APRIL 2019

PFAS POLLUTION ACROSS THE MIDDLE EAST AND ASIA

SUMMARY

Per- and polyfluoroalkyl substances (PFAS) is a large class of more than 4,500 fluorinated chemicals that have received significant public and media attention in Australia, EU, and the US, in part due to their toxicity, extreme persistence, and documented water pollution. However, information about PFAS in other parts of the world is largely lacking and the information which is available is difficult to access. In 2019, IPEN participating organizations in twelve Middle Eastern and Asian countries conducted surveys to explore possible PFAS uses and pollution sources, scientific studies and government actions, including under the Stockholm Convention. Countries covered include: Bangladesh, Egypt, India, Indonesia, Japan, Jordan, Lebanon, Malaysia, Nepal, Sri Lanka, Thailand, and Vietnam.[1]

KEY FINDINGS OF THESE SURVEYS ARE:

PFAS are poorly regulated in all countries examined

Some countries have restricted PFOS in line with the Stockholm Convention listing, but most PFAS substances remain unregulated in all 12 countries. No countries regulate use of firefighting foams at the site of a fire.

PFAS substances contaminate adults and infants

Studies have found PFAS contamination of breast milk (India, Indonesia, Japan, Jordan, Malaysia, Vietnam), blood (Japan, Malaysia, Sri Lanka, Vietnam), and cord blood (Japan). Levels in breast milk exceed drinking water health advisory levels and limits in some US states. A 2018 review of studies in Japan of a large cohort of pregnant women and their infants found that prenatal exposures to PFAS, such as PFOS and PFOA, may affect birth size, disrupt the homeostasis of several hormones (thyroid, steroid, sex hormones *et al.*), and affect the development of the nervous system, allergies, and infectious diseases.

Water pollution with PFAS substances is widespread

PFAS substances contaminate coastal water (Bangladesh, Japan, Malaysia), sediment (Bangladesh, Indonesia, Japan), river water (India, Japan, Nepal, Thailand, Vietnam), ground water (India, Japan, Thailand, Vietnam), and drinking water (India, Japan, Malaysia, Thailand, Vietnam). PFAS pollution includes PFOA contamination of the Sundarbans mangrove area, a UNESCO World Heritage Site. Wastewater treatment plants have been identified as PFAS pollution sources in Japan, Jordan, Thailand, and Vietnam.

Marine and terrestrial organisms are contaminated with PFAS

Available studies show that commonly consumed seafood is contaminated with PFAS substances in Bangladesh, India, Japan, Sri Lanka, and Vietnam. In India, terrestrial organisms contaminated with PFAS include pigs living on an open waste dump. In Japan, terrestrial organisms contaminated with PFAS substances include: brown hawk owl, carrion crow, cattle, cattle egret, chicken, common kestrel, cormorant, dog, eagle, Eurasian sparrowhawk, goat, great egret, gull, horse, Japanese sparrowhawk, large-bill crow, mallard duck, northern goshawk, pig, pintail duck, raccoon dog, swan, turtle, Ural owl and wild rats.

Firefighting foams and extinguishers containing PFAS are in use

In Indonesia, fire extinguishers containing PFAS (AFFF) are readily available for consumer purchase and vendors falsely claim that the product is, *"Not harmful to plants, animals, especially humans."* In Japan, an estimate of PFOS-containing firefighting foams shows that 47% (7000 tons) of stockpiles are in car-parking facilities. The second largest PFOS-

1 Participating organizations in the 12 countries are: Bangladesh: Environment and Social Development Organization; Egypt: EcoVision Society for Environment and Sustainable Development; India: Toxics Link; Indonesia: Balifokus; Japan: Japan Endocrine Disruption Prevention Action; Jordan: Land and Human to Advocate Progress; Lebanon: Innodev; Malaysia: Consumers Association of Penang; Nepal: Center for Public Health and Environmental Development; Sri Lanka: Center for Environmental Justice, Thailand: Ecological Alert and Recovery Thailand; and Vietnam: PanNature

containing foam stockpile (4200 tons) was held by the petrochemical industry and the third largest was contained in portable fire extinguishers (2000 tons). In Jordan, stockpiles of PFAS-containing foams include more than 292,000 liters of fluoroprotein foam and 28,000 liters of an alcohol-resistant fluoroprotein foam. Substitution of PFOS-containing firefighting foams for PFAS-containing foams has occurred in Lebanon and potential contaminated sites include firefighting practice areas and sites of factory and warehouse fires where the foams were used. According to the government inventory, the Sri Lankan Fire Brigade has a stockpile of around 50,000 liters of firefighting foams imported in the late 1980s – likely PFOS-containing foam. A major firefighting foam importer supplies PFAS-containing foams, but does not indicate the PFAS content in the documentation.

Consumer products are contaminated with PFAS

Consumer products containing PFAS include food contact papers (Egypt), cow milk (Jordan), coats (Bangladesh, Indonesia), shoes (Indonesia), food packaging such as noodle cup, instant rice porridge cup, microwave popcorn bag, beverage cup, ice cream cup, fried chicken box, fried chicken wrapper, French fries bag, French fries wrapper, French fries box, hamburger wrapper, pretzels box, pretzels wrapper, donut box, donut wrapper, and baking paper (Thailand), and textile products including diapers, shirts, pants, footwear, towels, uniforms, bags, curtains, upholstery, carpets, blankets, and table cloths (Thailand). In Japan, PFAS substances are present in sprays for textiles, car wash / coating products, and rust inhibitor products. The highest PFAS concentration was 25,000 ng/g for N-ethyl perfluorooctane sulfonamidoethanol (Et-FOSE), a PFOS precursor, in a spray for textiles.

PFAS substances contaminate dust and particulate air pollution

PFAS was found in particulate matter air pollution in India and Japan and in street dust in Japan. Household dust is contaminated with PFAS substances in Egypt, Nepal, Japan, and Thailand.

US military bases in Japan cause PFAS pollution

Use of PFAS-containing firefighting foams has caused high levels of PFAS pollution outside of the bases in Okinawa. Although the Japanese government has requested the US military to allow access for investigation, the US has continued to refuse the requests saying that, *"PFOS is not a regulated substance in the US and Japan."*

Japan is an important PFAS producer

Three prominent PFAS manufacturers include AGC, Daikin, and Mitsui-Chemours. Mitsui-Dupont polluted water with PFOA at their factory in Shimizu. At Daikin's factory in China, some of highest PFAS levels ever reported in the country were found in the Changshu Industrial Park. Daikin paid $USD4 million to settle a lawsuit stemming from PFOS and PFOA pollution downstream of their factory in Alabama, USA. In 2018, a US firefighter filed a class action lawsuit against AGC, Daikin, 3M, Archroma, Arkema, Chemours, Dyneon, DowDuPont, and Solvay to fund an independent investigation of links between exposure and health impacts of the entire class of PFAS substances.

PFAS elimination contributes to achievement of the Sustainable Development Goals (SDGs)

Due to the complexity and negative characteristics of PFAS, there is increasing interest in regulating PFAS as a class rather than as individual substances. As noted by Linda Birnbaum, Director of the US National Institute of Environmental Health Sciences and the National Toxicology Program, *"Approaching PFAS as a class for assessing exposure and biological impact is the most prudent approach to protect public health."* Actions to control and phase-out PFAS as a class contribute to achievement of several key Sustainable Development Goals (SDGs) due to the impacts of the substances on health and ecosystems including water pollution. These include SDGs 3, 6, 9, 12, 14, 15, and 16.

INTRODUCTION

PFAS is a large class of more than 4,500 persistent fluorinated chemicals that are widely distributed in the global environment due to their high solubility in water, low/moderate sorption to soils and sediments and resistance to biological and chemical degradation. The properties of PFAS have resulted in extensive use as surfactants and surface-active agents in products. Two widely-used members of this class have been perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). As these two substances have come under regulatory pressure, the industry has shifted to other PFAS with similar properties

Human exposure to PFAS is mainly by ingestion of contaminated food or water. These substances bind to proteins (not to fats) and persist in the body where they are mainly detected in blood, liver and kidneys. Studies indicate that PFOA and PFOS can cause reproductive and developmental, liver and kidney, and immunological effects in laboratory animals. Both chemicals cause tumors in animal studies along with a variety of other effects on infant birth weight, growth, learning, infant behavior, pregnancy, endocrine system, increased cholesterol, and thyroid function. Recent studies have linked a variety of PFAS substances to many human health effects: cardiovascular disease, markers of asthma, damage to semen quality, ovarian insufficiency, altered glucose metabolism, lower testosterone levels in male adolescents, association with shorter birth length in girls, elevated blood pressure, abnormal menstruation, lower birth weight in infants, possible increased risk of female infertility due to endometriosis, and decreased lung function in children with asthma.

The manufacture and use of PFAS and their use in a multitude of products has caused widespread pollution. PFAS are found in wildlife, accumulating in the blood, liver and kidneys of wildlife such as dolphins, polar bears, seals, birds, fish, and other marine wildlife. PFAS substitutes for PFOS and PFOA have been identified as potential global surface water contaminants and they have been found in more than 80% of 30 surface seawater samples from the North Pacific to Arctic Ocean. PFAS use in firefighting foams at military bases and airports is responsible for water pollution and contaminated communities in many countries, including Australia, Canada, China, Germany, Italy, Japan, Netherlands, New Zealand, South Korea, and Sweden.

Safer cost competitive non-fluorinated alternatives for PFAS use in firefighting foams have been adopted by an increasing number of major airports, including Auckland, Copenhagen, Dubai, Dortmund, Stuttgart, London Heathrow, Manchester, and all 27 major airports in Australia. Increasing awareness about the negative characteristics of PFAS has driven efforts to identify and market safer substitutes for other uses. Increasing awareness about the negative characteristics of PFAS has driven efforts to identify and market safer substitutes for other uses.

Due to the complexity and negative characteristics of PFAS, there is increasing interest in regulating PFAS as a class rather than as individual substances. As noted by Linda Birnbaum, Director of the US National Institute of Environmental Health Sciences and the National Toxicology Program, "*Approaching PFAS as a class for assessing exposure and biological impact is the most prudent approach to protect public health.*" Actions to control and phase-out PFAS as a class contribute to achievement of several key Sustainable Development Goals (SDGs) due to the impacts of the substances on health and ecosystems including water pollution. These include SDGs 3, 6, 9, 12, 14, 15, and 16.

For information about manufacturers' knowledge that PFAS substances were harmful, please see Annex 1. For information about the high cost of PFAS cleanup, please see Annex 2.

PFAS ARE POORLY REGULATED IN ALL COUNTRIES EXAMINED.

Some countries have restricted PFOS in line with the Stockholm Convention listing, but most PFAS substances remain unregulated.

Bangladesh: No PFAS substances are regulated in the country. Bangladesh became a Party to the Stockholm Convention in 2007 and the treaty added PFOS to its global restriction list in 2009. However, Bangladesh has not accepted the amendment listing this substance and it is unregulated, along with other PFAS.

Egypt: Egypt became a Party to the Stockholm Convention in 2004. The amendment listing PFOS came into force for Egypt in 2010 and the deadline for delivering Egypt's updated National Implementation Plan for PFOS and other substances listed at COP4 in 2009 was August 2012. However, Egypt has not delivered the updated National Implementation Plan.

India: No PFAS substances are regulated in the country. India became a Party to the Stockholm Convention in 2006 and the treaty added PFOS to its global restriction list in 2009. However, India has not accepted the amendment listing this substance and it is unregulated, along with other PFAS.

Indonesia: Indonesia became a Party to the Stockholm Convention in 2009 and the treaty added PFOS to its global restriction list in 2009. This amendment went into legal force in Indonesia in 2010. However, PFAS are essentially unregulated and not currently included in monitoring programs.

Japan: Most PFAS substances are not regulated in Japan, but there some regulations partially govern PFOA, PFHxA, PFHxS, and PFOS. The Stockholm Convention listing of PFOS went into legal force in Japan in 2010, but the country has registered the following time-unlimited acceptable purposes: photo-imaging; photo-resistant and anti-reflective coatings for semi-conductors; etching agent for compound semi-conductors and ceramic filters; and certain medical devices. No maximum levels for PFOS, PFOA or any other PFAS substance are set for tap water in Japan. There are no regulations regarding the use of firefighting foam extinguishing agents containing PFOS or any other PFAS substance at the firefighting site. PFOA, PFHxA and PFHxS are categorized as "General Chemical Substances" under the Chemical Substances Control Law which requires those who manufacture or import more than 1 ton of them to notify their amount to the Ministry of Economy, Trade and Industry. Under its Status of Forces Agreement with the US, Japan cannot enforce any regulations on polluting US military bases such as the bases in Okinawa.

Jordan: While PFOS has been banned as a result of the Stockholm Convention listing, other PFAS substances are not regulated. PFOS has been banned under three relevant laws:

- Environmental law 52/2006 in article 6, which regulates importing and exporting of hazardous wastes.
- Import, export and management of hazardous substances is banned by the bylaws no. 24, 2005 articles 7 and 8.
- Amended import Instruction no 1, 2012 by Ministry of Industry and Commerce allows for the import of used computers not more than three years old.

Lebanon: The Stockholm Convention entered into force for Lebanon in 2004 and the treaty added PFOS to its global restriction list in 2009. This amendment went into legal force in Lebanon in 2010. While some actions have been taken on PFOS, other PFAS substances are not regulated.

Malaysia: No PFAS substances are regulated in the country The Stockholm Convention added PFOS to its global restriction list in 2009, but Malaysia is not yet a Party to the treaty, so even this POP is not regulated or part of any elimination plan.

Nepal: Nepal became a Party to the Stockholm Convention in 2007 and the treaty added PFOS to its global restriction list in 2009. This amendment went into legal force in Nepal in 2010. However, other PFAS substances are essentially unregulated. A new Hazardous Substances Management Regulation is currently under discussion within the ministries.

Sri Lanka: Sri Lanka became a Party to the Stockholm Convention in 2005 and the treaty added PFOS to its global restriction list in 2009. This amendment went into legal force in Sri Lanka in 2010. However, most PFAS not regulated. A newly formed national waste management policy in response to a case filed by the Center for Environmental Justice (SCFR152/17) includes policies to manage all chemical wastes.

Thailand: Thailand became a Party to the Stockholm Convention in 2005 and the treaty added PFOS to its global restriction list in 2009. This amendment went into legal force in Thailand in 2010. However, other PFAS are essentially unregulated.

Vietnam: Vietnam became a Party to the Stockholm Convention in 2004 and the treaty added PFOS to its global restriction list in 2009. This amendment went into legal force in Vietnam in 2010. However, other PFAS substances are essentially unregulated. Four policy measures have been enacted dealing with PFOS: 1) Guidance on Inventory Techniques, Safety Management and Risk Control for Perfluorooctane sulfonic acid, salts and perfluorooctane sulfonyl fluoride issued by the General Department of Environment - MONRE (18/06/2014); 2) Vietnam National Standards on some substances that are banned or restricted in footwear materials and products (2016); 3) Decision no. 1598/QD-TTg on the National plan for the implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs) by 2025 with a vision to 2030 (17 October 2017); and 4) Plan No. 178 / KH-UBND about implementation of Decision no. 1598/QD-TTg in the province which was approved by the Provincial People's Committee on April 6, 2018.

PFAS SUBSTANCES CONTAMINATE ADULTS AND INFANTS

Studies have found PFAS contamination of breast milk (India, Indonesia, Japan, Jordan, Malaysia, Vietnam), blood (Japan, Malaysia, Sri Lanka, Vietnam), and cord blood (Japan). Levels in breast milk exceed drinking water health advisory levels and limits in some US states. A 2018 review of studies in Japan of a large cohort of pregnant women and their infants found that prenatal exposures to PFAS, such as PFOS and PFOA, may affect birth size, disrupt the homeostasis of several hormones (thyroid, steroid, sex hormones *et al.*), and affect the development of the nervous system, allergies, and infectious diseases.

India: A 2008 study found significant PFAS levels for PFOS, PFOA, PFHxS, and PFBS in women from Chidambaram, Kolkata, and Chennai. Overall, average PFOS levels in Indian breast milk averaged 46 ppt – more than 2 times higher than the drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined in the US State of Vermont. The highest level of PFOA exposure in Indian breast milk was more than 16 times higher than this drinking water health advisory limit.

Indonesia: A 2008 study found PFAS in breast milk in women from Jakarta and Purwakarta. PFAS substances included PFOS, PFHxS, PFNA and PFHpA. PFOS was found in all twenty women and PFHxS was found in 45% of them. Overall, PFOS levels in Indonesian breast milk averaged 84 ppt – more than 4 times higher than the drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined in the US State of Vermont. The highest level of PFOS exposure in Indonesian breast milk was more than 12 times greater than this drinking water health advisory limit

Japan: A 2018 study found PFHxS, PFOS, PFOA, PFNA, PFDA, PFUnDA, PFDODA, and PFTrDA in pregnant women. The highest levels were found for PFOS (30.28 ppb), PFOA (24.88 ppb), and PFNA (13.19 ppb). This confirmed an earlier study that found PFOA, PFNA, PFDA, and PFUnDA, and PFOS in 100% of the pregnant women that were tested in 2003, 2005, 2007, and 2009. In 2011, significant detection frequencies of other PFAS were detected including PFHxA (20%), PFHpA (50%), PFDoDA (97%), PFTrDA (97%), PFTeDA (13%), and PFHxS (77%). Between 2003 and 2011, plasma concentrations of PFOS and PFOA decreased, but PFNA and PFDA concentrations increased by 4.7% and 2.4% per year respectively. In 2004, the first study showing PFAS contamination of fetal cord blood found PFOS in all infants tested. Since then, cord blood has been tested for impacts of prenatal exposure as described in the next section.

A 2018 Japanese government review based on studies of a large cohort of pregnant women and their infants found that prenatal exposures to PFAS, such as PFOS and PFOA, may affect birth size, disrupt the homeostasis of several hormones (thyroid, steroid, sex hormones *et al.*), and affect the development of the nervous system, allergies, and infectious diseases. In males, there are negative correlations between prenatal exposure of PFAS and production of testosterone, estradiol, inhibin B, and insulin-like factor 3. In females, there are negative correlations between prenatal exposures to PFAS and production of progesterone, prolactin, and sex hormone-binding globulin (SHBG). A study of this same cohort noted that, "even low levels of PFOS and PFOA exposure can disrupt reproductive hormone imbalance in the fetus." A 2017 study found prenatal exposures to PFHxS and PFOS through the mother, were associated with a higher risk of infectious diseases in their children

A 2008 study found PFAS in breast milk in women from Ehime Prefecture. PFOS was found in 100% of the samples from Japan. PFOA and PFHxS were found in 92% of the samples; PFNA in 13% of them; and PFHpA in 25% of them. The results showed significant PFAS levels for PFOS, PFOA, PFHxS, PFNA, and PFHpA. Overall, average PFOS levels in Japanese breast milk averaged 232 ppt – more than 10 times higher than the drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined in the US State of Vermont. Average levels of PFOS in Japanese breast milk were the highest in all countries examined. The highest level of PFOS in Japanese breast milk (523 ppt) was more than 26 times higher than this drinking water health advisory limit.

Jordan: A 2015 study found significant levels of PFOS and PFOA in both breast milk and fresh cow milk. Overall, PFOA levels in Jordanian breast milk averaged 144 ppt – seven times higher than the drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined in the US State of Vermont. The highest level of PFOA exposure in Jordanian breast milk was more than 60 times higher than this drinking water health advisory limit and the highest PFOS level was nine times greater than this standard. The highest levels of PFOS and PFOA in cow milk were and 1.45 and 8 times higher than this limit.

Malaysia: PFOS levels in Malaysian breast milk averaged 121 ppt – more than 6 times higher than the Vermont health advisory limit (20 ppt). The highest level of PFOS in Malaysian breast milk was more than 17 times higher than this drinking water health advisory limit. Substances found include PFOS, PFOA, PFHxS, PFNA, and PFBS. Reported levels of PFAS in blood in Malaysia were 12.7 ppb PFOS, 1.98 ppb PFHxS, and 4.57 ppb PFOSA. To illustrate how high these levels are, note that they far exceed modern drinking water standards for these substances. For example, 12.7 ppb PFOS is 12,700 ppt vs. 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined health advisory limit in the US State of Vermont.

Reported levels of PFAS in blood in Malaysia were 12.7 ppb PFOS, 1.98 ppb PFHxS, and 4.57 ppb PFOSA. PFOA was not detected in blood at this time. These levels and those reported in other countries far exceed modern drinking water standards for these substances. For example, 12.7 ppb PFOS is 12,700 ppt vs. 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined health advisory limit in the US State of Vermont.

Sri Lanka: A 2005 study of tea plantation workers found PFOS, PFHxS, PFUnA, PFDA, PFNA, and PFOA in all sera samples. Relatively high levels were found and mean levels of PFOS and PFOA in conventional tea workers in the rural area (PFOS mean: 6.3 ng/mL; range: 1.8-17.5 ng/mL and PFOA mean: 9.06 ng/mL; range: 1.9-23.5 ng/mL) were similar to those in people living in the capital, Colombo. In contrast, organic agriculture tea workers had comparatively lower levels of accumulation than conventional tea workers. For example, PFOS levels in organic tea workers were 0.96 mg/ml compared to 6.3 ng/mL in conventional tea workers. Overall the PFAS with the highest concentration in sera was PFOA.

Vietnam: A 2008 study found significant PFAS levels for PFOS, PFOA, PFNA, PFBS and PFHpA in women from Hanoi and Ho Chi Minh City. Overall, average PFOS levels in Vietnamese breast milk were 3.75 times higher than the drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined in the US State of Vermont. The highest level of PFOS was approximately 20 times higher than this drinking water health advisory limit. In 2009, researchers studying PFAS in blood of women that had recently given birth found PFOS, PFOA and PFHxS in >98% of the women and levels were similar to those observed in the US. Levels were higher in an urban coastal area (Nha Trang) than a rural inland area (Dien Khanh). An earlier study found PFOS and PFOA in the blood of women from Hanoi with levels comparable to those observed in Osaka, Seoul, and Busan.

WATER POLLUTION WITH PFAS SUBSTANCES IS WIDESPREAD

PFAS substances contaminate coastal water (Bangladesh, Japan, Malaysia), sediment (Bangladesh, Indonesia, Japan), river water (India, Japan, Nepal, Thailand, Vietnam), ground water (India, Japan, Thailand, Vietnam), and drinking water (India, Japan, Malaysia, Thailand, Vietnam). PFAS pollution includes PFOA contamination of the Sundarbans mangrove area, a UNESCO World Heritage Site. Wastewater treatment plants have been identified as PFAS pollution sources in Japan, Jordan, Thailand, and Vietnam.

Bangladesh: A 2016 study measured PFAS in surface water, 10.6 – 46.8 ng/L (ppt), and sediment, 10.6 – 46.8 ng/L (ppt). PFOA and PFOS were the most abundant PFAS found. The areas of Chittagong and Cox's Bazar showed higher levels of PFAS in seafood and in surface water and sediment than other parts of the country. Paper and pulp industries, textile, and plastic industries situated on the bank of Karnafuli River and the coastal areas are the possible sources of PFAS releases in Chittagong and Cox's Bazar.

India: A 2018 study showed water aquifers greater than 100 meters deep were polluted with PFAS, pharmaceuticals and pesticides. PFOS levels ranged from <0.1 – 33 ppt, far higher than the drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined in the US State of Vermont.

A 2016 study found 15 PFAS in one or more locations in Ganges River surface water with levels ranging from 1.3 – 15.9 ppt. Short-chain PFAS (C_5 – C_8) were found more frequently and the authors indicate that this is likely due to ongoing substitution by industry. The study calculated the mean cumulative PFOS and PFOA discharges to the whole Ganges catchment area to be 240 g/day for PFOS and 210 g/day for PFOA. This area covers a population of approximately 400 million people. PFOS could not be detected at the River's origin in Rishikesh, but levels gradually increased downstream and elevated at the confluence with the Yamuna River in Allahabad.

The study also found PFAS in groundwater – which is used for drinking water as well as irrigation purposes in most of the Ganges basin. Fourteen PFAS were frequently detected and PFHxA and PFHpA were detected in all samples. The highest intakes per kg body weight were observed for children.

Another study found that the Noyyal River contains significant levels of PFOA at 93 ppt and PFOS at 29 ppt. The authors note that this could be due to extensive industrial activity in this area including textile factories that dump directly into the river.

PFOS has been found in the Cooum River (3.91 ppt) and in untreated sewage (12 ppt). Tap water samples from Goa, Coimbatore, and Chennai did not contain PFOS or PFOA – but shorter chain PFAS such as PFHxS (81 ppt) instead. Note that this is four time higher than the health advisory limit in US State of Vermont which sets a drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined.

In the Sundarban mangrove area, PFOA was found in all five sampled sites at an average level of 11.61 ppb dry weight. The Sundarbans contains four protected areas that are listed as UNESCO World Heritage Sites.

Indonesia: A 2012 study found PFOS and PFOA in Jakarta Bay sediments collected in 2004. PFOS was found in all samples. PFOA ranged up to 6.1 ug/kg dry weight – approximately ten times higher than the highest level observed in San Francisco Bay in the USA.

Japan: PFOS pollution has been found in 64 rivers and PFAS pollution is widely present in coastal areas including the Sea of Kushiro, Mutsu Bay, Hachinohe Bay, Jyodoga Coast, Miyako Bay, Kamaishi Bay, Honjyo Marina, Souma Bay, Nagasaki Bay, Chiba-Funahashi Bay, Yamashita Bay, Pacific Ocean, Nagoya Bay, Koshien Bay, Motoujina Shima coast, and Hakata Bay. A subsequent study of 18 rivers in Hokkaido, Tohoku, Kanto, Hokuriku, Chubu, Kinki, Chugoku, Shikoku, and Kyushu found PFAS in all of them and more than half of them had levels higher than 40 ppt. Predominant PFAS were PFOS, PFHpA, PFOA, and PFNA. In Hokkaido rivers, PFOS and/or PFHxS were detected around airports, probably due to the use of fire extinguishers. PFAS contamination from industrial facilities was also detected in paper mill effluents. These compounds are used in surface treatment of paper products.

In Tokyo Bay, 11 PFAS substances were found in pore water including PFHxS, PFOS, TH-PFOS, N-EtFOSAA, PFBA, PFPeA, PFHxS, PFHpA, PFOA, PFNA, and PFDA. Freshwater inputs are the likely source of these substances. A spatial survey of PFAS pollution in Tokyo Bay showed that PFNA was the most prevalent PFAS substance and that levels of PFHxA, PFHpA, PFOA and PFNA were 10 – 100-fold higher near production plants than in other areas. PFCA levels in coastal water (491 ng/L) and plant effluent (6024 ng/L) were described as "extraordinarily high." Estimated loadings from the six major rivers into Tokyo Bay were 96.6 kg/year for PFOA and 139.6 kg/year for PFOS. The authors conclude that, "the introduction of PFC [PFAS] regulations on the use/production/emission has not reduced PFC pollution."

A time study of PFAS in Tokyo Bay sediment showed a rapid increase after the early 1970s for PFUnDA, PFDoDA, PFTrDA; gradual increase from the 1950s for PFNA and PFDA; an unexpected peak in the later 1950s – 1960s and rapid increase after the late 1990s for PFOA; gradual increase from the 1950s and gradual decrease after the early 1990s for PFOS; and an unexpected peak in the late 1990s for precursors of PFOS such as N-EtFOSAA and N-MeFOSAA. The authors note that this might represent releases from firefighting foams or discharge from manufacturing facilities. In Osaka Bay, increasing levels of PFHxA were observed due to pollution from the Kanzaki River.

PFAS substances have been found in all Tokyo groundwater samples and PFOS (0.28-133 ng/L), PFHpA (<0.1-20 ng/L), PFOA (0.47-60 ng/L), and PFNA (0.1-94 ng/L) were the predominant substances. The authors note that, "groundwater contamination by PFOS will continue unless the precursors are regulated." In addition, they observe that, "since manufacturers are switching to shorter-chain PFCAs with <7 fluorinated carbons, these compounds could also contaminate groundwater." Another study found widespread PFAS pollution in Tokyo groundwater, springs, and confined aquifers with PFHxS, PFOS, PFHpA, PFOA, PFNA, and PFDA the most prevalent substances.

Sampling in the Iruna River upstream of the intake for Tokyo's drinking water treatment plants found PFHxA, PFOS, PFHpA, PFOA, PFNA, PFDA, PFUA, and PFDoDA in all samples. PFAS substances are also found in tap water. In Osaka, PFOS (0.20 – 22 ng/L) and PFOA (2.3 – 84 ng/L) contaminated all tap water samples. The highest levels of PFOS and PFOA in tap water exceeded drinking water limits set in some US states. For example, Vermont sets a drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined. In Tokyo tap water, total PFAS levels ranged from 0.72 to 95 ng/L and 12 PFAS substances were detected in the samples with the highest concentrations.

PFOS and PFOA have both been found in sediment cores from the Suruga Bay at depths of 800 – 850 meters. The authors note that the finding of PFAS in the deep-sea environment could be due to the coastal waters and "garbage such as plastic products, waste cans, and gum products are often observed in the deep-sea environment, and perfluoro organic compounds are considered to be eluted in this garbage."

Wastewater treatment plants receive a mixture of domestic and industrial wastewater and the PFAS removal rate is less than 50% but increases with frequent changes of activated carbon. A study of the processes found that sand filtration and ozonation did not remove PFOS or PFOA and that PFOS (0.51 – 7.6 ng/L) and PFOA (0.78 – 72 ng/L) were also found in activated carbon filter samples. The authors noted that older activated carbon was not effective at PFOS or PFOA removal. This raised concerns since activated carbon at water treatment plants is commonly used for several years At some plants, the effluent has even higher PFAS levels than the influent and they drain into rivers that serve as drinking water supplies. A 2010 study estimated daily discharges of PFAS from individual sewage treatment plants to range from 0.35–55.9 g/d. A sewage treatment plant discharge site on the Ina River near Osaka led to a level of 67,000 ng/L PFOA with an estimated 18 kg of PFOA discharged daily. Another plant discharging into the Tsurumi River released PFOS (78.7-689.9 ng/L), PFHxA (3.5 – 9.4 ng/L), PFHpA (5.5 – 7.2 ng/L), PFOA (17.8 – 24.9), PFNA (27.5 – 41.8), and PFDA (3.0 – 4.5 ng/L). Sampling at discharge sites in other rivers indicated that sewage effluent was the likely source of PFOS, PFHpA and PFNA. The total fluxes of sewage-derived PFAS were estimated to be: PFOS (3.6 t/year), PFHpA (2.6 t/year), PFOA (5.6 t/year), and PFNA (2.6 t/year). The authors note that these fluxes, especially for PFNA were remarkably high in Japan compared to rivers in Europe.

Jordan: A 2019 study examined the potential use of biochar filters to remove PFAS in lab experiments. The study found that biochar without biofilm remove 90% - 100% of PFOA, PFNA, PFUnDA, PFDoDA, PFOS, and FOSA by adsorption. However, shorter-chain PFAS, which represent the industry trend, were not effectively removed using this method. For example, removal of PFBA, PFPeA, and PFHxA averaged 20%, 30%, and 40% respectively. PFHxS removal averaged only 60%.

Malaysia: A 2017 study found Malaysia (and Philippines to be a likely source of PFAS pollution in the South China Sea. A 2011 study found high levels of PFAS contamination near the causeway connecting the Singapore Island and the Malay Peninsula across the Johor Strait where an industrial wastewater treatment plant discharges its effluent.

The Langat River is an important drinking water source for Selangor – a state with nearly six million people and the economic engine of Malaysia. A 2012 study found very high levels of PFOA and PFOS in the river, vastly exceeding US state regulatory limits.

Nepal: A 2012 study measured PFOS and PFOA in rivers in 15 countries and 41 cities. Median levels of PFOS in Nepal were 2.6 ng/L (ppt) – higher than samples measured in China, Malaysia, Laos, Sweden, Sri Lanka, Turkey, and Thailand.

Thailand: PFAS water pollution occurs in major rivers, ground water, tap water, and bottled drinking water. The Chao Phraya River covers 160,000 km^2 (30% of Thailand's area) and supplies water to millions of people. In the Chao Phraya River, PFOS levels ranged up to 20 mg/L (ppt) and PFOS ranged from 0.7 – 20 ng/L (ppt). Levels increased from the upstream area to the outlet and the highest levels were found at the port where one of Bangkok's wastewater treatment plants discharges effluents. Industrial wastewater contained PFOS with average levels of 264 ng/L (ppt) and reaching 6,200 ng/L (ppt) – a very high level. The authors suggest that the data indicates that industrial wastewater is one of the major sources of PFOS contamination in the water system in Bangkok.

PFAS pollution occurs in ground water near municipal waste dumps and an industrial waste disposal site, including PFOS, PFOA, PFHpA, PFNA, PFUnA, and PFHxS. Some of the PFAS levels exceed modern health advisory and regulatory standards in US states.

The main tap water source in Bangkok is the Chao Phraya River which is known to contain PFAS substances including 20 – 30 ppt PFOA. Wastewater released into the river is known to contain up to 6000 ppt PFOS.

A 2018 study found five types of PFAS in bottled water in Bangkok with concentrations between 3.31 – 25.79 ppt. The highest levels exceed the health advisory limit in the US state of Vermont of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined. PFOA was the predominant PFAS found.

A 2015 study found that conventional wastewater treatment processes could not effectively remove PFAS substances. PFOA was the predominant PFAS but other PFAS substances included PFBA, PFHxA, PFHpA, PFNA, PFUnA, and PFOS.

Industrial estates serve many types of industries including textile, electronics, plastics, personal care products, chemicals, glasses etc., mostly belonging to multinational companies. Industrial wastewater treatment plants in central and eastern Thailand contained PFOA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFHxS and PFOS. Both plants were ineffective at removing PFAS and one plant actually increased PFAS levels. PFAS levels in effluents varied from 662 – 1143 ng/L (ppt). PFOS levels were higher than similar plants in US, Singapore, Switzerland, and Japan. A 2010 study found daily mass PFAS discharges from the studied industrial estate wastewater treatments plant ranged from 1.34–36.6 g/d. The Thai samples from industrial estates showed higher PFAS levels than samples from Japan. Techniques such as aerobic and anaerobic biological treatment, sand filtration, chlorination, ozonation, and activated carbon were all found to be ineffective at removing PFAS substances. The authors hypothesize that multinational companies are shifting PFAS use to developing countries such as Thailand where they are not regulated.

Vietnam: A 2015 study found PFAS contamination in surface water, river water, and ground water. The most frequently detected PFAS substances in surface water were PFOA (98%), PFNA (84%, and PFOS (59%). PFBA, PFHpA, PFOA, PFNA, PFDA, PFHxS and PFOS were the major PFAS found in ground water with PFOS and PFOA being the most prevalent. The highest levels were observed in samples from highly populated and industrialized areas, perhaps sourced from sewage. The authors noted that the high detection frequencies of PFOS and PFOA, "demonstrated that these chemicals are ubiquitous in the Vietnamese urban aquatic environment…".

Sampling for a 2016 thesis found PFAS in Danang tap water up to 52 ppt and in surface water up to 132 ppt. Both exceed the drinking water health advisory limits in US states. The study also found high PFAS levels (292 ppt) in the discharging channel of an industrial zone.

A 2017 study found the greatest concentrations of PFOA (53.5 ppt) and PFOS (40.2 ppt) were found in a surface water sample collected from a channel that receives wastewater treatment plant discharges. PFOS and PFHxS were found as the predominant PFAS substances in sediments. The variety of PFAS found in water included PFHxA, PFHpA, PFOA, PFNA, PFDA and PFUnDA indicating use of these substances or sources from precurors such as fluorotelomer alcohols in commerical products.

MARINE AND TERRESTRIAL ORGANISMS ARE CONTAMINATED WITH PFAS

Available studies show that commonly consumed seafood is contaminated with PFAS substances in Bangladesh, India, Japan, Sri Lanka, and Vietnam. In India, terrestrial organisms contaminated with PFAS include pigs living on an open waste dump. In Japan, terrestrial organisms contaminated with PFAS substances include: brown hawk owl, carrion crow, cattle, cattle egret, chicken, common kestrel, cormorant, dog, eagle, Eurasian sparrowhawk, goat, great egret, gull, horse, Japanese sparrowhawk, large-bill crow, mallard duck, northern goshawk, pig, pintail duck, raccoon dog, swan, turtle, Ural owl and wild rats.

Bangladesh: A 2017 study found PFAS in commonly consumed seafood from the coastal area of Bangladesh. Levels ranged from 0.32 – 14.58 ng/g wet weight in finfish and 1.31 – 8.34 ng/g wet weight in shell fish. The authors noted that these levels were comparable to levels observed in China, Spain, Sweden and USA

India: A 2009 study found PFOS in almost all of the fish samples from the Ganges River along with PFUnDA, PFDA, PFNA, and PFOA. Ganges River dolphins contained PFUnDA, PFDA, and PFNA in 80%, 87% and 53% of the samples. The study found that PFAS concentrations increased from the lower trophic level (shrimp) to higher tropic level organisms (fish, dolphins).

A 2010 study measured PFAS in the livers of pigs living on a large-scale municipal waste dump site in Perungudi near Chennai. Female pigs contained substantially higher levels of PFOS (71 ng/g wet weight) than male pigs (9 ng/g wet weight). Piglets contained higher levels of PFOS than adult females (13 ng/g wet weight). Other substances found in female pigs included PFHxS, PFDS, PFOSA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, and PFDoDA. PFAS levels in female pigs from the dump site (71 ng/g wet weight) were significantly higher than PFAS levels in female pigs from the reference site (19 ng/g wet weight).

Japan: A variety of PFAS substances contaminate marine organisms such as bream, carp, crab, filefish, flounder, jack mackerel, lugworm, medaka, mudskipper fish, mussel, oyster, porpoises, sandfish, sardines, sea bass, shark, and trout. Birds and both wild and domestic terrestrial organisms contaminated with PFAS substances include: brown hawk owl, carrion crow, cattle, cattle egret, chicken, common kestrel, cormorant, dog, eagle, Eurasian sparrowhawk, goat, great egret, gull, horse, Japanese sparrowhawk, large-bill crow, mallard duck, northern goshawk, pig, pintail duck, raccoon dog, swan, turtle, Ural owl and wild rats.

Sri Lanka: A 2008 study found PFOS in fish up to 12.4 ng/g wet weight and PFOA up to 0.74 ng/g. PFAS in water included PFOS, PFOA, N-EtFOSAA, PFOSA, and THPFOS.

Vietnam: A 2011 study measured the PFAS content of fish in samples of carp, snakehead, and catfish from India, Japan, Vietnam, Malaysia, and Thailand. Fish samples from Vietnam were collected in Bac Ninh, Hung Yen, and Long Xuyen. PFOS and PFNA levels were as high as 10 ng/g wet weight. The authors noted that PFOS and PFUA concentrations in livers of snakehead in Vietnam were greater than those in India and Malaysia, "suggesting that the degree of contamination with PFSs [PFAS] in Vietnam was greater than that in other tropical Asian developing countries." A subsequent study in 2016 found PFAS in a variety of seafood species. Dominant pollutants were PFUnDA in fish, PFTrDA in crustaceans, PFHxS in gastropods, and PFNA in bivalves.

FIREFIGHTING FOAMS AND EXTINGUISHERS CONTAINING PFAS ARE IN USE

In Indonesia, fire extinguishers containing PFAS (AFFF) are readily available for consumer purchase and vendors falsely claim that the product is, *"Not harmful to plants, animals, especially humans."* In Japan, an estimate of PFOS-containing firefighting foams shows that 47% (7000 tons) of stockpiles are in car-parking facilities. The second largest PFOS-containing foam stockpile (4200 tons) was held by the petrochemical industry and the third largest was contained in portable fire extinguishers (2000 tons). In Jordan, stockpiles of PFAS-containing foams include more than 292,000 liters of fluoroprotein foam and 28,000 liters of an alcohol-resistant fluoroprotein foam. Substitution of PFOS-containing firefighting foams for PFAS-containing foams has occurred in Lebanon. According to the government inventory, the Sri Lankan Fire Brigade has a stockpile of around 50,000 liters of firefighting foams imported in the late 1980s – likely PFOS-containing foam. A major firefighting foam importer supplies PFAS-containing foams, but does not indicate the PFAS content in the documentation.

Indonesia: Fire extinguishers containing PFAS (AFFF) are readily available for consumer purchase. In fact, vendors mention that the fire extinguisher contains PFOA and PFOS as a hydrocarbon-based surfactant and falsely claim that the product is, *"Not harmful to plants, animals, especially humans."*

Japan: There are large historical stockpiles of PFOS-containing firefighting foams in Japan, along with current use of PFAS-containing foams. A 2017 research paper reports that there were 15,000 tons of stockpiles of PFOS-containing aqueous film-forming foam in 2012 and 47% of the total amount (7000 tons) was due to stockpiles in car-parking facilities. According to the government, there are more than 20,000 multi-story car-parking facilities in Japan and each one stocks 400 kg of PFAS-containing firefighting foam on average. The second largest PFOS-containing foam stockpile (4200 tons) was held by the petrochemical industry and the third largest was contained in portable fire extinguishers (2000 tons). PFAS contamination likely due to firefighting foams has also been found in the Ina River downstream from the Osaka International Airport. There are no regulations regarding the use of firefighting foam extinguishing agents containing PFOS or any other PFAS substance at the firefighting site.

Jordan: According to the Revised National Implementation Plan under the Stockholm Convention firefighting foams are the likely major source of PFAS in the country. Use of fluorine-containing fluoroprotein firefighting foams by the Civil Defense Directorate between 2010 and 2013 ranged from 16,524 – 22,744 liters. The Directorate has large stockpiles of PFAS-containing foams including more than 292,000 liters of fluoroprotein foam and 28,000 liters of an alcohol-resistant fluoroprotein foam. Use of PFAS-containing firefighting foams by the Jordan Petroleum Refining Company and electrical generation companies such as the AL Hussein thermal station are not currently known.

Lebanon: A 2017 government inventory showed 6,240L of PFOS-containing firefighting foam was used for 10 fire incidents between 2006 – 2014 and that that PFAS-containing AFFF foams are imported into Lebanon, primarily for use at gas stations. PFOS releases from firefighting foams are estimated at 5.5 – 16.5 kg based on imports from one supplier; 0.11 – 0.34 kg PFOS released in 2001 from the activities of Middle East Airlines; and 50 – 150 kg PFOS released between 2006 – 2014 from the Beirut Fire Department. The Beirut Fire Department has moved to PFAS-containing AFFF and fluoroprotein foams and the current foam composition used by the military is not known. Potential contaminated sites include firefighting practice areas in the country and sites of fires where foams were used including warehouses and factories.

Sri Lanka: According to the Revised National Implementation plan under the Stockholm Convention firefighting foams are the likely major source of PFOS in the country with 17,837 kg/ year as an upper estimate. According to the government inventory, the Sri Lankan Fire Brigade has a stockpile of around 50,000 liters of firefighting foams imported in the late 1980s – likely PFOS-containing foam. A major firefighting foam importer supplies PFAS-containing foams, but does not indicate the PFAS content in the documentation.

CONSUMER PRODUCTS ARE CONTAMINATED WITH PFAS

Consumer products containing PFAS include food contact papers (Egypt), cow milk (Jordan), coats (Bangladesh, Indonesia), shoes (Indonesia), food packaging such as noodle cup, instant rice porridge cup, microwave popcorn bag, beverage cup, ice cream cup, fried chicken box, fried chicken wrapper, French fries bag, French fries wrapper, French fries box, hamburger wrapper, pretzels box, pretzels wrapper, donut box, donut wrapper, and baking paper (Thailand), and textile products including diapers, shirts, pants, footwear, towels, uniforms, bags, curtains, upholstery, carpets, blankets, and table cloths (Thailand). In Japan, PFAS substances are present in sprays for textiles, car wash / coating products, and rust inhibitor products. The highest PFAS concentration was 25,000 ng/g for N-ethyl perfluorooctane sulfonamidoethanol (EtFOSE), a PFOS precursor, in a spray for textiles.

Bangladesh: A 2014 Greenpeace investigation found that waterproof coats (body 100% polyester; lining 65% polyester, 35% cotton) manufactured in Bangladesh and sold to Argentina contained 29.7μg/ kg ionic PFAS and 6967μg/ kg volatile PFAS and a total PFAS level of 557 $\mu g/m^2$. To illustrate how significant these levels are, note that the EU regulates PFOS at 1 μg/m✲ in textiles

Egypt: A 2016 study found PFOA in 79% of food contact papers analyzed. The highest levels were found in two food paper wrappers at 65 ng/g and 94 ng/g and these same samples also showed higher levels of PFHxA, PFNA, PFDA and PFUnA. PFOS was found in 58% of the food contact samples with a median concentration of 0.29 ng/g. PFAS precursors, 6:2 monoPAPs and 8:2 monoPAPs were detected in a French fries cardboard box and two sandwich wrapping papers respectively.

Indonesia: A 2014 Greenpeace investigation found five types of soccer shoes manufactured in Indonesia that contained PFOA and PFBS. The levels ranged from 5.28 – 14.5 $\mu g/m^2$ for PFOA and 14.5 – 37.9 $\mu g/m^2$ for PFBS. A study from the German Federal Environmental Agency found a coat made in Indonesia with a variety of PFAS substances at a total level of 42.9 $\mu g/m^2$. To illustrate how significant these levels are, note that the EU regulates PFOS at 1 μg/ m✲ in textiles.

Japan: A 2015 study found PFAS in sprays for textiles, car wash / coating products, and rust inhibitor products. The highest PFAS concentration was 25,000 ng/g for N-ethyl perfluorooctane sulfonamidoethanol (EtFOSE), a PFOS precursor, in a spray for textiles. Sprays for textiles and car wash / coating products were the categories that contained PFAS levels greater than 1000 ng/g. PFAS were detected in two out of three rust inhibitor products, including PFPeA. The PFAS substance with the highest detection frequency was PFNA (16%). PFNA also had the second highest average concentration of 220 ng/g. The authors suggest that PFNA may have been substituted for PFOA in Japan.

Jordan: A 2015 study found significant levels of PFOS and PFOA in both breast milk and fresh cow milk. In cow milk, PFOS and PFOA were found in 96% of the samples. PFOA levels ranged from 9 – 160 ng/L (ppt) and average levels were 86 ng/L (ppt). The average PFOA level in cow milk was more than four times higher than the drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined in the US State of Vermont. The highest PFOA level in cow milk was eight times higher than this limit. PFOS levels ranged from 6 – 178 ng/L (ppt) and average levels were 29 ng/L (ppt). The average PFOS level in cow milk was 1.45 times higher than the drinking water health advisory limit of 20 ppt for PFOA, PFOS, PFHxS, PFHpA and PFNA combined in the US State of Vermont. The highest PFOS level was almost eight times higher than this limit.

Thailand: PFAS substances have been found in textile products on the Thai market including diapers, shirts, pants, footwear, towels, uniforms, bags, curtains, upholstery, carpets, blankets, and table cloths. The highest PFOS levels were found in a carpet (0.61 ug/m^2) and the highest PFOA levels were found in bags (14.14 ug/m^2). Both PFOS and PFOA were released into washing water with the highest levels after the first washing. The authors note that, *"The data presented in this study showed that textiles could be a significant direct and indirect source of PFOS and PFOA for both human and environmental exposure. Migration of PFOS and PFOA into the human body from textiles through sweat during wearing and the risk assessment of PFOS and PFOA in textiles, should be further studied."*

A 2012 study found PFOA and PFOS in packaging: noodle cup, instant rice porridge cup, microwave popcorn bag, beverage cup, ice cream cup, fried chicken box, fried chicken wrapper, French fries bag, French fries wrapper, French fries box, hamburger wrapper, pretzels box, pretzels wrapper, donut box, donut wrapper, and baking paper. The authors noted that, *"there is a potentially significant negative impact on human health from the consumption of food* *and beverages contained in paper packaging."* The authors also noted that PFAS would be released from this packaging when the products become wastes.

PFAS SUBSTANCES CONTAMINATE DUST AND PARTICULATE AIR POLLUTION

PFAS was found in particulate matter air pollution in India and Japan and in street dust in Japan. Household dust is contaminated with PFAS substances in Egypt, Nepal, Japan, and Thailand.

Egypt: A 2016 study examined PFAS substances in dust from 17 homes, 5 workplaces and 9 cars in Cairo. PFAS levels in dust ranged from 1.09 to 55.2 ng/ng and included FTOHs > FOSEs > FOSAs > FTAs. The 8:2 FTOH substance was the dominant substance followed by 6:2 FTOH and 10:2 FTOH. Similar levels and substances were observed in workplaces and cars. The authors note that the prevalence of FTOHs could reflect their use in consumer products. PFOS (4.09 ng/g) and PFOA (2.16 ng/g) were also dominant substances in dust and PFHxA (21% of samples), PFNA (13% of samples), and PFDA (29% of samples) were also detected. PFAS levels in dust in Egypt are lower than in other countries and the authors note that imported wall to wall carpeting is typically not used in Egyptian homes while locally manufactured carpets and furniture which are typically not treated with PFAS substances are commonly employed.

India: PFAS in particulate air pollution in Chennai was in the 2.5 – 10 um range with a $PM_{2.5}$ / PM_{10} ratio of 0.38. PFOA was the dominant component in samples. Ultrafine particles ($PM_{0.1}$) had the largest PFAS mass fraction. The largest PFAS concentration was found in Hong Kong followed by Chennai and the two locations in Japan.

Japan: High levels of PFOS (15 – 2500 ng/g) and PFOA (69 – 3700 ng/g) were found in all samples of house dust. The authors note that "small children spend their life in the space near the floor, and the compounds have been used in floor wax and carpets." PFAS precursor substances such as polyfluorinated phosphate esters (PAPs) were frequently detected in household dust samples from Canada, the Faroe Islands, Sweden, Greece, Spain, Nepal, Japan, and Australia. The median levels of monoPAPs and diPAPs ranged from 3.7 ng/g to 1,023 ng/g and 3.6 ng/g to 692 ng/g, respectively, with the highest levels in Japan. Dust from Japan had the highest level of PFCAs (230 ng/g) and unlike other countries, PFNA was the predominating substance instead of PFOA. PFOS, PFOA, PFNA, PFDA, and PFUA have also been found in street dust in Tokyo

Nepal: PFAS precursor substances such as polyfluorinated phosphate esters (PAPs) were frequently detected in household dust samples from Canada, the Faroe Islands, Sweden, Greece, Spain, Nepal, Japan, and Australia. The median levels of monoPAPs and diPAPs ranged from 3.7 ng/g - 1,023 ng/g and 3.6 ng/g - 692 ng/g, respectively, with the lowest levels found in Nepal and the highest in Japan.

Thailand: A 2011 study found eight PFAS substances in household dust samples collected in Bangkok. The highest levels were for EtFOSA (940 ng/g or ppb) – a substance that degrades to PFOS. The authors note that dust may be an important PFAS exposure pathway for young children.

US MILITARY BASES IN JAPAN CAUSE PFAS POLLUTION

Use of PFAS-containing firefighting foams has caused high levels of PFAS pollution outside of the bases in Okinawa. Although the Japanese government has requested the US military to allow access for investigation, the US has continued to refuse the requests saying that, *"PFOS is not a regulated substance in the US and Japan."*

Japan: Surveys by the Okinawa Prefectural Enterprise Bureau since 2013 showed that Kadena Air Base and Marine Corps Air Station at Futenma are major sources of PFAS pollution that have contaminated water outside the base. Internal US government documents reveal large spills and leaks of firefighting foams and US military officials have admitted using PFOS-containing firefighting foams at the base, after the substances were detected in groundwater wells and streams running through the base. Internal US government documents described in a 2019 report indicate extreme PFAS contamination inside and outside of the Kadena Air Base. For example, foam fire extinguisher located around a pond situated 200 meters from the Kadena town hall contained 90,000 ppt PFOS. A map shows the growing number of polluted sites. Although the Japanese government has requested the US military to allow access for investigation, the US has continued to refuse the requests saying that, *"PFOS is not a regulated substance in the US and Japan."*

JAPAN IS AN IMPORTANT PFAS PRODUCER

Three prominent PFAS manufacturers include AGC, Daikin, and Mitsui-Chemours. Mitsui-Dupont polluted water with PFOA at their factory in Shimizu. At Daikin's factory in China, some of highest PFAS levels ever reported in the country were found in the Changshu Industrial Park. Daikin paid $USD4 million to settle a lawsuit stemming from PFOS and PFOA pollution downstream of their factory in Alabama, USA. In 2018, a US firefighter filed a class action lawsuit against AGC, Daikin, 3M, Archroma, Arkema, Chemours, Dyneon, DowDuPont, and Solvay to fund an independent investigation of links between exposure and health impacts of the entire class of PFAS substances.

Japan: PFAS manufacturing began in 1947 in Japan and between 1988 and 2017, production nearly doubled, rising from 16,398 tons to 30,151 tons. Three prominent manufacturers include AGC, Daikin, and Mitsui-Chemours.

In Japan, Mitsui-Dupont polluted water with PFOA at their factory in Shimizu. DuPont tracked PFOA in the blood of the workers at the facility as revealed in US EPA filings and internal company documents. PFOA was also found in water at 10 wells at the factory site with levels up to 1,540,000 ppt. The site was sold to DuPont spin-off company, Chemours and Chemours-Mitsui Fluoroproducts is a 50:50 joint venture between the two companies. In 2019, US EPA filed a notice of violation against Chemours – its first under the new Toxic Substances Control Act. The company had five serious violations including manufacturing a substance for commercial purposes that was not even on the regulator's inventory list. In China, Daikin is located in the Changshu Industrial Park in Jiangsu Province along with other foreign PFAS manufacturers such as Solvay and Arkema. In 2013, scientists measured some of the highest PFAS levels ever reported in China in the industrial park. In 2016, the US Northern Alabama water and sewer authority sued 3M and Daikin America due to pollution of the Tennessee River drinking water supply with PFOS and PFOA. The area is downstream of Daikin's factory in Decatur, Alabama. Local residents were warned by authorities not to drink the water. Daikin settled their part of the lawsuit for USD$4 million in 2018 to pay for a carbon filtration system. However, the settlement does not prevent individual residents from pursuing legal action.

In 2018, Kevin Hardwick, a US firefighter, filed a national class-action lawsuit against nine PFAS manufacturers including AGC and Daikin, along with 3M, Archroma, Arkema, Chemours, Dyneon, DowDuPont, and Solvay. The purpose of the lawsuit is to fund an independent investigation of links between PFAS exposure and health impacts, including the entire class of PFAS substances.

PFAS ELIMINATION CONTRIBUTES TO ACHIEVEMENT OF THE SUSTAINABLE DEVELOPMENT GOALS (SDGS)

Due to the complexity and negative characteristics of PFAS, there is increasing interest in regulating PFAS as a class rather than as individual substances. As noted by Linda Birnbaum, Director of the US National Institute of Environmental Health Sciences and the National Toxicology Program, "*Approaching PFAS as a class for assessing exposure and biological impact is the most prudent approach to protect public health.*" Actions to control and phase-out PFAS as a class contribute to achievement of several key Sustainable Development Goals (SDGs) due to the impacts of the substances on health and ecosystems including water pollution. These include SDGs 3, 6, 9, 12, 14, 15, and 16.

ANNEX 1. PFAS MANUFACTURERS KNEW THAT THE SUBSTANCES WERE HARMFUL

Recently obtained documents indicate that the original manufacturers of PFOS and PFOA knew about the harmful characteristics of both substances decades ago.

A lawsuit filed by the US State of Minnesota against 3M produced internal company documents that demonstrated that the company knew PFOS and PFOA were accumulating in people for more than 40 years. 3M had previously withheld required documents from US regulators which resulted in a USD$1.5 million fine in 2006. In 1975, university researchers found a fluorinated substance in human blood and 3M confirmed that it was PFOS. Subsequent company testing found PFOS levels in 3M personnel at levels 50 – 1000 times higher than normal levels. In 1978, tests on monkeys feed PFOS resulted in all the animals dying and those given PFOA developed lesions on their spleen, lymph nodes, and bone marrow, all relevant to a functioning immune system. By 1989, the company knew that PFOS suppressed the immune system, caused tumors in animals, and that rates of cancers of the digestive organs and prostate were elevated in its own workers. The company proceeded to produce the substance anyway.

Internal company documents reveal that DuPont knew decades ago that PFOA affected the livers of dogs and humans, encouraged the growth of testicular tumors in rats, and appeared to result in endocrine disorders and kidney cancer in workers. In 1978, the company documented immunotoxicity and other adverse effects in tests on monkeys exposed to PFOA and PFOS. By 1984, DuPont knew that PFOA was toxic, didn't break down, accumulated in blood, transferred from mothers to the fetus, and polluted drinking water supplies. DuPont decided to keep producing it anyway as it became incorporated into a multitude of products and processes. The company's real attitude about the consequences of PFOA production is revealed in its internal documents as "the material 3M sells us that we poop to the river and into drinking water."

DuPont was fully aware of PFOA's hazards, but a study of the company's decision-making processes noted that DuPont made a calculated, rational decision to pollute anyway. The authors estimate that for DuPont, "it was value-maximizing to pollute if the probability of getting caught was less than 19%." In reality the probability was much less than that and now communities and governments bear the burden of that private sector decision.

ANNEX 2. THE HIGH COST OF PFAS CLEANUP

PFAS manufacturing and use in a multitude of products such as firefighting foams has resulted in widespread pollution – especially in water due to the solubility of PFAS substances. PFAS-contaminated sites have been identified in Australia, Canada, China, Germany, Italy, Japan, Netherlands, New Zealand, South Korea, Sweden, and the US, including a large number of military bases that contribute to 172 PFAS contamination sites in 40 states. In 2018, the US State of Minnesota entered into an agreement with 3M for the company to pay the state USD$850 million for costs associated with cleanup of PFAS including PFHxS due to manufacturing and releases by the company.

Clean up of PFAS pollution is difficult and costly. According to the Polluter Pays Principle, and sound economic policy, these types of external costs should not be borne by taxpayers, the state or national treasury, or by any other third party. Rather, these costs should be internalized within producer industries to avoid market distortion. As noted by UN Environment in 2012, "The vast majority of human health costs linked to chemicals production, consumption and disposal are not borne by chemicals producers, or shared down the value-chain. Uncompensated harms to human health and the environment are market failures that need correction."

Recently, the US State of New Jersey has taken a polluter pays legal action against Chemours, DowDuPont, Solvay and 3M for millions of US dollars for investigation and cleanup of PFAS pollution. State regulators noted PFAS contamination of surface water, groundwater, sediments, soils, air, fish, plants and other resources. Catherine McCabe, New Jersey Environmental Protection Commissioner noted that, *"The chemical companies—not New Jersey residents—should pay for the investigation and remediation of PFAS."*

Examples of estimated and actual cleanup costs for PFAS pollution include:

- Recent US government agency estimates for the cost PFAS clean-ups and associated monitoring due to use of firefighting foams at US military bases are more than USD$2 billion. There are also expensive clean up costs and estimates in a variety of US states including Alaska, New Jersey, New York (see also here and here), Vermont, Virginia, and Washington.
- The World Bank estimates that if just 20% of fluorinated firefighting foam in China is used for training or fire extinguishing, remediation costs would exceed USD$800 million.
- Remediation of PFAS-containing firefighting foam at the Düsseldorf Airport in Germany will take years or even decades. Cleanup costs cited by the European Chemicals Agency exceed €100 million. There are additional documented remediation costs due to PFAS pollution in Germany – see here, here, and here.
- Clean up due to use of 3M's "Light Water" firefighting foam containing PFOS and PFHxS at 18 military bases in Australia is estimated to cost hundreds of millions of dollars. The cleanup of just a single firefighting training college in Australia is estimated to cost AUS$80 million.
- To clean up groundwater polluted by PFAS around firefighting areas in Norway costs €3.5-5.5 million per training site.
- Firefighting training sites are the main sources of PFAS pollution in Sweden leading to €1 million in annual costs for charcoal filtering of water in Uppsala and a new water supply in Ronne costing €3 million. Extrapolated estimates for advanced cleaning of all waste water treatment plants in Sweden would only moderately remove fluorinated compounds but still cost USD$230 million per year.
- New Zealand has budgeted NZE$1 million to investigate cleanup of PFAS associated with firefighting foam use by military bases.

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