

“THE PERILS OF PVC PLASTIC PIPES” Fact or Fiction?

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Date: April 20th 2023



Phantom
Plastics

Introduction

In April 2023, Beyond Plastics released a report entitled “**The Perils of PVC Plastic Pipes**”. The report stated that Congress have allocated \$15 billion to replace lead pipes. They then express concern that plastic pipes might be chosen and go on to specifically endorse the use of copper pipes over plastic.

Many questions arise from this report. Who are Beyond Plastics? What are their motives? Can they be trusted? Who is funding them? Is the report a sound and fair representation of all the facts? Would copper be the best choice of pipe material?

Beyond Plastics

From the Beyond Plastics website:

“We use our deep policy and advocacy expertise to build a well-informed, effective movement seeking to achieve the institutional, economic, and societal changes needed to save our planet, and ourselves, from the negative health, climate, and environmental impacts of the production, usage, and disposal of plastics.”

Thus, the goal of the organization is to be against plastics. We should get our advice from impartial sources and peer-reviewed science, not from an organization created to be anti-plastic. Recently, Beyond Plastics testified for Congress in the US and comparison of the statements made to peer-reviewed science revealed a concerning disparity between the two. Let us see whether this latest report from them holds up to scientific scrutiny.

Environmental Impact

Beyond Plastics claim to be against plastics to:

“...save our planet, and ourselves, negative health, climate, and environmental impacts of the production, usage, and disposal of plastics.”

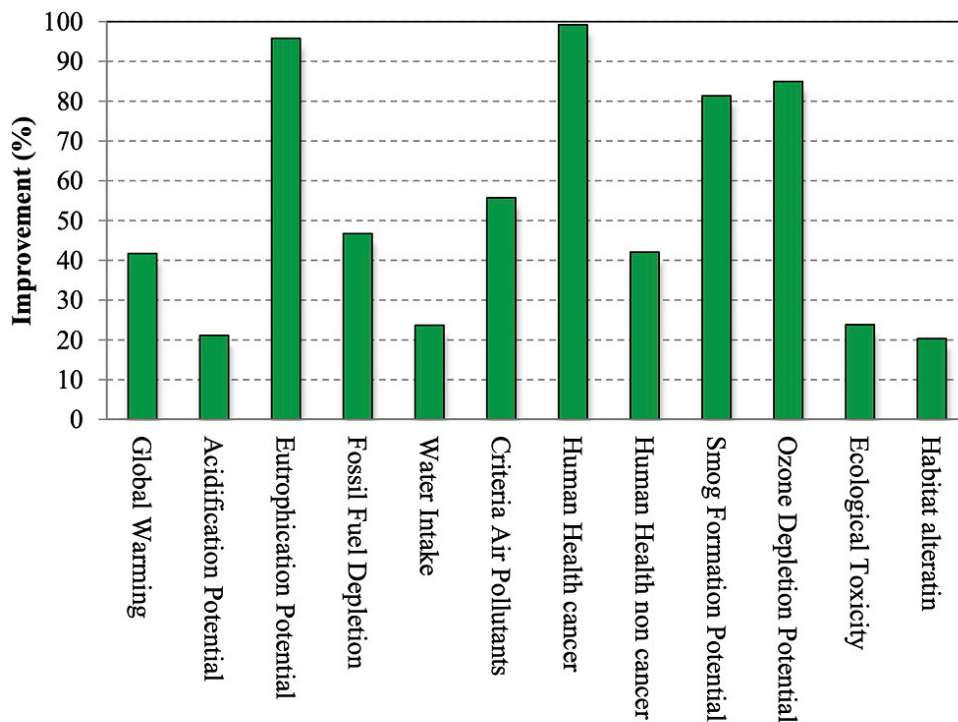
If this is the true intention of Beyond Plastics, then one would expect their report to investigate the environmental effect of PVC plastic pipes compared to other alternatives including the copper pipes they specifically endorse as a better option. However, far from looking into that topic, there is not one word about the life cycle analysis, i.e. environmental impact, of different pipe materials.

Here are the conclusion of one such life cycle analysis of water pipes:

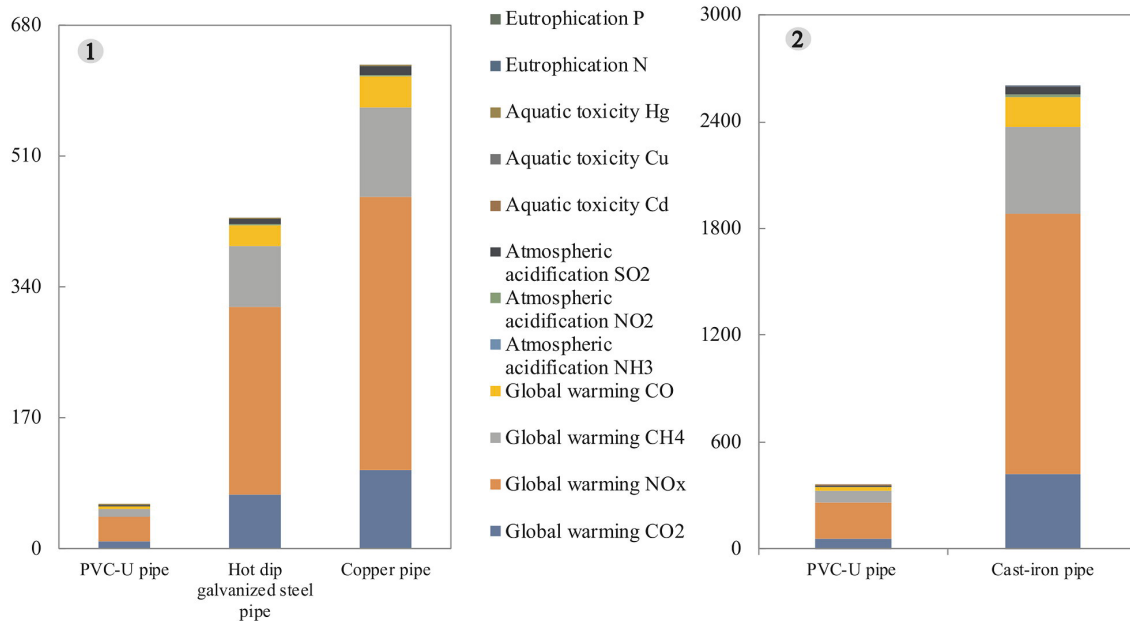
“The results of the analysis indicate that use of PEX piping instead of the traditional copper piping systems in residential buildings, would considerably reduce the total cost of the building up to 63% over its life cycle. Moreover, it can significantly reduce the carbon dioxide (CO₂) emissions (approximately 42%) and lessen the negative effect of environmental impacts to land, water and air.”

A. Asadi et al., Environmental and economic life cycle assessment of PEX and copper plumbing systems: A case study, Journal of Cleaner Production, 137, pp 1128-1236, 2016

Here is their data where the green bars indicate how much better PEX (cross-linked polyethylene plastic) pipes are for the environment compared to copper pipes.



It is clear that the PEX pipes are far greener by every measure. Why then do Beyond Plastics endorse them so wholeheartedly? Was that study unique? In fact, all life cycle analyses on pipes show that metal pipes including ductile iron and copper, are far worse for the environment. Here is data from a lifecycle analysis comparing PVC and copper pipes for building water supply and drainage.



J. Xiong et al., The application of life cycle assessment for the optimization of pipe materials of building water supply and drainage system, Sustainable Cities and Society, 60, 2020

Once again, we see that copper pipes are vastly more harmful. Why would a self-proclaimed environmental group push for \$15BN of public money to be spent on a material that massively increases harm to the environment?

Here are the conclusions from yet another life cycle assessment on pipes.

“To evaluate the effectiveness of different pipe materials (concrete, reinforced concrete (RC), steel, cast iron, ceramic, polyvinylchloride (PVC), polyethylene (PE), polypropylene (PP), glass reinforced plastic (GRP)), the properties and cost were analyzed. Eleven criteria were selected for the evaluation: variety of diameters, mass, resistance of lifting, thermal resistance, abrasion resistance, surface roughness (hydraulic property), nominal stiffness, nominal pressure, embodied energy, CO₂ emission, and cost (product + installation). According to the results the most effective material for pipes used in water supply and sewerage systems is polyethylene PE and polyvinylchloride PVC.”

V. Gurskis et al., Multi-Criteria Comparative Analysis of Water-Supply & Sewerage Pipes Manufactured from Different Materials, Proceedings of the 10th International Scientific Conference Rural Development 2021

Beyond Plastics are recommending action proven to increase harm to the environment.

Chemicals from Pipes and in Water

Beyond Plastics propose copper pipes specifically saying:

“Other research on safer alternatives indicates that copper can be a good choice.”

What “other research”? They presented not one shred of evidence to support that statement. In fact, they talk only about potential issues with plastic pipes without one word about concerns around metal pipes. Is that the behaviour of an organization that genuinely wants the best outcome for the public?

The Beyond Plastics report claims, without evidence, that forest fires result in the plastic pipes degrading and releasing toxic chemicals like benzene into the drinking water. This is given as a major problem with plastic pipes but how valid is that concern?

It has been shown that plastic when heated to 200-400°C can release substances including benzene but there was no evidence that actually occurred in a forest fire. The pipes are buried and thereby heavily insulated from heat.

K. P. Isaacson et al., Drinking water contamination from the thermal degradation of plastics: implications for wildfire and structure fire response, *Environ. Sci.: Water Res. Technol.*, 7, 274–284, 2021

Benzene has been detected in water after forest fires but there is no evidence that the pipe degraded or that it came from the pipe. Once again, Beyond Plastics are making allegations without proof. Where could the benzene have come from if not from the pipes?

“For example, a study of a typical residential area in Finland showed that wood combustion contributes as much as 70% to local benzene sources. “Wood combustion was clearly the most important source for many compounds (e.g., benzene).”

H. Hellén et al., Influence of residential wood combustion on local air quality, *Sci Total Environ.*, 393(2-3):283-90, 2008

In fact, it was found that 1g of benzene was formed for every 1kg of wood burnt.

“In addition, the data presented here improve the current knowledge base for the types of pollutants emitted from wood combustion and their emission rates; especially hazardous air pollutants such as 1,3- butadiene, benzene, formaldehyde, and others that are not considered in current assessments of wood combustion emissions.”

J. D. MacDonald et al., Fine Particle and Gaseous Emission Rates from Residential Wood Combustion, Environ. Sci. Technol. 2000, 34, 11, 2080–2091, 2000

It turns out to be well-known that burning wood produces massive amounts of benzene. Picture the scene – there is a forest fire with thousands of trees burning, each one creating large concentrations of toxic benzene. Rather than consider that as a source for the benzene, Beyond Plastics decide to blame it on the tiny amount of plastic pipe safely buried underground. Beyond Plastics have failed to accurately represent the science on this topic as well.

As mentioned earlier, Beyond Plastics claim that copper pipes are safer but without presenting any evidence whatsoever to support their claim. Is copper completely safe? I searched for scientific papers mentioning metal drinking water pipe corrosion and found this:

Copper is a gastrointestinal tract irritant and can be highly toxic (NRC, 1977). There are reports of infant mortality and an outbreak of copper poisoning associated with contaminated drinking water (Semple *et al.*, 1960; Walker-Smith & Blomfield, 1973). Some of the high copper concentrations in the collected water samples are plotted on Fig. 2. A majority of the water samples contained copper higher than the highest desirable limit and many above the maximum permissible limit suggested by WHO (1971).

I. A. Alam & M. Sadiq, Metal contamination of drinking water from corrosion of distribution pipes, Environmental Pollution, 57,167-178, 1989

Clearly then, copper can be highly toxic. They go on to say:

“...it was revealed that higher copper concentrations were found in water samples collected from locations with copper pipes in the branch lines. It is obvious that corrosion of the copper distribution pipes was responsible for the build-up of copper in these samples.”

So, it has been shown by peer-reviewed science that corrosion of copper pipes can lead to unsafe levels of toxic copper in the drinking water. I would not make

the claim that copper pipes are unsafe based on this evidence alone, but it does cast further doubt on the credibility of Beyond Plastics. A fair report would have considered all evidence, rather than glorifying copper and demonizing plastic.

Permeation of Chemicals

The Beyond Plastics report claims that the PVC and other plastic pipes are unsafe because chemicals can travel through the pipe and contaminate the water. The evidence they provide is from an old scientific paper from 1991. The screenshot below shows that permeation events are incredibly low for all types of pipe. Their scientific basis for arguing that PVC pipes should not be used when they have been used safely for decades.

| Parameter | Pipe Material | | | |
|--|---------------|-----------|-----------|---------|
| | Metal | PE | PB | PVC |
| Incidents/10 ⁶ connection-years | 0 | 3.6 | 16.5 | 2.2 |
| Total number of service-years | 83,517,872 | 7,052,063 | 1,701,753 | 461,620 |

| Parameter | Pipe Material | | | | |
|--------------------------------------|---------------|--------------------|-----------------|----------|-----------|
| | PVC | Cast Iron or Steel | Asbestos-Cement | Concrete | Overall |
| Incidents/10 ⁵ mile-years | 4.6 | 0.1 | 0.3 | 0 | 0.34 |
| Total mile-years | 64,821 | 1,110,954 | 291,222 | 42,142 | 1,509,139 |

AUGUST 1991

They claim that many chemicals have the potential to migrate from and through plastic pipes. But, policy choices should not be made based on “potential” problems, but rather on real data and solid evidence. In fact, all the pipes are tested according to NSF/ANSI 61 and found to be safe. They rely heavily on the work of B. R. Stern but that paper states “This research was partially funded by the International Copper Association”. So, that casts reasonable doubt about the impartiality of the study.

B. R. Stern & G. Lagos, Are There Health Risks from the Migration of Chemical Substances from Plastic Pipes into Drinking Water? A Review, Human and Ecological Risk Assessment, 14: 753–779, 2008

Organotin Compounds

The report expressed a great deal of concern over organotin compounds claiming that they could leach from PVC pipe and they should be regulated. Is the concern justified? The World Health Organization (WHO) issued a report looking at that very topic. There is no evidence of harm to humans, the only scientific evidence is work on rats. They found that level of exposure are far too low to be of concern and that regulations were not needed. In fact, even with a safety factor of 100x more than that used in the rat study, exposure was too low to be of concern. The WHO report states:

“Based on the chronic immunotoxicity studies in rats (Wester et al. 1988, 1990; Vos et al., 1990), a TDI of 0.25 µg/kg bw (0.1 µg/kg bw as Sn) was established. This involved applying an uncertainty factor of 100, to account for interspecies differences and intraspecies variability, to the lowest NOAEL for TBTO (the reference organotin for assessment of combined exposure to TBT, DBT, TPT and DOT) of 0.025 mg/kg bw/day. Allocating 20% of the group TDI of 0.25 µg/kg bw to drinking-water and assuming that a 60 kg person consumes 2 L of drinking-water per day, a health-based value (HBV) of 1.5 µg/L can be derived for the sum of TBT, TPT, DBT and DOT concentrations. Based on TBTO molecular mass, this group HBV is equivalent to 0.6 µg/L as Sn. Because intake of these organotin compounds is likely to be very low – typically less than a few hundred nanograms per day – there is no need to establish a formal guideline value (GV) for this group of organotin compounds. This implies that incorporation of these organotin compounds into national standards is usually unnecessary.”

Organotins in drinking-water: Background document for development of WHO Guidelines for drinking-water quality, World Health Organization, 2020, WHO/HEP/ECH/WSH/2020.7

Their report admits that exposure levels are extremely low with no apparent threat to health, but then they choose to quote one outlier scientist (Dr. Blumberg) who feels differently, despite the evidence. Once again, we find that the Beyond Plastics report expressed concern where none is justified.

Phthalates

The Beyond Plastics report talks at length about phthalates, which is surprising because phthalates are not used in PVC water pipes. In fact, such pipes are made of “uPVC” where the “u” stands for unplasticized. So, the pipes contain no phthalates or plasticizer of any kind. In any case, phthalates have been studied in great detail for decades, so we know what they are, where they are and how much is present. Exposure comes from many sources including cosmetics, perfumes and so on. We also know that finding phthalates in tap water does not mean that they came from the pipes, because phthalates are found in ground water and river water too. The levels are reported to not be of concern.

“The DBP was found in both river and tap water samplers, whereas DMP and DEP were found in only drinking water samples. The DBP was found to make the highest average contribution to pollution in both river and tap water. The DEHP was not found in both the river and tap water because it is one of the most regulated phthalates. The highest phthalate contamination was found in the Manzanares river and in those areas that receive treated water from the Tagus river. The phthalates found in river and tap water in the RM do not represent a potential oestrogenic risk for the aquatic environment or humans.”

N. Domínguez-Morueco et al., Phthalate occurrence in rivers and tap water from central Spain, Science of the Total Environment 500–501, 139–146, 2014

“Our investigations show that phthalates are rarely found in raw and treated tap water in France. In raw water, DEP was the predominant compound at a maximum concentration of 406 ng/L. In contrast, DBP was the most frequently detected compound in treated water with a maximum concentration of 1300 ng/L. DEHP, which the most popular and widely used phthalate, was found in only one sample of raw water at 813 ng/L. This concentration value does not exceed the concentration limits of international regulations.”

C. Bach et al., National screening study investigating nine phthalates and one adipate in raw and treated tap water in France, Environmental Science and Pollution Research, October 27 (29), 36476-36486, 2020

It is worth noting that exposure to phthalates from perfume is likely to be of far greater concern because in that case the chemical is in direct contact with the skin and in high concentration. As mentioned, phthalates are not used in uPVC pipes, so focusing on that is not justified.

I. Al-Saleh and R. Elkhatib, Screening of phthalate esters in 47 branded perfumes, Environ Sci Pollut Res Int. January 23 (1), 455-68, 2016

Here is the FDA statement on phthalates in food packaging after decades of research and monitoring:

“The FDA currently allows nine phthalates in food contact applications (eight for use as plasticizers and one for use as a monomer) in the production of food contact polymers. Phthalates are not authorized to be directly added to food.”

FDA Phthalates in Food Packaging and Food Contact Applications, <https://www.fda.gov/food/food-ingredients-packaging/phthalates-food-packaging-and-food-contact-applications>

What does the Center for Disease Control and Prevention (CDC) have to say on the subject of phthalates and human health?

“Some types of phthalates have affected the reproductive system in animals. Human health effects from exposure to low levels of phthalates are not as clear. More research is needed to assess the human health effects of exposure to phthalates.”

And

“Finding a detectable amount of phthalate metabolites in urine does not mean the levels will cause harmful health effects.”

CDC Phthalates Fact Sheet https://www.cdc.gov/biomonitoring/Phthalates_FactSheet.html

We see that after decades of study and hundreds of investigations, there is still no evidence of harm to humans at the levels of exposure that actually occur. Why then do Beyond Plastics hype this up into something of huge concern? Their decision to frighten us about PVC pipes, which have no phthalates added anyway, is highly dubious and unjustified by the scientific evidence.

“PVC is a horror show”

This is a statement taken from the Beyond Plastics report. It is hyperbole and not how professional, impartial scientists normally express themselves. The next quote is:

“We don’t have much science on how much gets out [from PVC pipes] and gets into people, but we know a lot about the effects of the chemicals themselves, and we know a fair bit about their effects in animals. We should be concerned about the possible effects on humans.”

As we have seen, the statement is not correct. There are decades of data on pipes and extensive measurements on the very low concentrations of chemicals that may leach out of them. Presenting this topic as a frightening unknown is a disservice to the public. Every pipe is tested for release of chemicals and has to pass the NSF/ANSI 61 standard to be used for drinking water.

Safety of the Industry

The Beyond Plastics report spends time to highlight the recent train derailment in Ohio and to present that as an argument against PVC. Is that a fair point? Surely, we all know that all activity results in some accidents. If Beyond Plastics were genuinely interested in accidents, rather than the biased demonization of plastics, then they would have also reported accidents associated with the copper industry. But they chose not to do so.

Here are a few hits found in mere minutes. Note that while the Ohio train accident did not result in any fatalities, in contrast, copper mining and processing results in regular deaths.

Dozens killed in DRC Glencore copper mine accident

At least 36 illegal miners killed by collapse in open excavation pit

<https://www.theguardian.com/business/2019/jun/27/at-least-36-believed-to-have-died-at-glencore-copper-mine-in-congo>

Work suspended at Botswana's Khoemacau copper mine after accident kills two

<https://www.reuters.com/world/africa/work-suspended-botswanas-khoemacau-copper-mine-after-accident-kills-two-2022-05-21/>

Four Miners Crushed by Falling Ore in Copper Mine

<https://apnews.com/article/5586f37a26f83f571f1bb90110b7a512>

Two of three deaths at Copper Mines of Tasmania 'avoidable', coroner finds

<https://www.abc.net.au/news/2021-06-18/copper-mine-tasmania-deaths-avoidable-coroner-finds/100225168>

If Beyond Plastics were genuinely interested in the safety record of the industries, then they would have been fair and included data on copper as well. Instead, they chose to selectively present the evidence, in order to demonize plastics.

It is not only copper mining that results in human fatalities, but also smelting of the ore which leads to health problems including cancer.

"The additional follow up confirms the earlier finding that at low doses the increments in death rates for respiratory cancer for a given increment in dose are greater than at high doses. The additional follow up also shows significant increases in cancer of the large intestine and bone, and SMRs > 150 for cancer of the buccal cavity and pharynx, rectal cancer, and kidney cancer."

P. E. Enterline et al., Cancers related to exposure to arsenic at a copper smelter, *Occup. Environ. Med.*, Jan; 52(1): 28–32, 1995

"A survey of mortality among copper smelter workers in the western United States revealed that a respiratory cancer excess previously observed during the period 1938 through 1963 continued from 1964 through 1977. When analyzed in relation to smelter employment prior to 1964, the recent increase in respiratory cancer was linked to work in plant areas where airborne arsenic concentrations were elevated and to a cumulative arsenic exposure index, although some excess risk was also associated with long term employment in jobs with limited exposures to arsenic. The arsenic-related excess remained after adjustment for work in areas of the plant with elevated concentrations of sulphur dioxide, which was not found to have an independent influence upon cancer risk. Increased rates for nonmalignant respiratory disease were also observed, but were not significantly associated with arsenic exposure."

J. H. Lubin et al., Respiratory Cancer Among Copper Smelter Workers- Recent Mortality Statistics, Journal of Occupational Medicine, Vol. 23, No. 11, November 1981

"Significantly increased standardized mortality ratios (SMRs) were found for all causes (SMR = 1.14), all cancers (SMR = 1.13), respiratory cancer (SMR = 1.55), diseases of the nervous system and sense organs (SMR = 1.31), nonmalignant respiratory diseases (SMR = 1.56), emphysema (SMR = 1.73), ill-defined conditions (SMR = 2.26), and external causes (SMR = 1.35). Internal analyses revealed a significant, linear increase in the excess relative risk of respiratory cancer with increasing exposure to inhaled airborne arsenic. The estimate of the excess relative risk per mg/m³-year was 0.21/(mg/m³-year) (95% confidence interval: 0.10, 0.46)."

J. H. Lubin et al., Respiratory Cancer in a Cohort of Copper Smelter Workers: Results from More Than 50 Years of Follow-up, American Journal of Epidemiology, Volume 151, Issue 6 (15), pp 554-565, March 2000

Illinois Jury Awards \$72 Million in Toxic Tort Case

"Jurors in Illinois awarded 12 plaintiffs \$72 million after finding a copper tubing manufacturer liable for emitting pollutants that caused the plaintiffs to develop cancer and other health issues."

"The trial required a detailed and scientific explanation as to what dioxins are, how they cause cancer, and why they were a by-product of Cerro's daily operation for decades," said plaintiffs' attorney Lloyd M. Cueto. "Our plaintiffs are wonderful people who have faced tremendous adversity in their battles with cancer. Every one of them had the courage to testify at trial."

<https://www.enjuris.com/blog/news/illinois-copper-plant-verdict/>

Beyond Plastics attacked PVC emitting dioxins when it burns but "forgot" to mention that copper pipe production releases dioxins at levels proven to cause harm.

Pipe Alternative Comparison

A summary of the main water pipe materials reveals that all are tested and found to be safe according to strict standards. However, the metal pipes are far more expensive and far worse for the environment. Why would an organization that claims to care about the environment specifically endorse copper pipes, that are so much worse? They create far more carbon dioxide and require the burning of far more fossil fuel. That is the problem in trusting an organization that has set about to be against plastics.

Pipe comparison

| Material | Green? | Safe? | Cheap? |
|---------------|--------|-------|--------|
| Copper | No | Yes | No |
| Steel | No | Yes | No |
| Polyethylene | Yes | Yes | Yes |
| Polypropylene | Yes | Yes | Yes |
| PEX | Yes | Yes | Yes |
| PVC | Yes | Yes | Yes |

- ❖ According to >10 independent life cycle studies, metal pipes cause far more harm than plastic pipes
- ❖ Metal and plastic pipes are tested according to NSF 61 and are proven safe
- ❖ Copper and steel pipes are ~6x more expensive
- ❖ Choosing metal massively increases environmental harm and cost to the taxpayer and all for no tangible benefit
- ❖ Choosing metal would be an irrational, expensive mistake

Beyond Plastics contend that we should spend \$15BN of taxpayers' money on copper pipes that are far worse for the environment according to every life cycle analysis and which cost many times more per foot. This lobbying effort by Beyond Plastics would result in much more CO₂ creation, fossil fuel use and overall harm.

Reasons not to use copper pipes

It has been found that copper from copper pipes gets into the water and causes degradation of plastic pipes. This is another factor against the use of copper pipes, but was not mentioned in the Beyond Plastics report.

“ATR-FTIR analysis showed that at 55°C, PEX pipes connected to copper and brass components had the greatest oxidation functional group peak intensity (COOC, CO, and COC). This study highlights potential downstream plastic pipe degradation and metal deposition, which may cause plumbing problems and failures for building owners, inhabitants, and water utilities.”

X. Huang et al., Corrosion of upstream metal plumbing components impact downstream PEX pipe surface deposits and degradation, Chemosphere 236, 124329, 2019

Conflict of Interest

Scientific publications contain a “conflict of interest” statement where the authors disclose whether, for example, they were funded by an interested party, which could potentially cast doubt on the impartiality and credibility of the authors. The Beyond Plastics report contains no such statement. In fact, the report reads as though it were funded by the copper pipe industry. Why does it give that impression? There are many options for pipes that are known to be viable and safe. They include PE, PEX, PP and ductile iron for example. If Beyond Plastics were genuinely concerned about the safety of uPVC pipes, then they could have recommended all of those alternatives, but they chose instead to repeatedly endorse copper without a single piece of evidence given for that specific recommendation. Why not endorse steel pipes, for example?

The Beyond Plastics report does disclose some sources of financing for the report but because those are non-profits, they do not have to disclose where their funding came from. Also, the Beyond Plastics report does not say if other parties, not mentioned, also contributed.

Without conflict statements from all contributors to the report, the document must be viewed with skepticism, especially as \$15BN of public money is at stake.

In contrast, this report was researched and written by an independent scientist without any funding or external influence. It was written because I care about facts and leaving a better planet for future generations. Note also that this report looks only at the evidence and makes no endorsement of any product.

Conclusions

The Beyond Plastics report does not stand up to scientific scrutiny. It appears to be designed to frighten the public, rather than a balanced representation of the evidence. The stated goal of Beyond Plastics is to be against plastics, not to do what is best for us and for the environment, and that is reflected in the report. In fact, the report is just what one would have expected if Beyond Plastics had been paid to ensure that the \$15BN from Congress went to the copper pipe industry. Concerningly, the report contains no statement regarding conflicts of interest, so, for all we know, it could well have been funded by interested parties.

There are several well-proven, viable and safe options for drinking water pipe. All thoroughly tested and used for decades all over the world. The endorsement of Beyond Plastics for copper pipes goes against the scientific evidence and would result in massively more environmental impact according to multiple peer-reviewed life cycle studies as well as a significant increase in cost to the taxpayer.



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Short Biography

Chris DeArmitt PhD FRSC
President – Phantom Plastics LLC

Chris is considered one of the top plastic materials experts and problem-solvers in the world, which is why companies like HP, Apple, P&G, iRobot, Eaton, Total, and Disney come to him for help.

A deep understanding of materials combined with high creativity allows Chris to quickly solve even the toughest challenges. As one example, he solved a serious production issue that had plagued BASF for 30 years and cost them millions.

He has also received six open innovation cash prizes, placing him among the top 0.01% of innovators. In 2016, he published the book *Innovation Abyss* which reveals the true reasons for innovation failure and the proven path to success.

In 2018, Chris was featured on CBS's *60 Minutes* with Scott Pelley as an expert witness in a class-action lawsuit related to Marlex mesh plastic implants. He helped thousands of women get settlements. Later television appearances include Sky News and the BBC as well as assorted radio and internet media interviews.

In 2020, Dr. DeArmitt published *The Plastics Paradox*, the first comprehensive, scientific overview of plastics materials and the environment covering all topics including waste, litter, microplastics, degradation, ocean plastics and more.

Chris has a multitude of granted patents as well as numerous articles, book chapters, encyclopedia chapters, and conference presentations to his name. He is an award-winning keynote speaker educating global audiences on plastic materials science and the environmental effects of plastics.

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