EXECUTIVE SUMMARY

# MERCURY THREAT TO WOMEN & CHILDREN ACROSS 3 OCEANS

## ELEVATED MERCURY IN WOMEN IN SMALL ISLAND STATES & COUNTRIES

**Lee Bell, IPEN**

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BIODIVERSITY RESEARCH INSTITUTE
innovative wildlife science

IPEN
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## ELEVATED MERCURY IN WOMEN IN SMALL ISLAND STATES & COUNTRIES

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**IPEN** is a network of non-governmental organizations working in more than 100 countries to reduce and eliminate the harm to human health and the environment from toxic chemicals.

**www.ipen.org**


**Biodiversity Research Institute** is a non-profit ecological research group whose mission is to assess emerging threats to wildlife and ecosystems through collaborative research, and to use scientific findings to advance environmental awareness and inform decision makers. BRI is the leading international institute supporting the global mercury monitoring efforts for the Minamata Convention on Mercury.

**www.briloon.org**

## KEY FINDINGS

- 757 women of child-bearing age from 24 locations in 21 countries participated in this study. 58% of the women who participated had mercury levels greater than 1 ppm—the level that approximately corresponds to the US EPA reference level.* 75% of women had mercury levels greater than 0.58 ppm mercury, a more recent, science-based threshold based on data indicating harmful effects at lower levels of exposure. Mercury is a health threat to women and the developing fetus.
- The majority of sampled women of Small Island Developing States (SIDS) in the Caribbean, Indian Ocean and Pacific Ocean have elevated mercury body burden above the US EPA reference level, primarily due to contamination of their fish-rich diet.
- Distant air emissions of mercury from sources such as coal-fired power plants and mercury use in small-scale gold mining contaminate ocean fish that serve as a primary protein source for SIDS populations. SIDS are impacted by the negative consequences of these polluting activities yet receive none of the benefits.
- Mercury contamination of the Pacific Ocean has spread as far as the Hawaiian Island of Molokai, where high levels of mercury were recorded in women.
- Coal-fired power plant and cement plant emissions contribute mercury contamination to adjacent waterways and elevate mercury levels in Sri Lankan women living nearby.
- Indigenous women on St. Lawrence Island (Alaska) have mercury levels of concern due to their subsistence diet of sea mammals and fish. Consumption of locally available seals may be a key source of mercury exposure caused by distant industrial emissions.
- Women who ate few fish, small fish or who ate fish infrequently recorded the lowest mercury levels in this study.
- Burning coal for energy and using mercury in small-scale gold mining are primary drivers of atmospheric and ocean mercury contamination leading to elevated mercury body burden in women living in SIDS and SIDS-like locations.

* This is the daily exposure that US EPA considers "likely to be without an appreciable risk of deleterious effects during a lifetime."

# EXECUTIVE SUMMARY

Mercury is a potent neurotoxic metal that is especially damaging to the developing brain and can affect the developing fetus months after the mother's exposure. The harmful effects of mercury, that can pass from a mother's body to a developing fetus, include neurological impairment, IQ loss, and damage to the kidneys and cardiovascular system. High levels of mercury exposure can lead to brain damage, mental retardation, blindness, seizures and the inability to speak.

While researchers have studied mercury body burden in specific regions of the world, information on developing and transition countries remains lacking. Earlier joint studies by IPEN and BRI exposed elevated mercury levels in developing countries around the globe with some of the highest levels measured in Pacific island and arctic communities far from the major sources of mercury pollution.[1] This study was designed to examine whether mercury levels in women of child-bearing age from mercury contaminated fish is comparable across in the world's three major oceans. It is the first to evaluate mercury in women across the Caribbean and Indian Ocean.

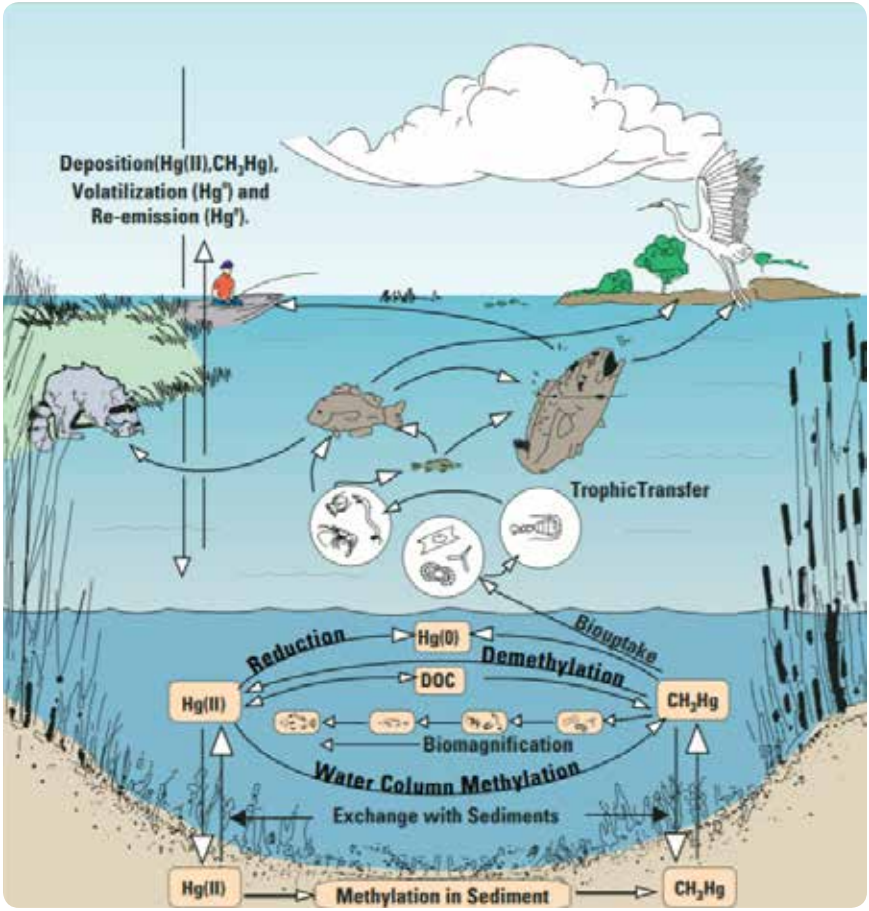
IPEN and BRI focused on measuring the mercury body burden of 757 women of child-bearing in Small Island Developing States (SIDS) and SIDS-like locations in the Pacific Ocean, the Caribbean and the Indian Ocean as well the US islands of Molokai (Hawaii) and Saint Lawrence Island (Alaska) where, like SIDS, populations are remote from mercury sources, industrial development levels are low and the population relies on local fisheries as a major source of dietary protein. Sri Lanka was also included as an island state with a large coal fired power plant though it is not officially a SIDS.

The mercury that women are exposed to is almost entirely from their seafood diet. The mercury is originally released in emissions from coal fired power production and small-scale gold mining where it enters the atmosphere and travels long distances before eventually deposits into the ocean as part of an ongoing cycle. Following atmospheric deposition, naturally occurring bacteria convert elemental mercury and other mercury compounds into methylmercury,[2] which is far more bioavailable than other forms of mercury and which accumulates through the food chain, resulting in high concentrations in top feeding predatory fish such as swordfish, shark and king mackerel.[3] Mercury also accumulates in fish further down the predatory chain but not at such high concentrations. Consumption of

fish contaminated with methylmercury directly transfers that mercury to the human body where it can impact the health of women, and if of child-bearing age, the fetus.

The data indicates that there is a serious, substantial, and present threat to women and children's health from mercury exposure in most of the locations where sampling took place.

**The mercury cycle after deposition to waterways**



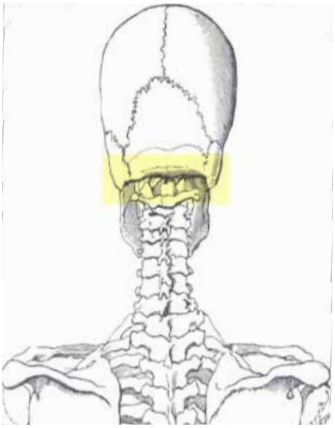
Children, Vanuatu

# METHODOLOGY

Sampling was undertaken across the globe during 2018 by public interest Participating Organizations (POs) of IPEN, civil society organizations (CSOs) in the Caribbean and, in some cases, medical professionals who worked cooperatively with identical methodologies and sampling protocols at all locations. Logistics, communications, shipping and networking were ably supported by the Island Sustainability Alliance – Cook Islands (ISACI), the Basel Convention Regional Centre (BCRC) for the Caribbean, Arnika Association (Czech Republic), Biodiversity Research Institute (BRI, US) and IPEN. IPEN Participation Organizations (POs) and CSOs reached out to communities that may be susceptible to mercury contamination of food supplies such as fish, which can transfer their methylmercury (MeHg) body burden to humans when consumed. Nearly all the locations sampled, with the exception of Sri Lanka, were SIDS or exhibited SIDs-like characteristics of being remote island communities with limited dietary protein other than seafood.

The study resulted in hair samples being taken from 757 women in 24 locations across 21 countries. The methodology for the study required on-the-ground teams to identify groups of 30-35 women of child-bearing age (denoted as 18 - 44 years old) in one or two locations in each country and invite them to participate. The women provided signed consent to

**Hair samples were taken from the base of the head. (Right) Hair sampling in Trinidad and Tobago.** Source: Friends of Botanic Garden, Trinidad and Tobago



participate in the study. Participants were also required to provide a small sample of hair, taken according to protocol, and to complete a questionnaire to assist with contextual analysis. The samples of hair were shipped to the laboratories of BRI in the United States for analysis. Women in this age range were selected as they constitute part of the vulnerable subpopulation groups at risk from mercury, a powerful neurotoxin that can affect the health of the mother and impact on a range of developmental endpoints in the developing fetus with lifelong consequences.[4]

Sample results were assessed against the internationally recognized reference level of 1 ppm total mercury (THg), above which health effects to the developing fetus of pregnant women may occur. The basis for the use of this reference level in this study is that it corresponds closely with the US EPA's reference dose (RfD) of 0.1 µg/kg bw/ day and a blood mercury concentration of 4 - 5 µg/L.[5]

For some time, the scientific literature has suggested that adverse effects on the sampled individual begin to occur at or above the reference level of 1 ppm.[6,7] However, the latest scientific literature concludes that negative developmental effects may occur at even lower levels[8] and that a threshold level of 0.58 ppm should be adopted as the level below which impacts on the developing fetus are negligible.[9] For the purposes of this study we used the accepted threshold of 1 ppm to assess elevated mercury levels in participants. However, where appropriate we have also included references to the proposed science-based threshold concentration of 0.58 ppm for comparison.

**Women in the Comoros have their hair sampled for mercury and fill out surveys.** Photos by Hemsing Hurrynag

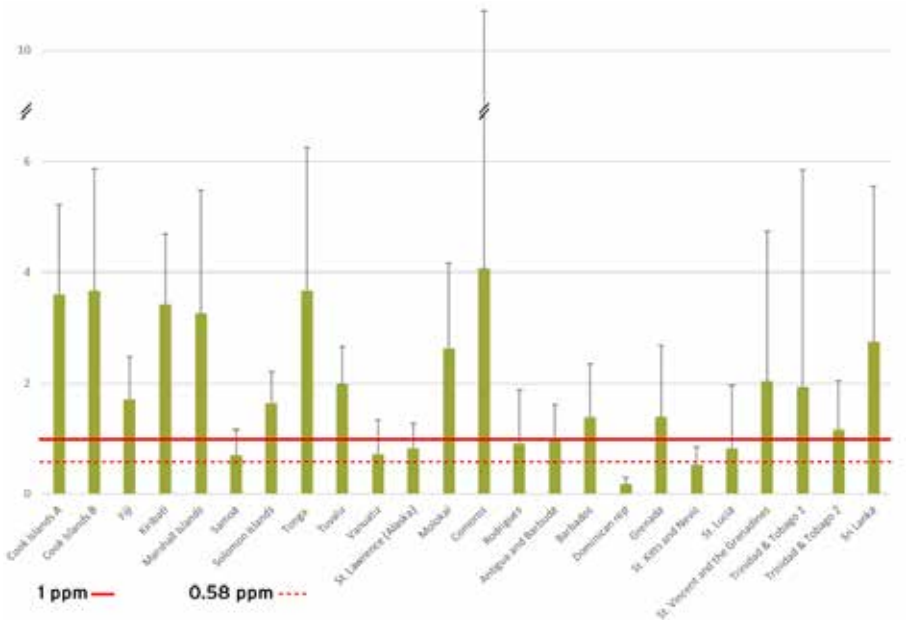
## KEY FINDINGS

Of the 757 women of child bearing age who took part in this study 58% had a mercury body burden (as measured in hair) that exceeded 1 ppm Hg - the level that approximately corresponds to the US EPA reference dose. Locations where the mean (average) level of participants exceeded the 1 ppm reference level for mercury were the Barbados, Comoros, Cook Islands, Fiji, Grenada, Kiribati, Marshall Islands, Molokai, St. Vincent and the Grenadines, Solomon Islands, Sri Lanka, Tonga and Trinidad and Tobago. In addition, 75% of all women who participated had mercury levels greater than 0.58 ppm mercury.

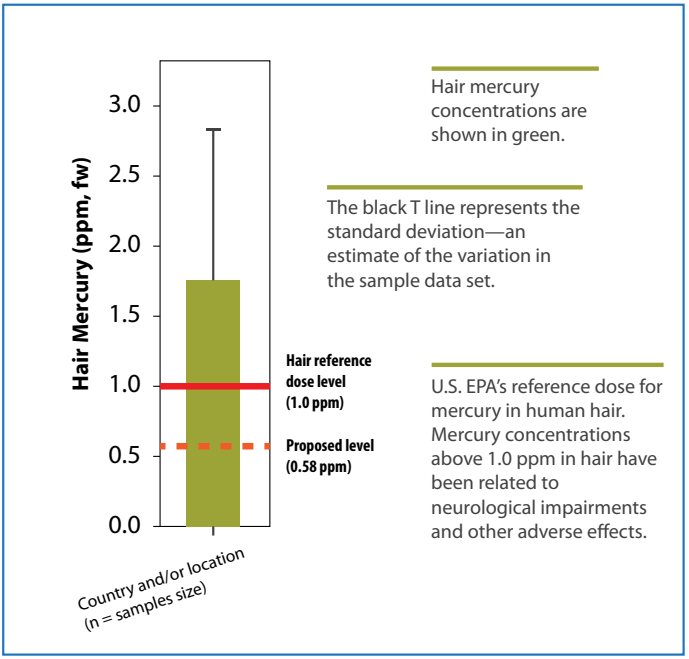
The majority of sampled women of SIDS in the Caribbean, Indian Ocean and Pacific have elevated mercury body burden above the US EPA reference level, primarily due to contamination of their fish-rich diet. Mercury contamination of the Pacific Ocean can be found throughout the Pacific, reaching as far as the Hawaiian Island of Molokai, where high levels of mercury were recorded in women who eat fish frequently.

The most likely cause of the elevated levels among women who live in locations where there is minimal local mercury pollution is distant air emissions of mercury from sources such as coal-fired power plants and

**Mean mercury levels reported for all participants in each location.**




**Interpreting the hair mercury concentration chart**



**Sri Lanka traditional pole fishing method**

other industries, as well as air emissions from mercury use in small-scale gold mining. This contaminates ocean fish that serve as a primary protein source for SIDS populations.

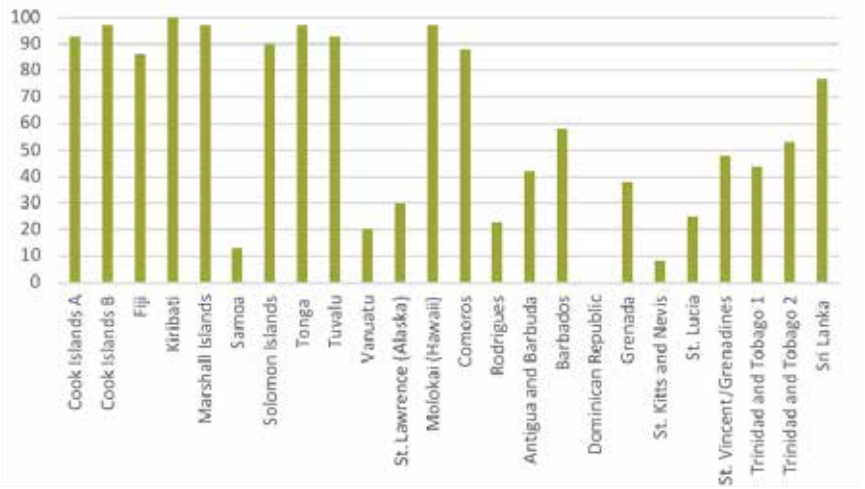
Coal-fired power plant emissions are known to have long-range pollution impacts. This study indicates that local impacts from these power stations are also relevant. In one location studied, coal-fired power has contributed to contamination of waterways used for subsistence fishing, leading to elevated mercury levels in Sri Lankan women living nearby.

Indigenous women on St. Lawrence Island (Alaska) have mercury levels of concern due to their subsistence diet of sea mammals and fish. Human consumption of locally available seals may be a key source of mercury exposure for Yupik women, as studies demonstrate the seals have elevated mercury levels due to fish consumption which, in turn, have been impacted by long-range emissions from industry.

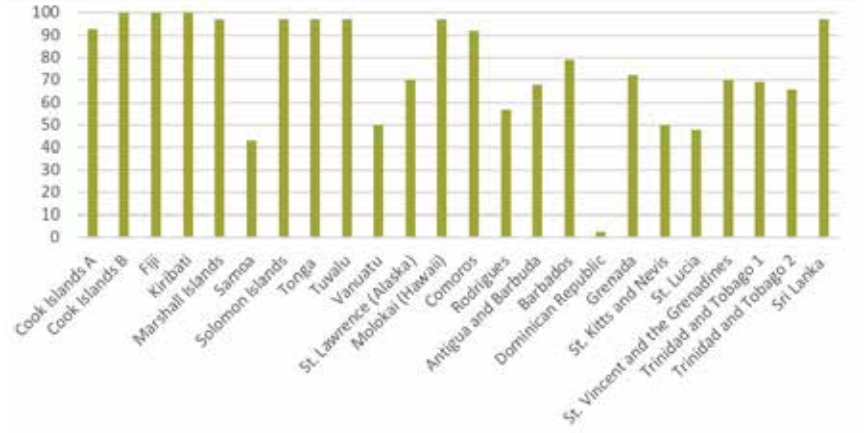
**Racks with sea mammal meat drying in Gambell, Saint Lawrence Island, Bering Sea, Alaska.**

According to the questionnaire data, women who ate few fish, small fish, fish from lower trophic levels or who ate fish infrequently recorded the lowest mercury levels in this study.

**Percent of hair samples over reference level (Hg 1 ppm) by location**




**Percent of hair samples over proposed reference level (Hg 0.58 ppm) by all locations**




Burning coal for energy and using mercury in small-scale gold mining are primary drivers of atmospheric and ocean mercury contamination leading to elevated mercury body burden in women living in SIDS and SIDS-like locations.

Mercy Ritte, a mother and resident of Molokai, had her hair tested for Mercury.
Source: Matt Yamashita

# CONCLUSION

This study has collated the hair sampling results from over 750 participating women to assess their hair mercury levels and therefore their body burden. The results were surprisingly high, even when compared to previous IPEN/BRI studies across the globe. This evidence, combined with past IPEN/BRI mercury sampling studies in both fish[10] and women of child-bearing age, consolidate the evidence that clearly shows industrial mercury emissions such as coal-fired powered stations are a primary driver of ocean contamination. Small-scale gold mining (ASGM) using mercury is the other major contributor to atmospheric contamination that is polluting ocean food chains both close to and distant from the source activity. While ASGM location sampling was not within the scope of this report, previous biomonitoring by IPEN/BRI in ASGM locations has shown very high levels in women of child-bearing age.[11]

In 2013, approximately 66 million people populated Small Island Developing States. By 2040 that number is expected to exceed 82 million people.[12] When considered collectively it is apparent that a sizable portion of the world's population is impacted by mercury pollution through their direct consumption of contaminated seafood.

The absence of local mercury polluting industries, gold production or other sources of significant mercury emissions in most SIDS, coupled with the remote distribution of the islands, indicate mercury contamination of seafood as the primary factor in the elevated mercury body burden in most of these women. This is supported by a strong correlation between those women with a high fish diet and elevated mercury levels as well as some locations where women had a low fish diet and low mercury levels. This points to a serious food chain contamination problem caused by global mercury deposition from in-

**Comoros islands man carries a tuna.**

dustrial emissions to oceans. Subsequent bacterial methylation of mercury in oceans[13] results in its magnification through the food chain, impacting women reliant on fish as dietary protein women in SIDS.

Data about mercury levels in women from the Caribbean Islands and in Indian Ocean Islands has, until now, been very limited. The results in this study demonstrate that island communities bear a very heavy burden of potential health impacts, and the subsequent economic impacts, that mercury pollution of the food chain causes. Importantly, results from some locations where mercury levels are very low indicate that consumption of mercury-contaminated fish is the driver for elevated levels. For most of the women who participated in this study and the communities they live in, there are very few protein alternatives available.

***The solution to this problem is not for women to avoid eating fish but for non-SIDS nations to stop emissions of mercury from coal-fired power plants and other industrial sources, implement renewable energy and stop trading mercury, so much of which ends in ASGM use.***

## ECONOMIC IMPACTS OF ELEVATED MERCURY BODY BURDEN

While the health impacts of elevated mercury levels in the human body are well documented, a recent ground-breaking study[14] by Trasande *et al.* has estimated the economic losses attributable to lost productivity in those populations where levels of mercury body burden exceed 1 ppm. The study analyzed hair samples from 15 developing countries and countries in economic transition. The results showed that 61% of all participants had hair mercury concentrations greater than 1 ppm. Using a linear dose response relationship and an assumed 0.18 IQ point decrement per part per million (ppm) increase in hair mercury concentrations, an estimate of lost productivity was developed. This data was used to estimate increases in intellectual disability and lost Disability-Adjusted Life Years (DALY). A total of USD$77.4 million in lost economic productivity was estimated assuming a 1 ppm reference level, and USD$130 million if no reference level was used. The Trasande et. al. study points to far-reaching economic impacts from mercury pollution that will be borne by those countries least able to address the source of the mercury pollution and least able to bear such costs. Therefore, it is important to consider the whole scope of mercury pollution impacts in terms of human health, economic burden and ecological integrity.

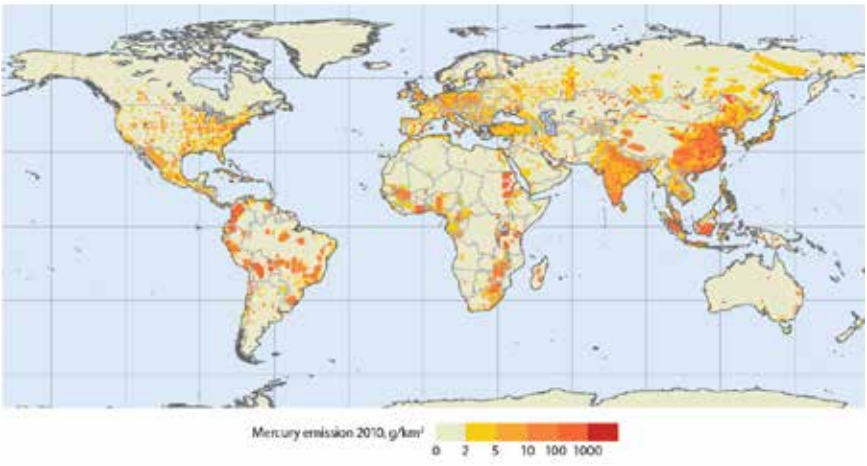
## COAL, THE COMMON DENOMINATOR FOR ACTION ON MERCURY CONTAMINATION & CLIMATE CHANGE

A secondary element of our study was to establish if global mercury contamination of the oceans by global coal-fired thermal power generation and other industrial sources of mercury is comparable across the two major oceans and the Caribbean Sea. The results of the hair sampling project demonstrate that mercury pollution is definitely affecting vast areas of the global oceans in terms of seafood contamination and the exposure of women who consume these fish. These findings mean that Parties to the Minamata Convention must act rapidly to take much stronger action under this Treaty and/or other Multilateral Environmental Agreements (such as the Paris Agreement) that address climate change given the synergies that can be achieved.

Methylation of mercury in the ocean results from atmospheric deposition from known mercury sources such as coal-fired power plants, cement kilns, metal processing smelters, chlor-alkali plants, vinyl monomer production facilities in China, and gold production. The primary industrial source is identified as coal-fired power stations.[15]

Coal fired power plants are not the sole source of mercury contamination of the oceans. However, coal fired power plants are both a significant source of mercury contamination in the world's oceans and a key source of

**2010 map of the global distribution of mercury emissions to air due to human activity shows the heavy emissions from coal fired power plant activity most heavily concentrated in South East Asia, India, and China.**
From UNEP, 2013. Global Mercury Assessment




carbon emissions impacting climate change. Coal-fired power represents a double threat to SIDS communities – rising seas caused by climate change are flooding islands while the mercury in the emissions poisons their food sources.

As such, strong action on eliminating coal fired power promises synergistic benefits reducing mercury contamination of the oceans as well as reducing the atmospheric carbon load.

The Minamata Convention requires Parties to apply Best Available Techniques and Best Environmental Practices (BAT / BEP) for mercury emission and release control on known sources such as coal- fired power stations. However, this provision only applies to new plants, and exempts older plants, and can only be legally enforced five years after the Treaty enters into effect for any given Party. The implementation of BAT / BEP for coal-fired power plants includes the installation of air pollution control devices (APCD) and can reduce mercury emissions from individual facilities by between 24 and 70%.[16]

There are three key problems with this approach:

- The first is that the Minamata Convention has no impact on existing coal-fired power stations, which are likely to have older equipment and higher pollution levels. Currently the estimated number of coal-fired power stations globally is around 3,700; however, there are

currently proposals or construction underway for an additional 1600 facilities, increasing global coal power capacity by 43%.[17] If all these facilities are constructed within the next four years, then BAT / BEP for mercury will not apply to 5,300 coal-fired power plants unless countries take action outside of the Convention to implement such measures (and some have done so already).

- The second issue is that there is no limit on the number of new coal-fired facilities that a Party can construct. Even when the time limit is reached, where BAT / BEP must be implemented for new facilities, the number of facilities that may be constructed is limitless. In turn, the sheer volume of mercury emissions may swamp the reductions generated by BAT / BEP implementation.
- A third issue is the concept of BAT / BEP itself. The premise of developing BAT / BEP guidance for coal-fired power plants is based on the practical question – "How can we optimize the operation of a polluting facility to reduce the amount of pollution it creates?" It is not based on the question, "How can we generate electricity with minimum pollution release?" As a result, the implementation of renewal energy generation is considered a separate issue to the more efficient operation of coal- fired power plants under the Treaty and its BAT / BEP guidance.

The Paris Agreement seeks to limit the rise in global temperature to well below 2 degrees Celsius above pre-industrial levels and to attempt to prevent the rise from exceeding 1.5 degrees Celsius. The focus of the Paris Agreement is on Nationally Determined Contributions which is a set of emission targets which each country must attempt to meet and report back on to the Convention. The financial objective of the Paris Agreement is to inject USD $100 billion a year into developing countries to combat

**Artisanal fisherfolk Rodrigues.** Source: Mauritius Attractions

climate change. While the Paris Agreement is not prescriptive about how Parties must reduce their overall national greenhouse gas (GHG) emissions by source, coal-fired power generation is an obvious target as renewable energy substitution is now commercially viable.

The "atmospheric mercury levels" chart above reveals that a high concentration of mercury emissions are associated with developing countries in south Asia and south east Asia and this suggests that substitution of coal-fired energy in those areas would greatly mitigate both mercury and GHG emissions.

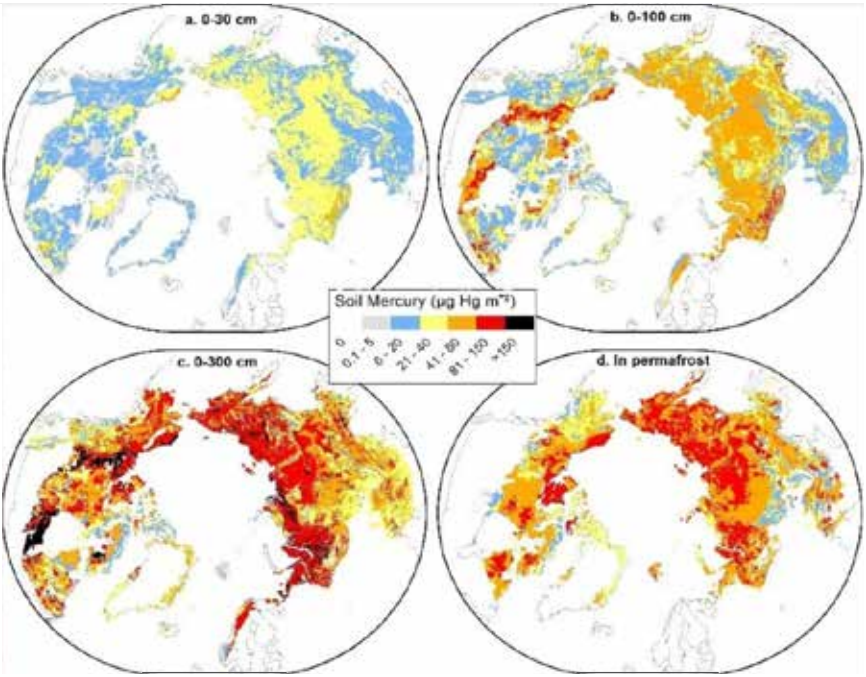
The substitution of coal-fired power with other energy sources such as renewable energy generation is an obvious measure to prevent additional sources of carbon pollution and also to reduce mercury emissions from the energy sector. Other fossil fuels generating energy such as oil and gas use also produce mercury pollution but at much lower levels. The Minamata Convention on Mercury seeks to reduce mercury emissions by adding additional pollution controls to coal-fired power stations over time. There are clearly synergies to achieve both objectives by limiting and reducing the amount of new and existing coal-fired power generation through substitution with renewable energy. In both cases the benefits of reduction of impacts on human health and the environment will last for generations. The impact of those reductions will depend on the urgency with which measures such as substitution are taken.

## CLIMATE FEEDBACK LOOPS CAN DESTROY MERCURY CONTROL EFFORTS

Climate science has warned of the devastating impacts that may occur if 'feedback loops' develop before we can reduce carbon emissions to tolerable levels. This is a scenario where climate impacts feed off themselves and accelerate the impacts beyond human control, irrespective of our emission control efforts. An example is polar ice melting. The bright, reflective nature of ice ensures that a large proportion of sunlight which strikes it is reflected back into space reducing climate warming. As the atmosphere continues to heat, more ice melts reducing the reflectivity of light and heat into space and revealing more of the darker earth's surface which absorbs heat. This causes further warming and ice melt and the system keeps intensifying.

The melting of arctic permafrost is another. The thaw of permafrost has been found to release large amounts of trapped methane, a very potent GHG, which for thousands of years has been locked away in the permafrost. This accelerates global warming and in turn accelerates methane release and the "feedback loop" continues to intensify.

**Maps of mercury concentrations in Northern Hemisphere permafrost zones for four soil layers.** Source: Schuster et al./GRL/AGU




The permafrost "'feedback loop" has now been found to have a dangerous mercury pollution aspect. Recent studies have found that vast deposits of mercury are also locked up in the permafrost and that climate warming is starting to release it. The volume of mercury is so large that it has been estimated at 10 times the amount of all mercury released in the world over the last 30 years.[18] If global warming releases significant amounts of this mercury through volatilization and erosion, then it may overwhelm global efforts to control anthropocentric emissions and intensify contamination of the marine food chain to unprecedented levels.

If we want to prevent mercury pollution spiralling out of control, we must act urgently to combat climate change.

Given the current trends in mercury pollution and climate change, it is clear that ambitious action, swiftly implemented, will be required both within and outside the frameworks of the Paris Agreement and the Mercury Treaty to prevent long-term consequences linked to coal-fired power production and other burning of fossil fuels.

## POLICY RECOMMENDATIONS

- The immediate cessation of the global mercury trade to prevent atmospheric and terrestrial pollution from small scale gold mining. Countries must unilaterally ban mercury import and export.
- Mercury and cinnabar mining should be banned in all countries immediately to ensure that domestic use of mercury does not grow despite import and export bans.
- Action to clean up mercury contaminated sites from gold mining and industrial operations must be accelerated to prevent significant releases and emissions to the global atmosphere.
- Real action on climate change emissions from the coal-based energy sector. Substitution of coal power with renewable energy is the only realistic solution. Fossil fuel substitution for coal is pointless.
- The developed world must substantially finance the rapid transition to renewable energy in developing countries for the benefit of the global ecosystem and human health.
- More extensive mercury biomonitoring should be conducted to fill data gaps on human and ecological exposure levels and to help measure progress on mercury pollution reduction.
- Women in Small Island Developing States should be provided with advisories and guidance on how to modify their existing seafood diet to reduce their mercury exposure and body burden.

***Full version of the report available at:***

***IPEN.org/IslandsMercury***

# ENDNOTES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BWC Enterprise, *Antigua and Barbuda*

Caribbean Youth Environment Network (CYEN) *Antigua and Barbuda*

Development Indian Ocean Network (DION), *Mauritius*

Ministry of Health, Social Security and International Business, *Grenada*

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Dr Roger Duncan, *Saint Vincent and the Grenadines*

BCRC-Caribbean, *Trinidad and Tobago*

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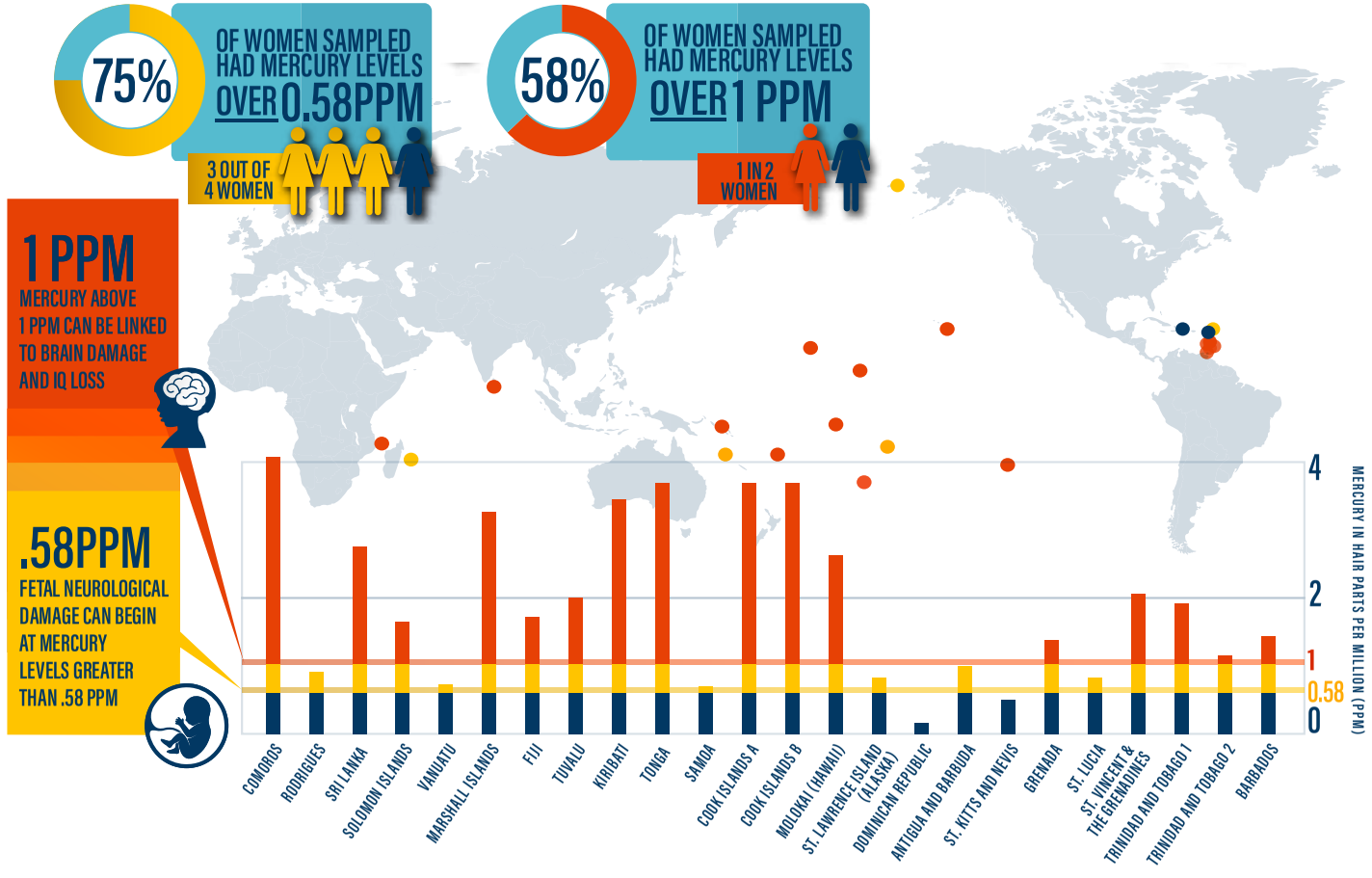
75%
OF WOMEN SAMPLED HAD MERCURY LEVELS OVER 0.58PPM
3 OUT OF 4 WOMEN
58%
OF WOMEN SAMPLED HAD MERCURY LEVELS OVER 1 PPM
1 IN 2 WOMEN
1 PPM
MERCURY ABOVE 1 PPM CAN BE LINKED TO BRAIN DAMAGE AND IQ LOSS
.58PPM
FETAL NEUROLOGICAL DAMAGE CAN BEGIN AT MERCURY LEVELS GREATER THAN .58 PPM
4
2
1
0.58
0
MERCURY IN HAIR PARTS PER MILLION (PPM)
COMOROS
RODRIGUES
SRI LANKA
SOLOMON ISLANDS
VANUATU
MARSHALL ISLANDS
FIJI
TUVALU
KIRIBATI
TONGA
SAMOA
COOK ISLANDS A
COOK ISLANDS B
MOLOKAI (HAWAII)
ST. LAWRENCE ISLAND (ALASKA)
DOMINICAN REPUBLIC
ANTIGUA AND BARBUDA
ST. KITTS AND NEVIS
GRENADA
ST. LUCIA
ST. VINCENT & THE GREMADINES
TRINIDAD AND TOBAGO 1
TRINIDAD AND TOBAGO 2
BARBADOS


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