP contamination and human exposures.*
>
> *Seafood is an important source of protein for populations around the world, and it may be time to implement the precautionary principle (Kriebel et al. 2001), based on the existing scientific evidence, and take steps in policy, industry, and society to minimize human exposures to foodborne MPs where possible."* [8]

Our demands below is sound and reasonable and is based on a precautionary principle. We need more strict regulations to avoid as much BPA and BPA in a combination with micro and nano sized particles of epoxy plastics released into the environment as possible.

Here are our demands:

1. We would like the placement of new large-scale installations that may cause the release of BPA and related chemicals into the environment may stop but **acknowledge that strict regulation and standards must be put in place to reduce the impact on the environment, ecosystems, food chain and on human health.**
   Scientific research must be prioritized where there is a lack of knowledge. A proper risk assessment must be conducted before new projects that may cause release of BPA and similar chemicals to the environment. All deployment of epoxy related industries must be put on halt until proper scientific standards are met to show them safe to the environment, climate, biodiversity, and human health. This applies to both productions, use and dismantling, recycling, and deposit of such materials.

2. **Complete product declaration on all products that contain BPA and similar chemicals must be present and follow the product on all stages from production until its recycled and reused or deposited.** The product declaration should also reflect restrictions and hazards through

[8] https://ehp.niehs.nih.gov/doi/10.1289/EHP7171

its intended life cycle, also including terms of application for sales and transfer of goods in accordance with applying directives.

The terms of a product declaration must include the following:

- Data sheet as a product declaration of amount, percentage, weight and volume of BPA and similar chemicals for all industries excluding food purposes.
- Content description/product declaration on all products for Activities of Daily Living (ADL) and food purposes. This will empower all customers to take responsible consumer decisions within a health- and environmental perspective.
- Branch based product declaration complying to set life cycle standards.
- Restrictions and regulations to product declarations and import/export applications to maintain national overview and control to meet nationally and internationally environmental standards and goals. This must also adhere to the goals set in the UN sustainability goals.

Industry and branches that is large scale consumers of epoxy related materials must be the first to undergo regulations that also meets the demands of a sustainable and environmentally friendly circular economy. Regulations must also include management of waste and deposal in compliance with the appropriate EU directives.

3. Relevant information must be given to public and governing bodies and to the public in general regarding the hazards of BPA and similar chemicals to human health and to the environment. Conscious consumers, both corporate and private must be a definitive goal regarding legislation, standards, and procedures regarding handling of BPA containing products within a life cycle timeframe.

4. Follow advice from WHO to decrease levels of pollutants in all water systems as soon as possible. Implement stricter levels of tolerance much earlier than 2026. The reasoning for this is based on current plans to implement new installations that contain BPA-related materials both onshore and offshore. This is most significantly related to wind power generation where the turbine blades are increasing in both size, volume, and numbers on an exponential rate. There is a significant problem with micro particles released into the environment due to Leading Edge Erosion (LEE). As we will show other places in this brief, this is potentially a much more environmental risk for the eco systems and our food chain than the same chemicals in their pure form due to the Trojan Horse effect.

5. Scientific research into the environmental and health related effects must be prioritized. We do have too little knowledge, especially towards long time effects, and the data we do have available show negative effects of grave concerns. Micro particles of epoxy, rubber, other plastics do seem to accumulate in the environment for each and every year, and thus also remain an ever growing and lasting environmental problem. Especially relevant to highlight the issues at hand is found in the following three quotes.

- ***"Bisphenol A in eggs causes development-specifc liver molecular reprogramming in two generations of rainbow trout"*** [9]

[9] https://www.researchgate.net/publication/320630432_Bisphenol_A_in_eggs_causes_development-specific_liver_molecular_reprogramming_in_two_generations_of_rainbow_trout/fulltext/59f37f8ca6fdcc075ec349ab/Bisphenol-A-in-eggs-causes-development-specific-liver-molecular-reprogramming-in-two-generations-of-rainbow-trout.pdf?origin=publication_detail

- ***"An increase in temperature or a pH change can cause the ester bonds between the BPA molecules in polycarbonate plastic and epoxy resin to be broken through hydrolysis and thus release BPA to the environment."*** [10] [11]
- (Original text-Swedish) *"Effekter från intag av plast har konstaterats för växt- och djurplankton, musslor, marina maskar, kräftdjur, fisk och fåglar. Biologiska effekter kan också orsakas av att tillsatskemikalier, som används för att ge vissa egenskaper till plasten, läcker ut och tas upp. På samma sätt kan monomerer och biprodukter som finns kvar i plasten från framställningsprocessen läcka ut. Dessutom så kan även kemikalier från den omgivande miljön, såsom långlivade organiska föroreningar ofta med hög affinitet till plast, adsorberas till partikelytan."*
  (Our translation) ***"Effects from consumption of plastics has been ascertained for phytoplankton and zooplankton, mussels, marine worms, shellfish, fish and birds.*** *Biological effects can also be caused by added chemicals, that is used to give certain characteristics to the plastic material, is released and absorbed. In the same way, monomers and by-products from the production process can leak out. External chemicals from the surrounding environment, such as long-lasting organic pollutants with high level of affinity to plastic, is to be absorbed to the surface of the plastic particle."* [12]

There must be set significant effort and resources towards scientific research that is aimed at establishing possible effects and mechanisms that can secure sound and environmentally friendly products and procedures.

The impact from BPA to our environment and food chain

The amounts of BPA and similar chemicals released to the environment can be enormous due to the huge increase in use of epoxy related materials in challenging environments. The research we refer, do show negative impact on the food chain at large, from the smallest plankton to large mammals, and even humans. If phytoplankton is significantly affected, their ability to capture CO_2 and release oxygen may similarly be affected. BPA is also shown to have generational impact on organisms.

The Trojan Horse effect in micro particles keep the chemicals inside shielded from environmental impact, and thus reduce the degradation of the chemicals. When consumed by organisms they are released into the organism when in contact with their digestive, often acidic fluids.

> *"An increase in temperature or a pH change can cause the ester bonds between the BPA molecules in polycarbonate plastic and epoxy resin to be broken through hydrolysis and thus release BPA to the environment."* [13]

Another problem with micro and nano sized particles is that they likely stay in the upper levels of the water body much longer and therefore is more likely be able to be consumed and absorbed into by small plankton and organisms and accumulated up through the food chain. Therefore, such micro and nano

[10] https://www.researchgate.net/publication/306184402_Human_exposure_to_endocrine_disrupting_compounds_Their_role_in_reproductive_systems_metabolic_syndrome_and_breast_cancer_A_review

[11] https://diegofdezsevilla.wordpress.com/2014/07/17/could-plastic-debris-coarse-fine-and-molecules-polymers-affect-oceans-functions-as-climate-regulator-co2-sink-albedo-evaporation/

[12] https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6772-4.pdf?pid=20662

[13] https://www.researchgate.net/publication/306184402_Human_exposure_to_endocrine_disrupting_compounds_Their_role_in_reproductive_systems_metabolic_syndrome_and_breast_cancer_A_review

sized particles do potentially represent a much more significant threat to the environment than each chemical in its pure form. The micro and nano sized particles in itself can be a serious health issue to the affected organisms, not to mention the added impact from contained chemicals. Brain damage and behavioral disorders in fish induced by plastic nanoparticles delivered through the food chain is recorded by scientists. [14]

The potential risks from BPA are not only connected to life and health only, but may also affect the planets potential to collect CO2 from the environment and also only its ability to produce oxygen through the mechanisms of phytoplankton.

> *"**Effects from consumption of plastics has been ascertained for phytoplankton and zooplankton, mussels, marine worms, shellfish, fish and birds.** Biological effects can also be caused by added chemicals, that is used to give certain characteristics to the plastic material, is released and absorbed. In the same way, monomers and by-products from the production process can leak out. External chemicals from the surrounding environment, such as long-lasting organic pollutants with high level of affinity to plastic, is to be absorbed to the surface of the plastic particle." (original text in Swedish – our transl.)* [15]

Researchers has discovered plastic microparticles in the digestive system of deep sea schrimp as far down as 11 km below the surface in and around the Pacific. Over 72% of the schrimp collected had one or more plastic microparticles in their body. Micro and nano sized plastic particles can now be found in every far away corner of our planet. [16]

> *"Seafood is an important source of protein for populations around the world, and it may be time to implement the precautionary principle (Kriebel et al. 2001), based on the existing scientific evidence, and take steps in policy, industry, and society to minimize human exposures to foodborne MPs where possible».* [17]

> *"**Upon uptake, micro- and nanoplastics can reach the brain**, although there is limited information regarding the number of particles that reaches the brain and the potential neurotoxicity of these small plastic particles".* [18]

> *"Although the transport of hydrophobic contaminants by plastic debris is not relevant in terms of masses, under authors' point of view their capability **to act as a Trojan Horse** for these contaminants to living organisms cannot be underestimated".*

> ***"Hence, their toxicity may be caused by the plastic polymer itself, the additives that it contains, and/or by other chemicals associated to MPs that might be released to the aquatic media".***

[14] https://www.researchgate.net/publication/319683370_Brain_damage_and_behavioural_disorders_in_fish_induced_by_plastic_nanoparticles_delivered_through_the_food_chain

[15] https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6772-4.pdf?pid=20662

[16] https://mikroplast.wordpress.com/2019/02/28/mikroplast-i-tarmen-pa-dypvannsreker/

[17] https://ehp.niehs.nih.gov/doi/10.1289/EHP7171

[18] https://www.researchgate.net/publication/342019198_The_plastic_brain_Neurotoxicity_of_micro-_And_nanoplastics

In fact, the highest contribution from beached plastics to seawater corresponded to the leaching of plastic additives (flame retardants and plasticizers) followed by PCPs, being also relevant that a significant proportion of less hydrophobic contaminants can be desorbed from plastics to seawater in the first 24 h.

There are 7 mechanisms that affect the role of MPs as carriers of co- contaminants summarized by Koelmans et al. as follow:

1. *absorption – ingestion-egestion of plastic, with chemical transferred from plastic to organism*
2. *cleaning – ingestion-egestion of plastic, with an increase of chemical excreted from organism*
3. *source – plastic acting as a source of co-contaminant in the environment*
4. *sink – plastic accumulate co-contaminants from the seawater and organisms*
5. *indirect source, dietary – desorption of chemical from plastic to natural food/prey followed by ingestion of prey*
6. *dietary – uptake of chemical by ingestion of regular contaminated food (i.e., NPs), and*
7. *dermal – uptake of chemical from any medium other than plastic and natural prey. In addition to hydrophobic contaminants such as POPs, some authors investigated how MPs and plastic debris may also concentrate metals.*

This is possible due to the oxidised form of the plastic surface that can carry functionalities that may bind metals. This last finding was unexpected, and it emphasizes the necessity to further investigate the behaviour of MPs in the environment with special attention to ageing MPs. MNPs due to their small size, similar to plankton, can be ingested by aquatic organisms, and therefore be introduced into marine food web. Setälä et al. observed that polystyrene (PS) microspheres can be transferred via planktonic organisms from one trophic level (mesozooplankton) to a higher one (macrozooplankton).

The study also confirmed the ingestion of PS based MP by mysid shrimps, copepods, cladocerans, rotifers, polychaete larvae and ciliates although some of the species ejected the microspheres after 12 h of ingestion.

MPs and NPs may also pose a risk to human health due to their potential accumulation in seafood reaching the consumers. For example, mussel Mytilus edulis have been reported as marine species able to ingest MPs.

However, MPs and NPs can be retained in some organs, and they may be translocated in living tissues.

Furthermore, evidence of physical size alteration of microplastics by a planktonic crustacean has been recently demonstrated. It is estimated that some of the plastics can reach concentration factors inside the organisms near to 1 million-fold increase". [19]

«Action must be considered in order to reduce human exposure». [20]

[19] https://www.researchgate.net/publication/341349798_Microplastics_in_Mediterranean_coastal_area_toxicity_and_impact_for_the_environment_and_human_health

[20] https://ehp.niehs.nih.gov/doi/10.1289/EHP7171

> *"Furthermore, phthalates and bisphenols are not covalently bound to the polymeric structure, from which with time, or due to physical and/or chemical factors such as heat and acidity, can be gradually released into the external environment, contaminating water, soil and sediments, and later the rest of the agro-food chain.".* [21]

BPA levels has been observed in urine samples from humans with extremely high frequency (up till 99%) (Ye et al. 2015) [22], which indicate a which level of pollutants in the environment [23]. BPA has been found in most samples of blood, brest milk og amniotic (Vandenberg et al. , 2007) [24]. Even low levels of BPA seems to have a very negative effect on the health of humans.

> *«It was concluded that low doses of BPA (1 and 10 nM) inhibit adiponectin secretion by human adipocytes cultures in vitro and stimulate the secretion of inflammatory adipokines such as interleukin-6 (IL-6) and tumor necrosis factor α suggesting its possible involvement in obesity, metabolic syndrome and insulin resistance (Hugo et al., 2008; Alonso-Magdalena et al., 2011)».* [25]

[21] https://pubmed.ncbi.nlm.nih.gov/27504873/

[22] https://pubs.acs.org/doi/abs/10.1021/acs.est.5b02135

[23] https://www.osti.gov/pages/biblio/1470902

[24] https://pubmed.ncbi.nlm.nih.gov/17825522/

[25] https://www.researchgate.net/publication/306184402_Human_exposure_to_endocrine_disrupting_compounds_Their_role_in_reproductive_systems_metabolic_syndrome_and_breast_cancer_A_review

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The fact that BPA enter the food chain is relatively new knowledge

It's first in recent years, science and research has concluded that epoxy plastics ends up un the digestive system of marine and aquatic species like algae, schrimps, shellfish, molluscs, fisk, ampfibians, mammals, and also land based microbes, insects and animals. This causes BPA introduced into and accumulated up through the food chain through their digestive systems.

> *"Recently, the environmental obesogen hypothesis, suggesting that environmental chemicals contribute to development of metabolic disorders in humans, including obesity, insulin resistance, type 2 diabetes, hepatic injury, dyslipidemia and cardiovascular diseases, is gaining weight*
>
> *In this context, the implementation of greater restrictions on the use of these substances in the products of daily use and the conduction of future studies to (i) identify other substances with potentially similar effects on animals and human health and (ii) investigate the mechanisms behind should be given particular consideration".* [26]

Even if the inflicted harm from BPA is well documented, it seems that we still do not have the full knowledge of the total impact on health and the environment. [27]
In all cases, it seems like epoxy plastics and compounds might act as a Trojan Horse of significant dimensions in the environment with its harmful load. This might impose severe implications for all nature, environment, climate and all earthly life itself.

In the following list we have included some of the references relevant to the subject at hand. This is only a partial list as there is much more research to be found on the various subjects within the scientific system of publications.

[26] https://pubmed.ncbi.nlm.nih.gov/27504873/

[27] https://www.researchgate.net/publication/306184402_Human_exposure_to_endocrine_disrupting_compounds_Their_role_in_reproductive_systems_metabolic_syndrome_and_breast_cancer_A_review

We know that:

1. **A long range of epoxy related products is exposed to erosion which release micro and nano particles from epoxyplastics into the environment.** The most significant sources stem from the auto industry, shipping and boat industry and from the wind power industry. [28] [29] [30] [31]
2. **We do not have a thorough collected overview on the total amount of epoxy related micro and nano sized particles** released into the environment within Europe, but we can clearly estimate the amount to be in the several hundred tons range, as it **is estimated from car lacquer/coating at 225 tons in 2013.** [32]
3. **Car tires and polycarbonates (PC) do also contain BPA** [33] [34]. There is significant amounts of micro and nano sized particles released into the environment.
4. **The production of wind turbine wings are among those with the highest consumption of epoxy plastics.** In 2013, 27% (69 000 tons) of all epoxy resin went to this production, and the production and use within this segment has undergone a significant increase since then. It's further estimated that a significant increase also will come in the coming years. [35]
5. **Yearly global production of BPA is more than 10 million tonnes, and a significant increase is expected in the coming years.** [36]
6. **Our water sources, waterways and oceans are all contaminated with high levels of BPA** and related chemicals and micro and nano sized particles of epoxyplastics. [37] [38]
7. **Epoxyplastics are made with Bisphenols, mainly with BPA, which make up approximately between 30-40 % of the total product by weight.** [39] [40]
8. **BPA and similar chemicals are very harmful for all life**, including algae, fish, invertebrates and vertebrates when introduced through their digestive systems. It is considered carcinogenic,

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[28] https://www.sciencedaily.com/releases/2010/03/100323184607.htm

[29] https://www.researchgate.net/publication/330151272_Temporal_and_Spatial_Distributions_of_Bisphenol_A_in_Marine_and_Freshwaters_in_Turkey

[30] https://www.researchgate.net/publication/319683370_Brain_damage_and_behavioural_disorders_in_fish_induced_by_plastic_nanoparticles_delivered_through_the_food_chain

[31] https://www.researchgate.net/publication/343209522_Leading_edge_erosion_of_wind_turbines_Effect_of_solid_airborne_particles_and_rain_on_operational_wind_farms

[32] https://epoxy-europe.eu/wp-content/uploads/2015/07/epoxy_erc_bpa_whitepapers_automotive-2.pdf

[33] https://www.researchgate.net/publication/343184657_Car_Tire_Crumb_Rubber_Does_Leaching_Produce_a_Toxic_Chemical_Cocktail_in_Coastal_Marine_Systems

[34] https://en.wikipedia.org/wiki/Bisphenol_A

[35] https://epoxy-europe.eu/wp-content/uploads/2018/11/Epoxy_Socioeconomic_Study_Main_Findings_August-2017.pdf

[36] https://www.researchgate.net/publication/306184402_Human_exposure_to_endocrine_disrupting_compounds_Their_role_in_reproductive_systems_metabolic_syndrome_and_breast_cancer_A_review

[37] https://www.miljodirektoratet.no/globalassets/publikasjoner/M176/M176.pdf

[38] https://www.researchgate.net/publication/330151272_Temporal_and_Spatial_Distributions_of_Bisphenol_A_in_Marine_and_Freshwaters_in_Turkey

[39] https://epoxy-europe.eu/wp-content/uploads/2015/07/epoxy_erc_bpa_whitepapers_automotive-2.pdf

[40] https://www.epoxy-europe.eu/wp-content/uploads/2015/07/epoxy_erc_bpa_whitepapers_wind-energy-2.pdf

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reduces the reproductive abilities, reduces weight, may cause brain damage, cause metabolic syndrome, cause insuline resistance and more. [41] [42] [43] [44] [45] [46]

9. **Nanoplastics can penetrate the blood-brain barrier** in fish and cause altered behavior. [47]
10. **Most of the chemicals in the Bisphenol group are hazardous and have different impacts on the environment, food chain and health** [48] [49]
11. **BPA and epoxyplastics (nano- and micro sized particles) are accumulated up through the food chain**, from phytoplankton and zooplankton and up to large fish, mammals and humans. [50]
12. **Epoxyplastics will release its harmful chemical componds when introduced to the digestive system of marine- and landbased species in all levels through the food chain.** This is the main cause why micro and nano sized particles can be of more environmental harm than the same chemicals in its pure form. [51]
13. **Epoxy is broken down through hydrolysis - ie in an environment that is acidic, wet and hot such as in the gastrointestinal tract of mammals.** *"An increase in temperature or a pH change can cause the ester bonds between the BPA molecules in polycarbonate plastic and epoxy resin to be broken through hydrolysis and thus release BPA to the environment".* [52] [53]
14. **The degradation period of epoxy and epoxy related materials in nature can be very long**, if we disregard the time its reacting to the chemicals in the digestive systems in organisms. This is of significant concern, as it is both accumulated into the environment and its chemical package is accumulated up through the food chain. [54] [55]
15. **UV-based filtrations systems doesn't degrade epoxyplastics**, and thus, BPA contained inside particles of epoxy will likely remain undamaged throughout the filtration process in facilities for purification- and drinking water.

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[41] https://www.researchgate.net/publication/320630432_Bisphenol_A_in_eggs_causes_development-specific_liver_molecular_reprogramming_in_two_generations_of_rainbow_trout/fulltext/59f37f8ca6fdcc075ec349ab/Bisphenol-A-in-eggs-causes-development-specific-liver-molecular-reprogramming-in-two-generations-of-rainbow-trout.pdf?origin=publication_detail

[42] https://forskning.no/kjemi-miljogifter-hjernen/bisfenol-a-kan-skade-nyfodte-hjerner/743277

[43] https://www.sciencedirect.com/science/article/abs/pii/S0300483X11003453

[44] https://www.researchgate.net/publication/319683370_Brain_damage_and_behavioural_disorders_in_fish_induced_by_plastic_nanoparticles_delivered_through_the_food_chain

[45] https://www.sciencedaily.com/releases/2010/03/100323184607.htm

[46] https://www.researchgate.net/publication/306184402_Human_exposure_to_endocrine_disrupting_compounds_Their_role_in_reproductive_systems_metabolic_syndrome_and_breast_cancer_A_review

[47] https://www.researchgate.net/publication/319683370_Brain_damage_and_behavioural_disorders_in_fish_induced_by_plastic_nanoparticles_delivered_through_the_food_chain

[48] https://www.miljodirektoratet.no/globalassets/publikasjoner/M176/M176.pdf

[49] https://www.researchgate.net/publication/343184657_Car_Tire_Crumb_Rubber_Does_Leaching_Produce_a_Toxic_Chemical_Cocktail_in_Coastal_Marine_Systems

[50] https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6772-4.pdf?pid=20662

[51] https://www.researchgate.net/publication/319683370_Brain_damage_and_behavioural_disorders_in_fish_induced_by_plastic_nanoparticles_delivered_through_the_food_chain

[52] https://bora.uib.no/bora-xmlui/handle/1956/21135

[53] https://www.researchgate.net/publication/306184402_Human_exposure_to_endocrine_disrupting_compounds_Their_role_in_reproductive_systems_metabolic_syndrome_and_breast_cancer_A_review

[54] https://www.sciencedaily.com/releases/2010/03/100323184607.htm

[55] https://diegofdezsevilla.wordpress.com/2014/07/17/could-plastic-debris-coarse-fine-and-molecules-polymers-affect-oceans-functions-as-climate-regulator-co2-sink-albedo-evaporation/

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16. **When the 2-component process is finished, not all the initial BPA is hardened** and will remain inside the material in its pure form. This might be small amounts but it is still a major concern due to the Trojan Horse Principle mentioned above.
17. **BPA has a relative long degradation period in water**, especially in salty sea water at temperatures sub 25 degrees Celsius. This is a significant concern given that the northern parts of Europe and Scandinavia has even lower temperatures than that, especially during the autumn and winter season. In an arctic and sub arctic climate very low temperatures will be present most of the year, which may give a more severe negative impact on the environment than in more tempered parts of Europe. [56]
18. **It may also be of concern that micro and nano sized particles from all corners of the earth may find its way to the same areas, so it is also important that countries and regions outside Europe implement stricter regulations as well.** [57]

[56] https://www.researchgate.net/publication/334505340_Degradation_of_Bisphenol_A_in_Natural_and_Artificial_Marine_and_Freshwaters_in_Turkey

[57] https://pubs.acs.org/doi/10.1021/acs.est.7b03889

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More data on BPA and microplastics as sources of hazardous pollution of the highest concern

As stated above, the problem of BPA and other similar substances of concern are deeply linked to various epoxy-, rubber- and plastic materials, which in nature are broken into smaller pieces and in large extent is non degradable. More on this below.

The environmental problems might be even bigger that the current scientific knowledge reflects due to data biased by the industry

Recent studies from Sweden and from the Republic of Korea suggest that the scientific papers on the toxicological properties of chemical pollutants, of which environmental policymakers rely for knowledge, is heavily related on publications associated with the industry. This raises several additional concerns. Especially what regards to the precautionary principle, where the numbers and conclusions from the industry may not in a significantly way reflect the actual problem. Proposed restrictions may not be as far reaching as they need to be to address the severity of the problem at hand.

> **Does the scientific knowledge reflect the chemical diversity of environmental pollution? – A twenty-year perspective**
> Kristiansson, E., Coria, J., Gunnarsson, L. et al (2021)
> Environmental Science and Policy, 126: 90-98 [58]
>
> ***Environmental policymaking relies heavily on the knowledge of the toxicological properties of chemical pollutants. We also show that university- and corporate-based research exhibit distinct publication patterns and that for some chemicals the scientific knowledge is dominated by publications associated with the industry.***
>
> *In this study, we investigated the scientific knowledge on environ- mental chemical pollution generated by the research community over the last two decades.*
> *Our results show significant changes in the research agenda with decreasing publication frequency of chemicals used as plant protection products while the publication frequency of pharmaceuticals increased.*
>
> ***We could, furthermore, conclude that the ecotoxicological research community is highly focused on a few well-studied chemicals, especially heavy metals, and this raises concerns about our ability to sufficiently cover the large chemical diversity of environmental pollutants.***
>
> ***There is, indeed, a large number of chemicals for which no, or very little, knowledge is available or where the knowledge is, to a large extent, generated through corporate-associated research.***
>
> ***We conclude that a continued expansion and/or a reprioritization of the ecotoxicology research is necessary to meet the challenges associated with the increasing chemical diversity***

[58] http://dx.doi.org/10.1016/j.envsci.2021.09.007

of the expanding chemosphere and to ensure that the need for independent and objective scientific knowledge *– as requested by the society – are properly met.*

Highlights
Environmental Science & Policy
Volume 126, December 2021, Pages 90-98

1. *The ecotoxicological research has been highly focused and as few as 65 chemicals dominates the scientific literature.*
2. *Over the last twenty years, the research interest has increased for pharmaceuticals and decreased for biocides.*
3. *Corporate-associated research has distinct publication patterns and compose large parts of the knowledge for some chemicals.*
4. *A large number of chemicals have little to no scientific knowledge about their toxicity.*
5. *Expansion of the ecotoxicological research field is necessary to catch up with the increasing diversity of the chemosphere.*
6. *"The scientific ecotoxicological knowledge is growing but it is not clear to what extent the research community manages to cover the large chemical diversity of environmental pollution." and*

"We also show that university-and corporate-based research exhibit distinct publication patterns and that for some chemicals the scientific knowledge is dominated by publications associated with the industry.

We conclude that there is a large number of chemicals with little, or no, scientific knowledge and that a continued expansion of the field of ecotoxicology will be necessary to catch up with the constantly increasing diversity of chemicals used within the society."

Environmental Science & Policy
Volume 126, December 2021, Pages 90-98 [59]

[59] https://www.sciencedirect.com/science/article/pii/S1462901121002537?via%3Dihub

The report on BPA from the Republic of Korea highlights the problem with industry driven research and manipulation even further:

Journal of Hazardous Materials 417 (2021) 126076

Drivers of owning more BPA

Md Saidur Rahman , Elikanah Olusayo Adegoke , Myung-Geol Pang *
Department of Animal Science & Technology and BET Research Institute, Chung-Ang University, Anseong, Gyeonggi-do 17546, Republic of Korea

4. Suspicious reference doses: do we need more evidence?
(page 5)

Despite the variety of human health effects following exposure to low doses of BPA, in a provisional CLARITY–BPA report, the US FDA stated that the currently approved doses (both TDI and NOAEL) are still safe (FDA, 2018). This statement is factually inaccurate and has been forcefully refuting by many experts (Vandenberg et al., 2019; Vom Saal, 2019).

Indeed, industrial lobbyists might have been responsible for driving such a decision. ***It has been noticed that industrial lobbyists use different strategies, such as sponsoring industry-friendly researches, limiting access to the information on risks of endocrine-disrupting chemicals (EDCs), launching misleading websites, influencing international trade negotiations, and using financial agreement to defeat BPA banning bills (Janssen, 2010; Erler and Novak, 2010).*** *For example, the NTP panel's review in 2001 indicated credible evidence that low doses of BPA produce harmful effects on specific endpoints' (Gross, 2007). To refute these findings, the American Plastics Council, consisting of all the major BPA producers and their trade groups, commissioned a review from the Harvard Center for Risk Analysis (HCRA). Surprisingly, the HCRA released a report showing that "the weight of the evidence for low-dose effects of BPA is very weak" (Gross, 2007).* ***Besides, the chemical industries have adopted fear tactics claiming that all canned food would disappear from store shelves if BPA bans were passed and have tried to manipulate the legislative process (Janssen, 2010; Erler and Novak, 2010). Moreover, their financial resources and a vast network with legislators made industrial lobbyists an unformidable force opposing the effort to pass more stringent regulations.*** *As such, the regulatory agencies, industrial researchers, and lobbyists' conscious efforts to sustain BPA uses might eventually follow the similar path of sugar overused in everyday food despite its harmful impact on healthy living. Therefore, it is vital to public health that the levels of BPA exposure be redefined according to the prevailing scientific consensus.*[60]

These findings are also in accordance with our experience. One example is Leading edge erosion (LEE) data, where microplastic particles from wind turbine wings are eroded and released into the environment, where a significant amount contains BPA. Media and the industry, in unison, rely unfiltered on undocumented data from the industry and their lobby groups. Any questions, even when documented by scientific findings, are automatically "debunked" by the same undocumented claims. In Norway, there are mainly two references, that supposedly document this industry view. One is from the Norwegian based Fred Olsen Renewables with a significant interest and investment in the wind power

[60] https://www.sciencedirect.com/science/article/abs/pii/S0304389421010402?via%3Dihub

industry, both domestically and abroad. The Norwegian premiere technical magazine Teknisk Ukeblad (TU) take their undocumented claimed data at face value to “debunk” and “fact check” all questions and claims from the public, concerned organizations and others with knowledge contradicting the industry claims. At the same time, the energy companies, and other groups with significant financial interests in the wind power industry remain among the main contributors to that magazine’s yearly ad revenue.[61]

The other main source for these undocumented claims is from the Norwegian interest and industry organization for renewable energy, NORWEA. They claim that, quoted:

> *«Microplastic is also a small problem for the modern wind power plants we have in Norway, and a wind turbine emits less microplastic than, for example, a car tire or a garment. (7) Emissions from a wind turbine are on average 150 grams per turbine per year, and it is mainly paint that is eroded away.”* [our translation][62]

NORWEA’s claim of 150 grams microplastic per turbine per year remain undocumented. Still these undocumented claims and industry opinions are much sited by the media, and more concerningly also find their way into the Norwegian government agencies as true facts. The Norwegian Ministry of Petroleum and Energy give this statement on their wind power Q&A page, quote:

> **How much microplastic does the wind turbine emit during its lifetime?**
> *Today, there is no comprehensive overview of the amount of microplastic emissions from wind power. It is important that plastic pollution is not trivialized, but even if emissions from turbine blades occur, it is still of limited importance. In the Norwegian Environment Agency's survey of Norwegian sources for the spread of microplastics, wind power is not mentioned in the overview. In feedback that NVE* ***has received from a wind power producer****, annual wear on modern turbine blades is in the order of up to 50 grams of microplastic per year per turbine blade. In order to increase the knowledge base on wear and wind power, NVE will work together with the Norwegian Environment Agency, as proposed in Meld. St. 28 (2019-2020).*
> [Our translation – this page is only available in norwegian][63]

Here, the Norwegian government at its highest level rely solely on undocumented claims from an unnamed wind power producer as their only source of truth. Please reread the two above reports from Sweden and the Republic of Korea. They are quite revealing.

It provides no confidence that undocumented claims from financial beneficiaries form the basis of governmental policy making and legislation. Serious claims and questions of significant environmental and health related concerns need a better approach from the governing authorities than being a dedicated lap dog and gate keeper for the industry. Our organization, Green Warriors og Norway/Norges Miljøvernforbund (NMF) has raised these questions and concerns several times with our governing authorities. A serious approach would be to conduct independent research into the matters at question,

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[61] https://www.tu.no/artikler/ni-pastander-om-vindkraft-vi-har-faktasjekket-dem/509409

[62] https://norwea.no/norwea-mener/2021/5/28/klare-faktafeil-fra-motvind-om-vindkraftforurensning

[63] https://www.regjeringen.no/no/tema/energi/landingssider/vindkraft-pa-land/sporsmal-og-svar----vindkraft-pa-land/id2770374/?expand=factbox2774088

but who remains independent?

From the Swedish study, by Kristiansson, E., Coria, J., Gunnarsson, L. et al (2021), as quoted above:

> ***Environmental policymaking relies heavily on the knowledge of the toxicological properties of chemical pollutants. We also show that university- and corporate-based research exhibit distinct publication patterns and that for some chemicals the scientific knowledge is dominated by publications associated with the industry.***

What they don't tell you..

Most of the information on LEE (Leading edge erosion) is based on natural occurring erosion, as rain, hail, airborne particles from salt and sand and other causes. What the industry never mentions is the other source of microplastic particles to the environment where much also contain BPA, which is the common procedure of in situ reparations. When mechanical open-air sanding is the main part of the operation, the amounts of microplastic particles released into the environment may even exceed the amounts caused by natural erosion. In most cases, where in situ maintenance repair procedures appear, you can easily at least double the industry pollution volume claims. It's not likely, however, that the financial beneficiaries have any interests than to keep their pollution data as low as possible.

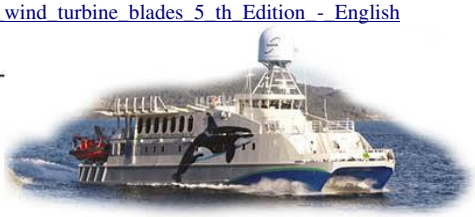
No microplastics pollution here..? Image show the commonly used practice of open air mechanical sanding at an in situ repair job. The industry won't tell you this, but this is common practice. Image from: YouTube.

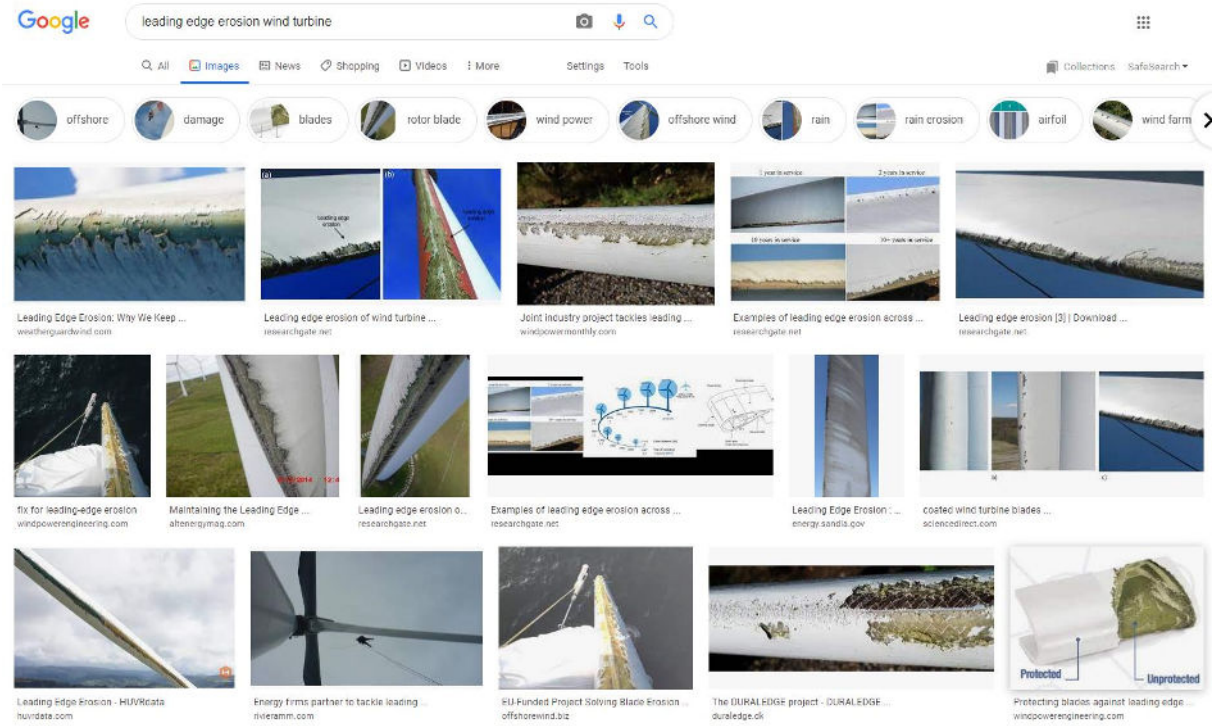
The report by Asbjørn Solberg, Bård-Einar Rimereit og Jan Erik Weinbach "THE TURBINE GROUP" JULY 2021, "Leading Edge erosion and pollution from wind turbine blades - 5 th. Edition", which has stirred much controversy among the wind power industry and its lobby, has still not been disproven. It has only, as far as we understand, been met with the same undocumented claims and opinions as we have documented above. The concerns and principles raised in that report therefore still remain true to

this day. Also, important to note is that the report doesn't consider in situ repair procedures as an additional source, as they only address natural occurring microplastics and BPA pollution. This show that vital information is clearly withheld by the industry groups and their lobby. Without the full data in public open and reviewable sources available, how can we trust that governmental policy makers make the right decisions or legislation? [64]

More on LEE (Leading edge erosion) and the common industry practice of in situ maintenance and repair on wind turbine wings further down below.

[64] https://www.researchgate.net/publication/353395665_Leading_Edge_erosion_and_pollution_from_wind_turbine_blades_5_th_Edition_-_English





A common web search revels that this problem is more common and severe that the industry like to admit.

New and updated information on LEE (leading edge erosion) from wind turbine blades, and the dangers of micro plastics and BPA pollution in the environment

The report by Asbjørn Solberg, Bård-Einar Rimereit og Jan Erik Weinbach "THE TURBINE GROUP" JULY 2021, "Leading Edge erosion and pollution from wind turbine blades - 5 th. Edition" highlight the vast and increased problem with erosion of micro particles from epoxy composites and other plastic materials in environments with much rain and aerial particles present. The report bases its findings on research conducted at the University of Stratdclyde in Scotland. [65] [66]

As the boundaries where the wind farms are pushed into more harsh and challenging environments, more and increased erosion must be taken into account. It's also problematic that colder environments as we find along the coast in arctic and sub arctic environments may also lead to slower bio degradation processes, and as such, a increased environmental problem than is experienced in more warmer and less harsh environments further south in Europe and the world.

[65] https://www.researchgate.net/publication/353395665_Leading_Edge_erosion_and_pollution_from_wind_turbine_blades_5_th_Edition_-_English

[66] https://drive.google.com/file/d/1z8YFP0JFmR-0ywpijtClfDEy2gT-6wFB/view

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A recent study, "Microplastics and bisphenol A in mussels along Italian and Croatian coast of the Adriatic Sea", May 2021, by Tanja Bogdanović, Ludovica Di Renzo, et al, show how severe this problem is even in warmer coastal climatic conditions.

Microplastics and bisphenol A in mussels along Italian and Croatian coast of the Adriatic Sea

The Mediterranean basin is one of the most impacted area by marine litter and within it the Adriatic Sea even more. Recent studies detected floating and sinking microplastics (MPs) in the aquatic environment, as well as in biota (Di Renzo et al, 2021). From ancient times, Adriatic coasts are particularly devoted to the mussel farming. Mytilus galloprovincialis is one of the most commercial interest species, it is widely consumed by humans. ***Mussels could be considered as particularly good trusted candidates for the assessment of human exposure to MPs, as they are filter-feeders directly exposed to MPs present in the environment*** *(Mercogliano et al, 2021).*

Nowadays, a broad range of complementary analytical methodologies has been applied regarding the detection and identification of MPs and their additives such as Bisphenol A (BPA), without any harmonized monitoring protocols by making difficult the comparison of disposable data on their occurrence in marine biota and the risk assessment for human health (Barboza et al, 2020).

Results:

- *The average number of MPs in Adriatic mussel is 1 item/g.*
- *Polyester and High Density Polyethylene were detected in 10 sampling sites, out of 17.*
- *Free PTA, PC and PET were revealed in all samples, free BPA in 76,5%.*

Risk assessment and conclusion

- This study provides evidences of microplastics contamination of mussels farmed along the Italian and Croatian coastline of the Adriatic Sea with Polyester (PE) and Polypropylene (PP) as the main polymer types.
- The median of bisphenols detected in Italian mussel resulted with considerably higher EDI values (3-fold higher) compared to Croatian results and the THQ values above 1.
- The THQ values of BPA based on the percentiles, representing a higher scenario of exposure, were above one suggesting that there is risk of exposure higher than the safety limits recommended by the EFSA.
- The obtained results also revealed a potential risk of exposure to microplastics and associated contaminants in mussels as a food source.
- PCA analysis showed the existence of the differences in the polymer abundance inside the mussel's tissue along the Adriatic coast despite the growth of mussels in the clear seawater and at distance from urban settlements. Probably, factors such as marine currents and sea depth affect the microplastics content in sessile organisms like mussels.
- Identification data should be combined with quantification data in order to estimate the mass of MP present in bivalves what is of great value for both environmental and human health risk assessment. [67]

[67] https://www.researchgate.net/publication/351330440_Microplastics_and_bisphenol_A_in_mussels_along_Italian_and_Croatian_coast_of_the_Adriatic_Sea?fbclid=IwAR1UTebMJ4BCixw4CX6WnPa-d8zKzpEA-rGfWYrbERSUFenRLgV9JzsNCF0

It's also of great concern that BPA seems to cause generational damage in organisms.

> "Bisphenol A in eggs causes development-specifc liver molecular reprogramming in two generations of rainbow trout"[68]

Leading Edge Erosion (LEE) may release significant amounts of micro plastic and epoxy resin particles, where some may also contain BPA.

LEE (leading edge erosion) from wind turbine wings is a significant source of micro plastics

In addition to the report from by Asbjørn Solberg, Bård-Einar Rimereit og Jan Erik Weinbach "THE TURBINE GROUP" APRIL 2021, «Forurensning fra vindturbinvinger» (wind turbine wings pollution), we also have corroborating evidence from other reports.

A probabilistic long-term framework for site-specific erosionanalysis of wind turbine blades: A case study of 31 Dutch sites [69]

Received: 28 August 2020 Revised: 20 February 2021 Accepted: 22 **February 2021**

Rain-induced leading-edge erosion (LEE) of wind turbine blades (WTBs) is associated with high repair and maintenance costs.

The effects of LEE can be triggered in less than 1 to 2 years for some wind turbine sites, whereas it may take several years for others. In addition, the growth of erosion may also differ for different blades and turbines operating at the same site.
Hence, **LEE is a site- and turbine-specific problem.**

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[68] https://www.researchgate.net/publication/320630432_Bisphenol_A_in_eggs_causes_development-specific_liver_molecular_reprogramming_in_two_generations_of_rainbow_trout/fulltext/59f37f8ca6fdcc075ec349ab/Bisphenol-A-in-eggs-causes-development-specific-liver-molecular-reprogramming-in-two-generations-of-rainbow-trout.pdf?origin=publication_detail

[69] https://onlinelibrary.wiley.com/doi/epdf/10.1002/we.2634

> In this paper, we propose a probabilistic long-term framework for assessing site-specific lifetime of a WTB coating system.
>
> Case studies are presented for 1.5 and10 MW wind turbines, where geographic bubble charts for the leading-edge lifetime and number of repairs expected over the blade's service life are established for 31 sites in the Netherlands.
>
> The proposed framework efficiently captures the effects of spatial and orographic features of the sites and wind turbine specifications on LEE calculations. For instance, **the erosion is highest at the coastal sites and for sites located at higher altitudes**. In addition, **erosion is faster for turbines associated with higher tip speeds**, and the effects are critical for such sites where the exceedance probability for rated wind conditions are high. The study will aid in the developmentof efficient operation and maintenance strategies for wind farms.[70]

These results compare very well to our own findings, that the harsher climatic impacts in coastal regions result in increased erosion and release of micro plastic particles than we find further inland. Also, the northernmost parts of Europe is also a vector that show increased climatic impact, and also a slower biodegradation rate vs. more tempered environments.

Another recent report **"Minimum Leading Edge Protection Application Length to Combat Rain-Induced Erosion of Wind Turbine Blades"** (2021), also collaborates the problems of LEE erosion.

> **Minimum Leading Edge Protection Application Length to Combat Rain-Induced Erosion of Wind Turbine Blades**
>
> Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 3, 2629 HS Delft, The Netherlands
> SINTEF Ocean AS, Otto Nielsens veg 10, 7052 Trondheim, Norway
> SE Blades Technology, B.V. Jan Tinbergenstraat 290, 7559 ST Hengelo (Overijssel), The Netherlands
> Department of Marine Technology, Norwegian University of Science and Technology (NTNU), 7052 Trondheim, Norway
> Department of Engineering Sciences, University of Agder, 4879 Grimstad, Norway
> *Energies* **2021**, *14*(6), 1629;
>
> **Published: 15 March 2021**
>
> Leading edge erosion (LEE) repairs of wind turbine blades (WTBs) involve infield application of leading edge protection (LEP) solutions. The industry is currently aiming to use factory based LEP coatings that can applied to the WTBs before they are shipped out for installation.
>
> **However, one of the main challenges related to these solutions is the choice of a minimum LEP application length to be applied in the spanwise direction of the WTBs. Generally,**

[70] https://onlinelibrary.wiley.com/doi/epdf/10.1002/we.2634

coating suppliers apply 10–20 m of LEP onto the blades starting from the tip of the blade using the "rule of thumb", and no studies in the literature exist that stipulate how these LEP lengths can be calculated.

In this study, we extend the scope of a recently developed long-term probabilistic framework to determine the minimum LEP application length required for WTBs to combat rain-induced erosion.
A parametric study is performed where different wind turbines with varying power ratings of 2.1 MW to 15 MW at different Dutch sites ranging from inland to coastal are considered.
The results of the study show that the **LEP application length is sensitive to the choice of the site, as well as the turbine attributes. Further, LEP lengths for WTBs are found to be the highest for turbines installed at coastal sites and turbines with higher power ratings.**

A detailed investigation is further performed to check the sensitivity of the LEP application length with the wind turbine parameters.
The results of the study are expected to provide guidelines to the industry for efficient repair strategies for WTBs.[71]

The report show that the the Leading Edge Lifetime (LEL) vary very much for each section of the turbine blade for the three different turbine models investigated (2.1 MW, 10 MW, and 15 MW). Coastal climatic has increased erosion than inland climate, and larger wind turbine blades has also shorter LEL due to higher wing tip speeds.

The reports show also that maintenance and repair must be conducted in shorter intervals, even as short as 1.25 times a year (9-10 months). However, as the wind industry doesn't take any environmental aspects into account, we may expect that they will stretch the interval between maintenance cycles to a maximum, simply due to economic considerations. This is especially a factor in coastal and offshore locations where maintenance operations are expected to be both very costly, weather dependent, and difficult to conduct, compared with smaller inland plants. Coastal plants may also experience a 3-4x increased LEL shortened lifetime over inland based plants.

We see that most of the research on this field are in large extent only focused on the economic side of the effect loss caused by LEE. It is also of concern that there's no industry standard defining Wing Tip Speeds as a parameter.

Most of the offshore wind plants in central and southern parts of Europe are in shallow waters where maintenance operations might be considered relatively easy to conduct. Still, they are conducted on a purely cost based cycle, rather than environmental concerns. When a wind turbine wing starts to erode, the process is rapidly increasing. Too long intervals in a maintenance cycle may therefore pose an unnecessary extra pollution factor, compared to an environmental focused maintenance cycle.

In Norway, most of the proposed offshore wind farms will, due to the added depths mostly be floating constructions far from shore. This is expected to increase the difficulty and costs of maintenance operations significantly, which is no good sign for the environment in regard to the pollution of micro

[71] https://doi.org/10.3390/en14061629

plastic particles and BPA. Also worth noting is that deep sea offshore wind still has to be constructed and built, and therefore must be considered as potential new sources of this problematic and non-biodegradable pollution.

These findings are also collaborated by another recent report, "A probabilistic rainfall model to estimate the leading-edge lifetime of wind turbine blade coating system" (2021), by Amrit Shankar Verma, Zhiyu Jiangb, Marco Cabonic, Hans Verhoef, et al., that states that:

> **A probabilistic rainfall model to estimate the leading-edge lifetime of wind turbine blade coating system** /2021)
> Amrit Shankar Verm, Zhiyu Jiang, Marco Cabonic, Hans Verhoef, Haraldvan der Mijle Meijer, Saullo G.P.Castroa, Julie J.E.Teuwen
>
> **Abstract**
> ***Rain-induced leading-edge erosion of wind turbine blades is associated with high repair and maintenance costs.*** *For efficient operation and maintenance, erosion models are required that provide estimates of blade coating lifetime at a real scale. In this study, a statistical rainfall model is established that describes probabilistic distributions of rain parameters that are critical for site-specific leading-edge erosion assessment. A new droplet size distribution (DSD) is determined based on two years' onshore rainfall data of an inland site in the Netherlands and the obtained DSD is compared with those from the literature. Joint probability distribution functions of rain intensities and droplet sizes are also established for this site as well as for a coastal site in the Netherlands. Then, the application of the proposed model is presented for a 5 MW wind turbine, where the model is combined with wind statistics along with an analytical surface fatigue model that describes lab-scale coating degradation.*
>
> ***The expected lifetime of the blade coating is found three to four times less for the wind turbine operating at the coastal site than for the inland site - primarily due to rainfall at higher wind speeds.*** *Further, the robustness of the proposed model is found consistent with varying data periods used for the analyses.*
>
> **1.1. Background**
> *The continuous demand in the growth of renewable sources of power production has led to rapid growth in the wind energy sector. Wind turbines, both at onshore and offshore locations, are in high demand and it is expected that by 2050, half of the EU's1 electricity demand will be met by wind energy alone.*
>
> *In order to achieve this goal, the current market trend involves deploying turbines with higher power ratings, along with turbines deployed at locations with larger wind speeds such as near coastal and offshore locations.* ***Such classes of turbines are profitable to the industry, however, this also presents enough challenges to the wind turbine owners and operators, especially from a maintenance perspective. For instance, large size blades rotating at high tip speeds are exposed to harsh environmental conditions such as frequent exposure to rainfall, thereby causing material degradation at the blade's leading-edge - commonly referred to as rain-induced leading-edge erosion (LEE) of WTBs.***
>
> *The impact between rain droplets and the rotating blade at high tip speeds, typically in the range of 70–110 m/s, develops large impact pressure, subsequently leading to a combination of complex damage modes such as pitting, roughening of the leading-edge surface, fatigue failure*

of the blade coating, and eventually structural damage. In Ref., it has been found that LEE increases the drag coefficient of the aerofoil section by more than 314% and decreases the lift coefficient by around 53%, thereby reducing the overall aerodynamic efficiency of the WTB. ***The damage modes associated with LEE and their effects on the turbine's performance can appear in less than two years of the blade's service life,*** *while the blade is expected to last for atleast 15 years continuously.*

As a result, costly repair and maintenance work is imperative to be performed in order to maintain the design power curve of the wind turbine, thereby contributing to the overall increase in the cost of energy. *It has been reported in Refs. that LEE repair and maintenance expenses cost the European offshore wind turbine sector over £56 million annually, and hence LEE of WTBs requires urgent attention.*[72]

The many challenges this report lists as severe obstacles before the wind power industry reaches an acceptable cost/benefit level on maintenance and lifetime of the turbine blades, doesn't seem to be reached anytime soon. Offshore wind will therefore remain a costly and expensive alternative, purely based on economic criteria. Deep sea offshore wind farms will also contribute to even higher costs due to the complexity of the installations itself, and the increased difficulties and costs associated with maintenance and repair operations. The effects of LEE can be triggered in less than 1 to 2 years for some wind turbine sites, whereas it may take several years for others.

[72] https://doi.org/10.1016/j.renene.2021.06.122

Current practice of in situ repair and maintenance adds significant amounts of microplastics erosion to the environment

While production of wing turbine blades is conducted in closed environments with strict procedures for work environment and filtering, most of the repair jobs are conducted in situ. Whether the operation is conducted by personnel hanging in ropes or by robots, most of the examples we have found are open air solutions where all microplastics and dust is released directly into the environment.

We must also assume that the volume removed mechanically by sanding machines are no less than what has been eroded naturally by LEE (Leading Edge Erosion). The governing authorities must put immediate and strict restrictions on all maintenance operations and ban all open air procedures.

In-situ repair may release more micro plastics into the environment than the natural erosion itself.

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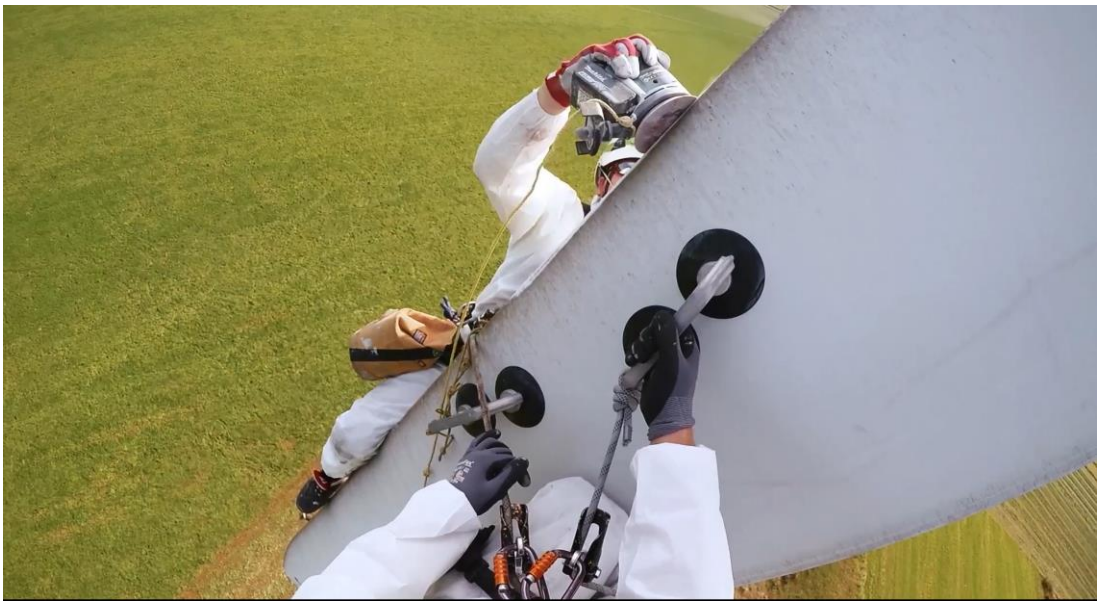
In-situ repair may release more micro plastics into the environment than the natural erosion itself.



It doesn't seem to be much difference, regarding the amounts of micro plastic particles released into the environment whether the operation is done by personnel or by robotic machinery.

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Another example of in-situ repair operation where all particles are released directly into the environment. Please notice the gas mask protecting the operator, while no effort has been established to protect the environment.

Another example of in-situ repair operation. Same method of open air release of micro plastic and epoxy particles to the environment.

Accidents do and will happen

One thing never change, and that is the fact that accidents do and will happen.

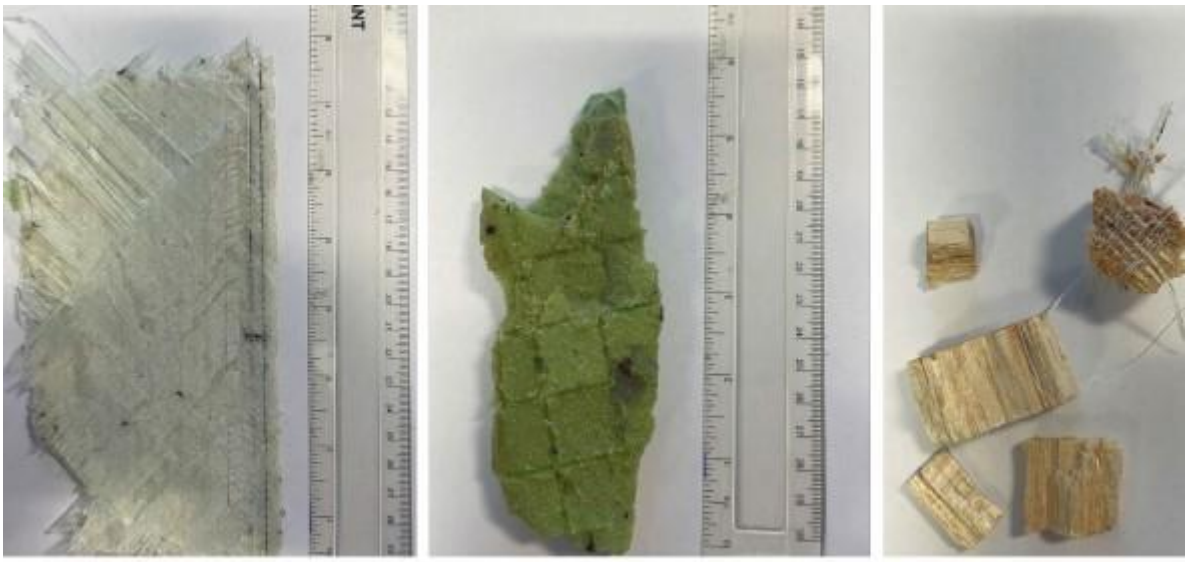
Here is a compilation of some of the many accidents regarding wind turbines around the world.[73]

[73] http://www.caithnesswindfarms.co.uk/fullaccidents.pdf

Offshore wind power plants also pose a heightened risk of collision with ships and other sea born vessels. Operations on the offshore turbines is also a posed risk factor that must be considered.

Just as recently as late October this year 21.10.2021, three 61-metre blades fell into the sea during a major component exchange at Ormonde offshore wind farm in the UK.

> *A hub, three 61-metre blades, and blade clamping tool have fallen into the sea during major component exchange at the Ormonde offshore wind farm in the UK, with majority of the parts and tools now resting on the seabed and debris from one broken blade reported to be on the sea surface.*
>
> *The MPI Adventure jack-up vessel was positioned alongside the wind turbine B01 when the parts fell into the water, adjacent to the vessel and in proximity to the B01 turbine.*
>
> *Along with the three turbine blades weighing 126 tonnes and blade clamping tool weighing around 3 tonnes, a hub containing three pitch motors, batteries, four electrical cabinets, grease pumps and other components was also dropped.*



Debris has fractured off from one of the blades and will likely reach the shore.[74] [75]

Video:
https://www.youtube.com/watch?v=HF5w2eWcKjI

[74] https://www.offshorewind.biz/2021/10/21/turbine-parts-dropped-into-sea-at-ormonde-offshore-wind-farm/?fbclid=IwAR3zF9FM6IUWtYdNy_bJDHJ7UUpoYsx9FIR9X91gOv38bBql12MVI0Q-iLE

[75] https://www.offshorewind.biz/2021/10/25/update-video-rotor-hub-and-blades-fall-into-sea-at-ormonde-owf-coastal-debris-could-be-widespread/

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We must also note that the falling wind turbine blades are completely broken into pieces by the impact on the water surface. Many accidents, both onshore and offshore are similar situations where a wing turbine blade is falling off and impacting on the below surface. When these types of accidents happen fare from shore it's not likely any, or most of the debris can be retrieved at nearby beaches.

Estimated BPA content of the three turbine blades weighing 126 tonnes is estimated to 15%, at a significant 20 tonnes of BPA. Just from this one accident alone.

The next image is from the Mehuken wind power plant in Norway 2011, after the hurricane "Dagmar" with measured wind speeds upwards at 80 m/s. Large parts of the accompanied wetland environment was littered with fragments afterwards.

Mehuken wind power plant 2011 - Image: Thomas Bikchardt/ Bickfoto

Wind turbine wings don't always fall off the nacelle in strong winds. Sometimes they have no explanations for the accident, as here recently this year on Frøya Vindpark, Norway.[76]

There are also several accidents where the whole turbine tower is collapsed, as here in Sweden earlier this year.[77] These kind of accidents and collapses contributes to large amounts of fragments that pose an increased source of pollution to the environment and our waterways and open sources of drinking water.

Here is a list of some of the latest wind power accidents. [78]

[76] https://www.nrk.no/trondelag/vingeblad-pa-froya-har-falt-av-vindturbin---tronderenergi-stanser-anlegg-1.15727620

[77] https://www.tu.no/artikler/svensk-vindmolletarn-kollapset-vindturbiner-i-valer-midlertidig-stanset/505557?key=Jgk2ZovJ

[78] https://www.wind-watch.org/news/tag/accidents/?titles=on

The environmental pollution of BPA and BPA containing fragments and micro/nano sized particles of various kinds of plastic and epoxy materials come to the human body through various ways and environmental sources, such as what's accumulated through the food chain and what is introduces though open surface sources of drinking water.

The new re-evaluated and established the new tolerable daily intake (TDI) of 0.04 ng Bisphenol-A (BPA) kg per day may still not be strict enough, but we value the increased focus BPA and other significantly harmful chemicals pose to the human body and health. They may in addition to this also be considered a direct threat to the reproductive capabilities of each species in the food chain itself, and by this also may contribute to a future collapse of our main sources of food.

The precautionary principle must be adhered to in all regulatory measures regarding the food safety protocols, environmental sources through our food chain and drinking water, and also to the established tolerance (TDI) levels.

With green regards,
Green Warriors of Norway
Norges Miljøvernforbund

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