

According to a new research, the residential burning of solid waste can be 1,000 times more toxic than burning dry firewood

Although it is illegal and extremely harmful to health, many people in Hungary still burn PET bottles, cloths, and other wastes in their stoves and outdoors. The international consortium led by the University of Pannonia carried out a research that examined the level of emissions associated with the burning of typical waste products of Hungarian households in a standard cast iron stove. They found that by burning solid waste significantly more and up to 1,000 (!) times more toxic air pollutants are released into the air than in the case of burning dry firewood.



Open air residential waste burning in Hungary (Photo: CAAG)

Every year, the Clean Air Action Group's Environmental Advisory Office receives thousands of complaints from residents suffering from toxic fumes as a result of domestic waste burning in their neighbourhoods all across the country. It has been known for a long time that burning solid waste in household stoves releases extremely harmful substances into the air, but insofar there has been no data on the emission factors. In Europe, domestic waste burning in households is illegal. Given that, in most EU countries the relevant standards are strictly enforced, the issue was out of the focus of scientific or regulatory research. In Hungary, apart from the documentation of some court cases, officially, we have very little information on the occurrence of this harmful practice. The study, recently published in Atmospheric Chemistry and Physics by an international consortium led by the University of Pannonia, was the first in the world to fill this gap.

The researchers carried out burning tests under controlled conditions in a cast-iron stove commercially available in Hungary, using the samples taken from the types of waste products that are most frequently burned by the people, such as PET bottles, tyres, polypropylene cups, pieces of PVC flooring, mixed textiles, chipboard and dry firewood as a benchmark (the waste types are shown in Figure 1).



Figure 1. The samples used in the research, from the types of waste most frequently burned by citizens

Explanation of the letter codes (samples of waste used in the experiment in parentheses):

PET = polyethylene terephthalate (soft drinks bottles without lids and foil); PS = polystyrene (yogurt and pudding glasses without foil, as well as pieces of Styrofoam); PP = polypropylene (sour cream cup, meat tray); PE = polyethylene (soft drink lids, bags, and wrapping foils); PVC = polyvinyl chloride (packaging foils, pipes, floor covering pieces); PU = polyurethane (kitchen sponges); ABS = acrylonitrile butadienesterol copolymer (computer monitor cover, shredded); TR = tyres (old and new car tyres); RAG = textile (a mix of cotton, polyester and polyamide samples); OSB = chipboard (a mixture of different brands of samples); LDF = low-density fiberboard (various fiberboard plates, including coloured laminated pieces); PAP = mixed paper (a mixture of coloured glossy paper and matte newspaper); WOOD = firewood (oak and acacia)

The researchers looked at the amounts and toxicities of particulate pollutants that were released into the air during the burning tests. such as PM10 particulates and polycyclic aromatic hydrocarbons (PAHs) – see the box below.

The particulate matter (PM10) emission factors of wood-based wastes (paper, chipboard, fiberboard) were similar to those of firewood (2.1 mg/g), however, the PM10 emissions of burning chipboard and fiberboard were two times higher than that of dry firewood, as these stuffs contain adhesives in addition to the woody material, have surface additives and hems. In terms of plastics, it was revealed that PM10 emission levels caused by burning textiles and PET bottles are roughly five times, while in case of polyethylene bags and polyurethane sponges, 10 times higher than those characteristics of burning dry firewood. The burning of other types of plastics, such as polypropylene packaging, car tyres, PVC flooring and computer cases, causes 20 to 40 times (!) higher PM10 emissions. The exact values are shown in Figure 2.

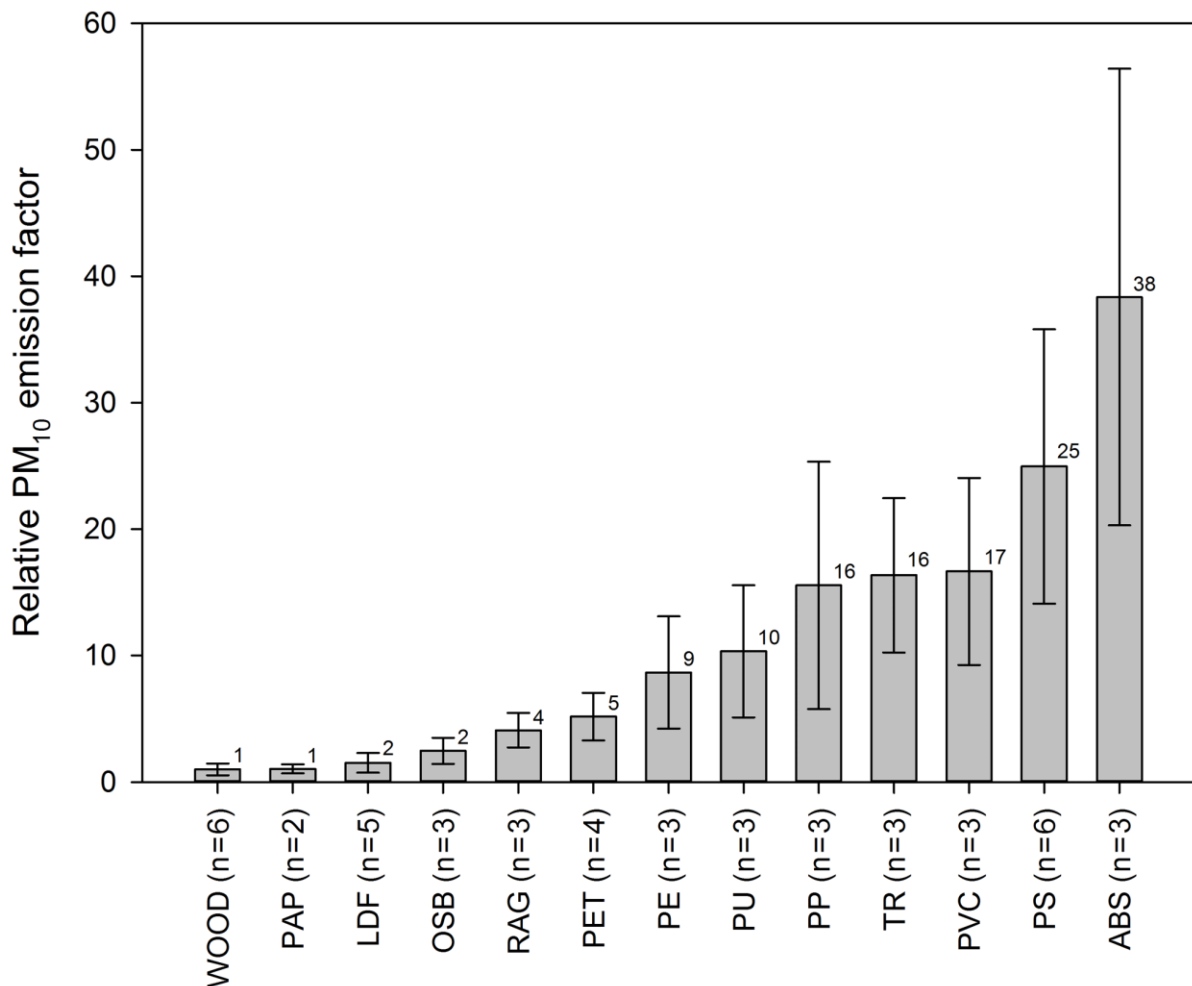


Figure 2. PM10 emission factors of the burning of different waste types compared to dry firewood (=1)

The emissions of particularly toxic, carcinogenic and mutagenic PAHs show an even greater deviation. Even the burning of wood-type wastes releases 3–8 times more PAHs than burning firewood. PAH emissions from burning textiles, car tyres and other plastic wastes can be up to 1,000 times (!) higher. The detailed results are shown in Figure 3.

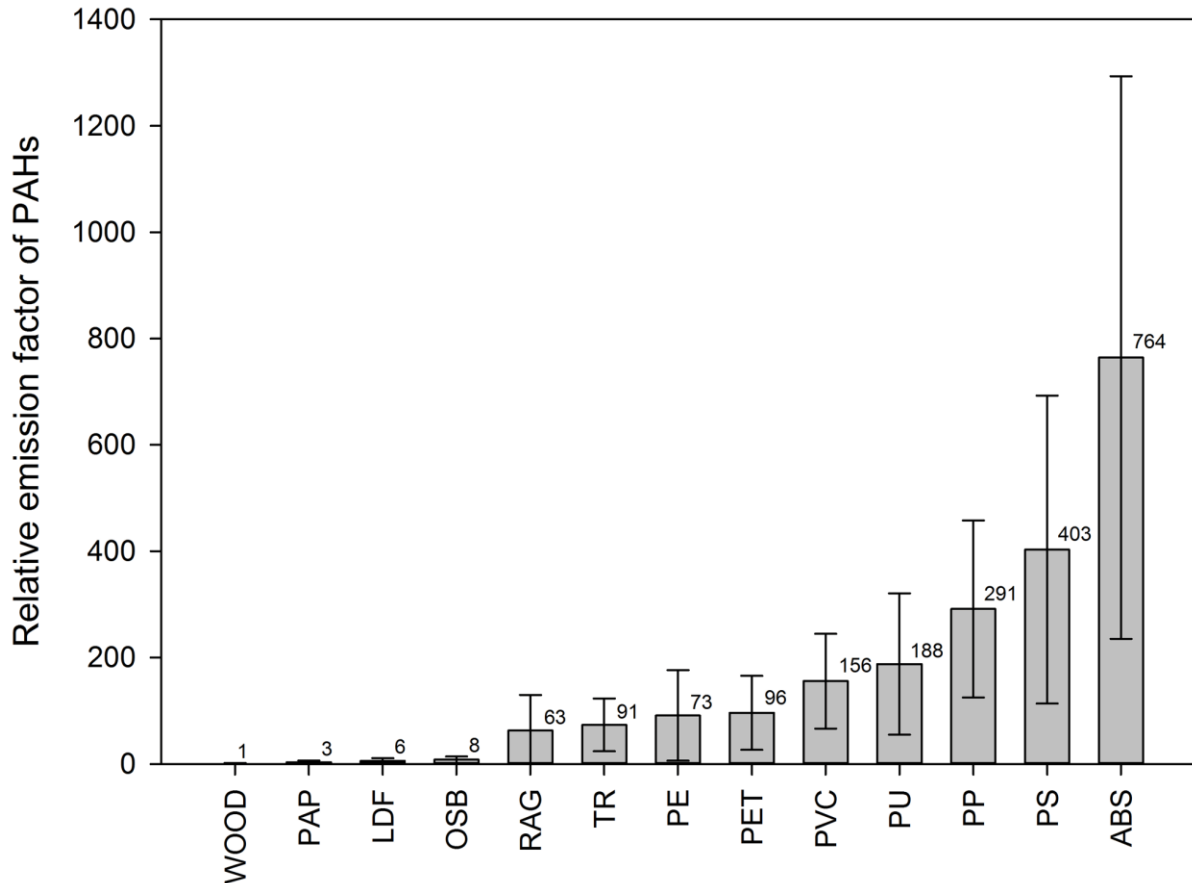


Figure 3. Polycyclic aromatic hydrocarbon (PAH) emissions measured during burning of different wastes compared to dry firewood (=1)

To be able to assess the risks of household waste burning as compared to fuel wood burning, which in itself is known to release significant amounts of pollutants, the researchers determined the toxicities of the PAHs emitted – i.e., as a measure of the health hazard posed by these substances. It was done by expressing the overall toxicity as equivalent concentration of the most toxic PAH, benzo(a)pyrene (BaP). The results were devastating: when burning wood (paper, chipboard, fiberboard) the overall toxicity of PAHs released was already around 30 times higher than that of firewood, and when plastics were burned, the substances released were in some cases 4,000 times (!) more toxic than in the case of burning firewood (per unit of mass). See Table 1 for details.

Table 1. Toxicity of polycyclic aromatic hydrocarbons (PCAs) emitted during the burning of firewood and waste samples expressed in benzo(a)pyrene (BaP) equivalent

Waste types	EFs of PM ₁₀		EFs of total PAHs		EF of total PAHs expressed in BaP toxicity equivalent		
	Mean	SD	Mean	SD	Mean	SD	Relative to wood
WOOD	2.1	0.70	0.34	0.19	0.0042	0.0055	1
PAP	2.2	0.11	1.2	0.83	0.16	0.12	37
LDF	3.2	1.3	2.0	1.3	0.14	0.12	32
OSB	5.2	1.4	2.7	1.4	0.14	0.094	34
RAG	8.7	0.22	21	19	1.63	2.0	390
PET	11	1.6	32	14	2.2	1.4	520
PE	18	7.2	31	23	1.2	1.1	280
PU	22	8.4	63	27	3.4	0.12	800
PP	33	18	98	8.3	16	4.7	3700
TR	35	6.0	25	9.1	2.0	1.8	480
PVC	35	10	52	5.1	5.3	1.9	1300
PS	53	15	135	60	11	4.8	2500
ABS	82	27	257	103	19	12	4500

In conclusion, the research revealed that the burning of solid waste is associated with much higher levels of respirable particulate (PM₁₀) emissions than wood burning, and on top of it, the PM₁₀ particles released by burning plastic wastes contained even higher proportion of PAH that are known to be highly toxic, carcinogenic, and mutagenic. From these shocking results it is already obvious that substantive and effective measures must be taken immediately to reduce the health hazards posed by the extensive and illegal activity of solid waste burning in households. Furthermore, the results of this research confirmed the importance of bringing together municipalities, authorities, and NGOs to markedly reduce the occurrence of illegal solid waste burning in households. Additionally, these measures would significantly improve air quality of the settlements, especially with respect to PM₁₀ and PM_{2.5} concentrations that were the critical pollutants in the recent lawsuit at the European Court of Justice. More importantly, since household waste burning releases vast amounts of extremely hazardous substances into the air, the associated health hazard can be substantially reduced.

Air pollutants in the focus of the research

PM10 are respirable aerosol particles (“particulate matter”) with a diameter of less than 10 micrometers (i.e., less than one sixth of the diameter of a human hair). Most of them are released into the air when solid materials (e.g., coal, biomass, waste) are burned or diesel engines are used. PM10 pollution in Hungary is responsible for the premature deaths of thousands of people every year, mostly causing cardiovascular and respiratory illnesses.

Polycyclic aromatic hydrocarbons, or PAHs, are among the most ubiquitous and hazardous combustion products because they are well known to be highly carcinogenic, and mutagenic (they may damage the DNS). PAHs containing five benzene rings are the most harmful, such as benzo[a]pyrene (BaP). The research targeted the 12 PAHs that are also known as the “dirty dozen”.